THE ROLE OF THE HOME ENVIRONMENT IN EARLY WEIGHT TRAJECTORIES

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UCL

Declaration

I, Stephanie Schrempft, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated.

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Abstract

Dramatic increases in the prevalence of overweight and obesity have prompted a focus on prevention. Weight is known to have a strong genetic basis, but the speed of change in rates of overweight and obesity against a relatively stable gene pool suggests that exposure to an ‘obesogenic’ environment is important. The home environment is thought to play a key role in early weight trajectories, providing an avenue for long-term obesity prevention. There is evidence for associations between various aspects of the home environment and energy-balance behaviours; however, evidence for associations with weight is limited, particularly in early childhood. Few studies have used comprehensive, psychometrically-tested measures of the home environment, and no studies have tested for gene-environment interaction in the home context. This thesis uses data from the Gemini twin cohort to further examine the role of the home environment. Study one describes the development of a comprehensive measure of the home environment in early childhood, including the quantification of the extent that the home is likely to be obesogenic. Study two explores the utility of a novel tool called *SenseCam* to examine and validate aspects of the home environment measure. Study three identifies a number of maternal characteristics associated with the obesogenic quality of the home environment. Study four shows associations between the obesogenic quality of the home environment and energy-balance behaviours; while study five finds no association with weight. Findings from study six highlight the role of gene-environment interaction, showing that the heritability of weight is higher among children living in home environments with greater obesogenic potential. Overall, the findings of this thesis further understanding on how the home environment contributes to the development of overweight and obesity. Implications, limitations, and avenues for future research are discussed.

Table of Contents

List of Tables

List of Figures

List of Appendices

Chapter 1. Defining and measuring the obesogenic home environment

1.1 The Obesity Epidemic

1.1.1 Prevalence and cost

Obesity is a leading cause of preventable death worldwide (Kuk & Ardern, 2009) and increases the risk for all-cause mortality, even in the absence of overt metabolic aberrations (Kuk & Ardern, 2009). Prevalence has escalated nearly twofold in recent years (Finucane et al., 2011). Even among children below 5 years of age, rates have increased (Onis, Blössner, & Borghi, 2010). If trends continue, it has been predicted that 60% of adult men, 50% of adult women, and 25% of children will be obese by 2050 (Butland et al., 2007). While some evidence suggests that obesity rates might be levelling (Nichols et al., 2011; Rokholm, Baker, & Sørensen, 2010), the current rates are extremely high and longer-term research is needed to see whether there is a temporary plateau preceding further increases.

In addition to substantial health risks, overweight and obesity place enormous strain on the economy. In the UK alone, direct costs of overweight and obesity to the NHS are estimated to be £4.2 billion. Wider costs to society and the economy due to reasons such as premature retirement, unemployment, benefit payments, and low productivity, are estimated to be in the region of £16 billion (Morgan & Dent, 2010).

1.1.2 Health consequences

Overweight and obesity pose substantial risk to both physical and psychological health. Excess weight dramatically increases the risk of developing a number of non-communicable diseases including diabetes, cardiovascular disease, liver disease, and some cancers (Renehan, Tyson, Egger, Heller, & Zwahlen, 2008; Y. C. Wang, McPherson, Marsh, Gortmaker, & Brown, 2011); with comorbidity increasing with higher body weight (Must, 1999). Many additional disorders, including infertility (Pasquali, Patton, & Gambineri, 2007), asthma (Shore, 2008), and sleep apnoea (Carmelli, Swan, & Bliwise, 2012), have been linked to excess body weight.

Adverse psychosocial outcomes of overweight and obesity include poor quality of life due to undesired physical or social consequences, low self-esteem, and poor body image, particularly in younger overweight individuals (Schwimmer, 2003; Williams, 2005). Stigmatisation of obese individuals is shown on both implicit and explicit attitudinal tests (Wang, Brownell, & Wadden, 2004), and discrimination is evident in the workplace, social settings, and interactions with health professionals (Puhl & Brownell, 2001). There is some evidence that overweight individuals experience higher levels of depression and anxiety compared with healthy weight individuals (Luppino, 2010; Zhao et al., 2009).

Childhood obesity is of particular concern given its consistent association with obesity in adulthood (Abraham & Nordsieck, 1960; Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007; Power, Lake, & Cole, 1997). Early-onset obesity may even confer additional health risks over obesity developing in adulthood (Reilly & Kelly, 2011; Rimm & Rimm, 1976) and has been associated with increased risk of premature death due to endogenous causes (Franks et al., 2010). Obesity is notoriously difficult to treat (Yanovski & Yanovski, 2003), particularly once established (Jeffery et al., 2000).

In the light of substantial health and financial costs, and treatment difficulty, early prevention of overweight and obesity is a priority, as emphasised in the most recent UN High-Level Meeting on non-communicable diseases (United Nations, 2011). In order to develop effective preventive efforts, research is needed to identify key influences.

1.2 Causes

1.2.1 Positive energy balance

A simple explanation of obesity is that it results from a chronic positive energy balance due to increased energy intake and reduced energy expenditure over time (Rosenbaum, Leibel, & Hirsch, 1997). Although various physiological processes play a role in body-weight regulation, food and activity-related behaviours are key to determining energy balance and risk for weight gain (J. O. Hill, 2006). In particular, consumption of energy-dense foods, limited physical activity, and sedentary behaviour are thought to promote weight gain. In the literature, these behaviours have been referred to as energy-balance behaviours (EBBs) (Brug, van Stralen, te Velde, et al., 2012; De Craemer et al., 2012).

1.2.1.1 Prevalence of energy-balance behaviours

The prevalence of EBBs seems to vary according to the demographic characteristics of the sample. For example, research indicates that older children, those of lower socioeconomic status (SES), and those from ethnic minority groups watch more TV than younger, higher SES, and white samples (Hoyos Cillero & Jago, 2010). Nevertheless, a consistent finding is that a large proportion of children engage in behaviours that promote positive energy balance. For example, many children do not meet the 5-a-day fruit and vegetable recommendation (Health Survey for England, 2011; Low Income Diet and Nutrition Survey, 2007), regularly consume energy-dense snacks and beverages (Ng, Mhurchu, Jebb, & Popkin, 2012; Piernas & Popkin, 2010), and engage in less physical activity (Health Survey for England, 2008b; Reilly, 2008) and watch more TV than is recommended (Ofcom, 2011; Reilly, 2008). These findings are concerning given that EBBs are relatively stable (Biddle, Pearson, Ross, & Braithwaite, 2010; Mikkilä, Räsänen, Raitakari, Pietinen, & Viikari, 2005; Y. Wang, Bentley, Zhai, & Popkin, 2002) and present risk for weight gain.

1.2.1.2 Associations between energy-balance behaviours and weight

Although the relative contributions of total energy intake and reduced physical activity to the obesity epidemic are debated (Cutler, Glaeser, & Shapiro, 2003; Prentice & Jebb, 1995; Swinburn, Sacks, & Ravussin, 2009), it is widely acknowledged that EBBs influence weight. However, findings from observational and intervention studies have been mixed. Reviews on the association between EBBs and weight in young children indicate that physical activity and TV viewing are more consistent predictors of weight status (Hawkins & Law, 2006; Reilly, 2008; te Velde et al., 2012), while evidence for associations with dietary intake or specific food and beverage consumption is weaker (Newby, 2007; te Velde et al., 2012). Mixed findings may partly be explained by differences in study design and measurement. Nevertheless, it is important to identify factors associated with EBBs as they could influence risk for weight gain if sustained over time.

1.2.1.3 Factors influencing energy-balance behaviours and weight

1.2.1.3.1 Genes

Parental BMI is one of the strongest predictors of child weight (Locard et al., 1992; K. L. Whitaker, Jarvis, Beeken, Boniface, & Wardle, 2010), with parental overweight as a risk factor for child overweight longitudinally (Francis, Ventura, Marini, & Birch, 2007). Studies have consistently shown that familial resemblance in weight largely parallels the degree of genetic relatedness among family members, suggesting shared genes rather than shared environments, predominantly underpin the similarity. Adopted children more closely resemble the weight of their birth mother than the adoptive mother (Stunkard et al., 1986) and twins reared apart have BMIs correlated to a similar extent as twins reared together (Stunkard, Harris, Pedersen, & McClearn, 1990).

In cases where twins are reared together, researchers can estimate the proportion of variation on a trait, such as weight, explained by genetic and environmental factors. Heritability analyses using twin data essentially compare the resemblance between monozygotic (MZ or identical) twin pairs (who share 100% of their genes) and dizygotic (DZ or non-identical) twin pairs (who share approximately 50% of their genes). It is assumed that MZ and DZ twin pairs experience equally similar environments in childhood; the greater the difference between MZ and DZ twins, the greater the heritability of the particular trait is (Plomin, 2008). Although heritability estimates have varied substantially between studies, ranging between 47% and 90% of variance in weight (Elks et al., 2012), researchers have consistently reported moderate to high heritability, with increasing heritability from birth to adolescence (Haworth et al., 2008; Lajunen et al., 2009) and a decline in adulthood (Carmichael & McGue, 1995; Nan et al., 2012). Shared (family) environmental effects are typically small but tend to be larger in early childhood when the shared home is likely a more prominent influence (Estourgie-van Burk, Bartels, van Beijsterveldt, Delemarre-van de Waal, & Boomsma, 2006; Koeppen-Schomerus, Wardle, & Plomin, 2001).

Another indication of a genetic contribution to obesity is the existence of monogenic forms of the disorder caused by mutations in single genes encoding appetite-regulating proteins such as leptin and melanocortin 4 (Clément et al., 1998; Farooqi et al., 2003; Montague et al., 1997). However, cases of single gene obesity disorders are rare; and multiple genes are believed to be typically involved in weight variation, with each making small but significant contributions (Barsh, Farooqi, & O'Rahilly, 2000). The FTO gene has been most consistently related to weight in children and adults (e.g. Cha et al., 2008; Chang et al., 2008; Dina et al., 2007; Loos & Bouchard, 2008). It has also been related to weight loss maintenance following intervention (Woehning et al., 2012). Although the exact function of FTO is unknown, it is thought to be implicated in appetite regulation rather than energy expenditure. FTO is highly expressed in the hypothalamus (Gerken et al., 2007), and has been associated with increased energy intake (Cecil, Tavendale, Watt, Hetherington, & Palmer, 2008; Speakman, Rance, & Johnstone, 2008), loss of control over eating (Tanofsky-Kraff et al., 2009) and diminished satiety (Wardle, Carnell, Haworth, Farooqi, et al., 2008). Most studies have not found associations between FTO and energy expenditure (Berentzen et al., 2008; Haupt et al., 2009; Speakman et al., 2008; Wardle, Carnell, Haworth, Farooqi, et al., 2008). Knowledge regarding the genetic control of physical activity is still at a very early stage (Lightfoot, 2011).

1.2.1.3.2 Environments

Although weight has a strong genetic basis, rapid increases in the prevalence of overweight and obesity cannot be due to changes in the gene pool; the environment must play a role. The modern-day environment has been described as 'toxic' or 'obesogenic' due to increased availability of energy-dense, palatable foods, fewer opportunities for physical activity, and conditions that promote sedentary lifestyles (Brownell & Horgen, 2004; Lobstein, Baur, & Uauy, 2004).

According to socio-ecological models of obesity, environmental influences play a key role in determining EBBs (Kremers et al., 2006; Sallis, Owen, & Fisher, 2008; Swinburn, Egger, & Raza, 1999). Most socio-ecological models distinguish between 'macro' and 'micro' levels of the environment. Macro environments represent the more anonymous infrastructure that influences EBB at a higher level.

Examples of macro environments include national or international policies, such as how foods are taxed, marketed, and distributed. Micro environments are defined as environmental settings that provide the opportunity for direct interaction between individuals and they are usually geographically distinct. Examples of micro environments include the home, school, workplace, and neighbourhood settings. Within each environmental level, there are multiple types of influence including physical, socio-cultural, political, and economic (Brug, Kremers, Van Lenthe, Ball, & Crawford, 2008). Because of the complexity of the environment, socio-ecological models advocate multi-component approaches when examining associations with health-related outcomes. **Figure 1.1** presents environmental influences on EBBs and weight from a socio-ecological perspective.

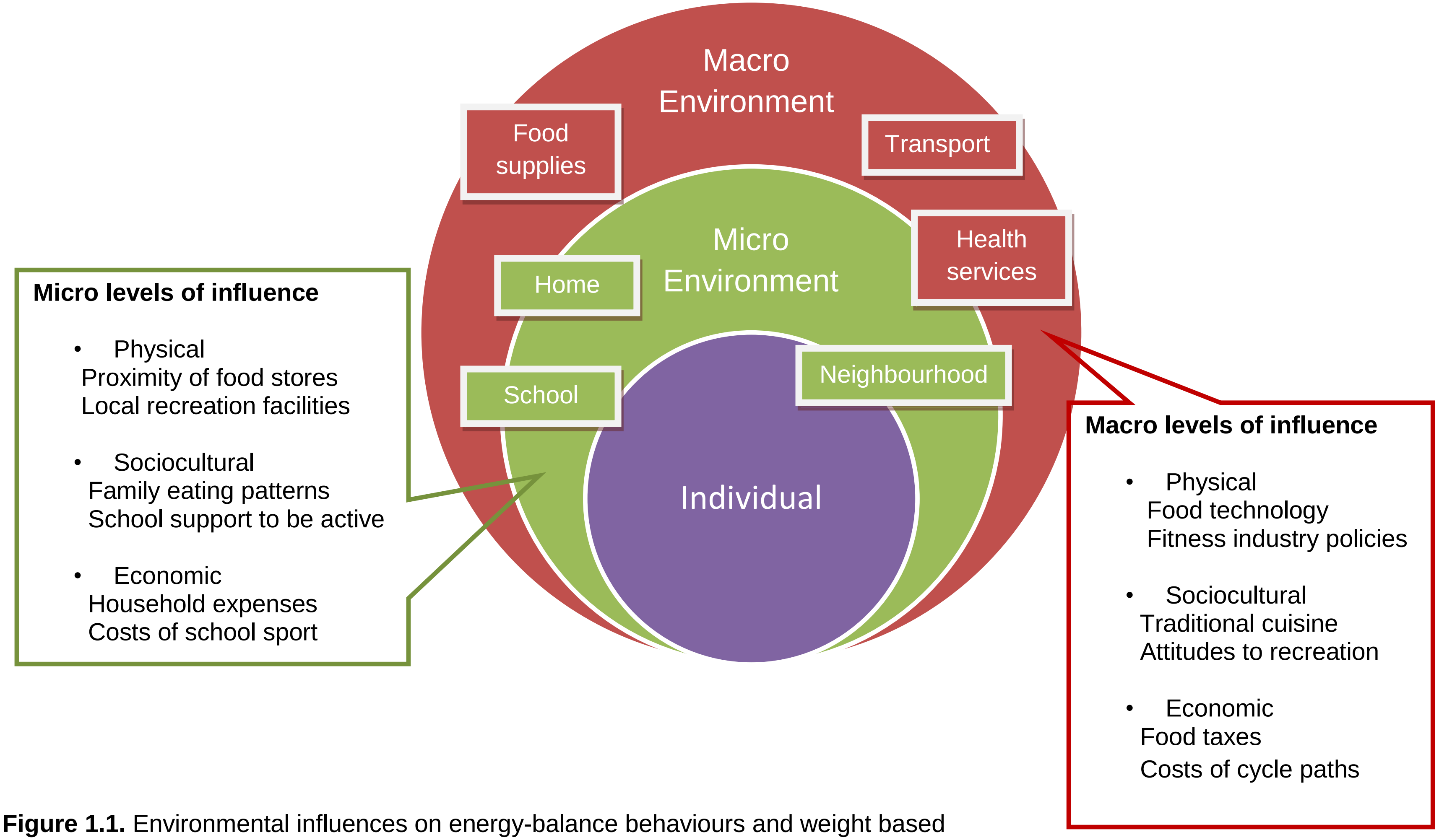

Figure 1.1. Environmental influences on energy-balance behaviours and weight based on Egger & Swinburn's (1997) ecological approach to the obesity epidemic.

Researchers approaching obesity from an ecological perspective have found associations between numerous environmental factors, EBBs and weight. Much of the environmental research to date has focused on the impact of macro- or community-level factors on weight and EBBs. In the food domain, increased availability of fast food restaurants (Maddock, 2004), access to convenience stores (Morland, Diez Roux, & Wing, 2006), and increasing portion sizes (Ledikwe, Ello-Martin, & Rolls, 2005; L. R. Young & Nestle, 2002) have been associated with excessive dietary intake and/or weight. In the physical activity and sedentary behaviour domains, increased reliance on motorised transport (Bell, Ge, & Popkin, 2002) and exposure to sedentary technologies (Gortmaker et al., 1996; Prentice & Jebb, 1995) have been associated with lower levels of activity and higher levels of sedentariness. One study found that immigrants living in the Unites States for more than 15 years had a fourfold higher risk of obesity than immigrants living in the Unites States for a shorter period, suggesting a dose-response relationship between exposure to American culture and obesity risk (Kaplan, Huguet, Newsom, & McFarland, 2004).

1.3 The role of the home environment in early childhood

The home environment is thought to play a particularly important role in early obesity prevention and weight management (Davison & Birch, 2001; Ebbeling, Pawlak, & Ludwig, 2002; Golan, 2006; Tabacchi, Giammanco, La Guardia, & Giammanco, 2007). Children consume approximately two thirds of their dietary intake within the home (Adair & Popkin, 2005) and much leisure time is spent at home (J. Robinson & Godbey, 1997; Tandon, Zhou, Lozano, & Christakis, 2011). Compared with older children and adolescents, who spend an increasing amount of time at school and in other social settings, young children tend to spend a significant proportion of their time at home under the care of their parents.

Parents play an integral role in shaping their child’s eating and activity behaviours, at least partly through the creation of the home environment (Golan & Crow, 2004; Hendrie, Coveney, & Cox, 2012; Savage, Fisher, & Birch, 2007). Parents provide the food and leisure equipment in the home, serve as models of eating and activity behaviour, and use a variety of practices to encourage or discourage these behaviours. At a national level, research suggests that parenting practices and other aspects of the home environment are less than optimal. Compared to previous years, families less frequently eat meals together and are more reliant on pre-prepared convenience foods (Cheng, Olsen, Southerton, & Warde, 2007). UK households with young children have high levels of access to sedentary equipment (95% have access to a digital TV service, 87% have access to the internet through a PC or laptop, and 84% have access to a fixed or portable games console) (Ofcom, 2011). A better understanding of early environmental influences on weight and related behaviours is a logical step towards child and longer-term obesity prevention.

Examining the role of the home environment in early weight trajectories is particularly relevant given that early childhood may be a critical period for the development of overweight and obesity (Dietz, 1994; Rolland-Cachera, Deheeger, Maillot, & Bellisle, 2006). From a behavioural perspective, young children develop their food preferences and refine their motor skills during this time, which influence later consumption and activity patterns (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009; Birch & Fisher, 1998; Savage et al., 2007).

1.3.1 Defining the obesogenic home environment

Previous researchers identified two main domains of the home environment: one representing food-related influences (food domain) and the other representing activity-related influences (activity domain). Sedentary or media-related influences were considered to be a part of the activity domain (Gattshall et al., 2008; Spurrier, Magarey, Golley, Curnow, & Sawyer, 2008). However, physical activity and sedentary behaviour can have independent effects on weight and other health outcomes (Dietz, 1996; Ford, Kohl, Mokdad, & Ajani, 2005; Must & Tybor, 2005), suggesting that environmental influences relevant to physical activity and those relevant to sedentary behaviour should be considered as separate domains. Thus, the home environment encompasses three main domains representing food, activity, and media-related influences. The phrase ‘media environment’ is used instead of ‘sedentary environment’ as media in particular has been identified as a major influence for both sedentary and other EBBs (Maibach, 2007; Story, Neumark-Sztainer, & French, 2002).

Using the socio-ecological model as a framework, various physical and social parameters of the home environment have been hypothesised to influence food intake, activity level, and sedentary behaviour, and thereby weight in childhood (Gattshall et al., 2008). Physical parameters include home availability and accessibility of food and beverages, physical activity facilities, and media equipment. Availability refers to whether foods or activity equipment (for example) are present in the home; accessibility refers to whether foods or activity equipment (for example) are in a form that facilitates associated behaviours (in this case consumption and physical activity). Social parameters include parental modelling of food intake, physical activity, and sedentary behaviour, and parental feeding practices, support of physical activity, and policies around media use. Modelling is a process of observational learning from significant others, which can have the consequence of the observed behaviour becoming habitual (Bandura, 1977). Parental feeding practices refer to ways in which parents try to influence their child's eating behaviour via some form of control (Faith, Scanlon, Birch, Francis, & Sherry, 2004; Wardle & Carnell, 2007). Parental support incorporates both tangible and intangible aspects of support, such as transporting the child to activity facilities, and verbally encouraging activity behaviour (Beets, Cardinal, & Alderman, 2010). Parental policies around media use can take several forms, and typically include whether the parent sets time limits, monitors content, or restricts the context within which media consumption takes place (Dorr, Rabin, & Irlen, 2013; Gentile & Walsh, 2002).

Figure 1.2 shows a simple conceptual model of the home environment from a multi-component perspective. Each domain of the home environment is hypothesised to influence the corresponding EBB. In particular, the food domain is hypothesised to influence food and beverage intake; the activity domain is hypothesised to influence physical activity behaviour; and the media domain is hypothesised to influence sedentary behaviour, namely TV viewing. By influencing EBBs, the home environment domains cumulatively influence weight.

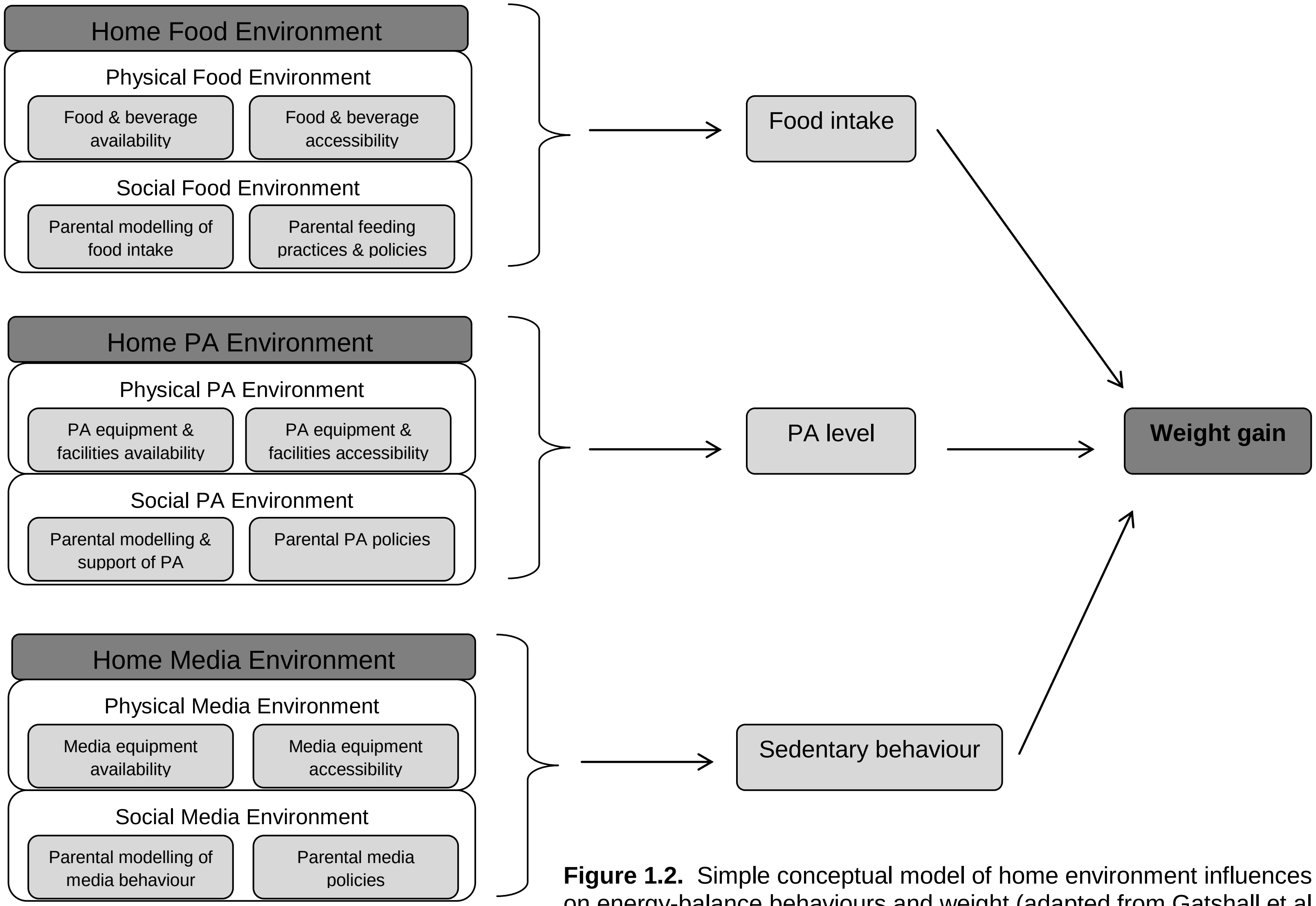

Figure 1.2. Simple conceptual model of home environment influences on energy-balance behaviours and weight (adapted from Gatshall et al, 2008). PA = physical activity.

1.3.2 Measuring the obesogenic home environment

Researchers have long been interested in the family environment in relation to child developmental outcomes. The Home Observations for Measurement of the Environment (HOME) instrument was developed three decades ago to assess the quality of cognitive stimulation and emotional support available to a child in the home environment (Elardo, Bradley, & Caldwell, 1975). There are now various forms of the HOME and these have been widely used in studies of children's health and development (Totsika & Sylva, 2004). Although the HOME has been related to risk for overweight in childhood, with elevated risk among those who experienced little cognitive stimulation at home (Strauss & Knight, 1999), the measure does not assess aspects of the home food, media and activity domains, which are important to consider when designing weight management interventions.

Numerous other measures have been used to assess aspects of the home food, media, and activity domains (Pinard et al., 2012). Most focus on a particular domain of the home environment, such as food or activity-related influences (e.g. Campbell et al., 2007; Sirard, Nelson, Pereira, & Lytle, 2008), or on a particular aspect of the home environment, such as food availability or parental modelling (e.g. De Bourdeaudhuij et al., 2005; Fulkerson et al., 2008). Overall, there has been more research focus on the home food environment; the home activity and media environments have received somewhat less attention. Even fewer measures incorporate physical and social aspects of the home food, media and activity domains. Moreover, few studies in the literature report the psychometric properties of their measures. Most studies reporting some psychometric testing report evidence of reliability rather than validity; criterion validity has rarely been reported (Pinard et al., 2012). Studies that have assessed criterion validity have tended to use one-off home visits that cannot capture behavioural or social aspects of the environment, such as mealtime interactions and parental modelling of behaviour (e.g. Bryant et al., 2008). Examples of measures that have received at least some psychometric testing are described in the sections below.

1.3.3 Physical aspects of the home environment: availability and accessibility

Measures of home food availability and accessibility include self-report shelf inventories (Crockett, Potter, Wright, & Bacheller, 1992), self-report questionnaires (Cullen et al., 2001), and observed inventories of all or selected items in the home (Coates, Jeffrey, & Wing, 1978). Although a valid approach, it is often not feasible to carry out intensive in-home checks. Most of the studies using in-home inventories (particularly those attempting to record all food items in the home) report high levels of participant and staff burden (Bryant & Stevens, 2006). Moreover, while social desirability bias is reduced when using observed inventories, evidence suggests that it is not completely eliminated. For example, one study found that obese families stored more food items than non-obese families at the time of the first home inventory, whereas the pattern was reversed at the time of the second inventory (Terry & Beck, 1985). This suggests that some families may make changes to the food they usually store when they know a researcher is coming to visit.

For practical reasons, most studies have used self or parent-report measures of home food availability and accessibility. Availability has been assessed in terms of the frequency with which foods are available in the home (e.g. 'how often do you have fruit in your home?') (Boutelle, Birkeland, Hannan, Story, & Neumark-Sztainer, 2007; Hanson, Neumark-Sztainer, Eisenberg, Story, & Wall, 2005; Neumark-Sztainer, Wall, Perry, & Story, 2003) and the amount or variety currently available (e.g. 'what types/how much fruit do you have in your home?') (Cullen et al., 2001; Hearn et al., 1998; Marsh, Cullen, & Baranowski, 2003). Accessibility has been assessed in terms of the physical location or visibility of foods and the degree to which food is prepared or ready for consumption (e.g. peeled, sliced carrot sticks in the refrigerator) (Cullen et al., 2001). A number of researchers have used predefined checklists completed by the participant either as a telephone interview or a mailed questionnaire. For example, Cullen and colleagues have developed a number of measures to assess home availability of fruit, vegetables, and high-fat and low-fat foods (Cullen et al., 2001, 2003, 2004). Overall, food availability and accessibility checklists have moderate internal consistency (Pinard et al., 2012). When compared to in-home observations, validity is generally supported except for perishable items such as fresh fruit and vegetables (Marsh et al., 2003).

Researchers have also tended to use checklist-based instruments to assess physical activity and media equipment in the home. Physical activity variables have included the presence of fixed activity items, such as a basketball hoop, trampoline, swing or slide, the presence of moveable items, such as bats and balls, and the presence and size of a garden. Media variables have included the number of TVs, DVDs or video players, games consoles, and computers, internet access, satellite or cable TV, and the presence of media equipment in the child's bedroom. An example of a particularly comprehensive self-report measure is the Physical Activity and Media Inventory (PAMI), designed to assess both the availability and accessibility (or usability) of various kinds of physical activity and media equipment in the home (Sirard et al., 2008). Criterion validity was assessed using home visits, with strong correlations between observed and reported values. Overall, test-retest reliability and internal consistency of physical activity and media equipment measures has been good (Pinard et al., 2012).

In addition to activity equipment and facilities within the home, some researchers have included features of the local neighbourhood environment in their measures. Variables assessed include proximity to parks and other recreation facilities such as gyms and community centres. Some researchers have used predefined 'buffer zones' to objectify participant responses; others have simply asked participants to use their own perception of proximity. As previously noted, the advantage of the subjective approach is that participants can respond without having to consider a definition of neighbourhood that may be wider or narrower than their own conception (Walton, Murray, & Thomas, 2008). Indeed, research has shown that adults' interpretations of their neighbourhood often differ from pre-defined boundaries (Smith, Gidlow, Davey, & Foster, 2010). Although perceived and objective definitions of neighbourhood may differ, studies that have used both definitions in the same sample have found that each measure related to weight status in adults (Boehmer, Hoehner, Deshpande, Ramirez, & Brownson, 2007; Catlin, Simoes, & Brownson, 2003; Giles-Corti, Macintyre, Clarkson, Pikora, & Donovan, 2003; Hawkins et al., 2009), supporting their predictive validity.

1.3.4 Social aspects of the home environment: parental modelling and support, feeding practices, and household policies

One form of social influence that has frequently been measured is parental modelling. Many studies have assessed modelling by asking parents to report some aspect of their own dietary intake, activity level, or sedentary behaviour. While this approach may capture parental influence on child behaviour, an important aspect of the modelling process is that the behaviour is observed by the child. Other studies have therefore specified whether the particular behaviour occurs in front of the child and whether the modelling is intentional (e.g. how often the parent eats certain foods or is active in front of their child to model healthy behaviours). Some researchers examining the home food environment have assessed parental modelling of specific food behaviours in addition to intake, such as eating from the pan, eating while watching TV, and taking second helpings (e.g. Gattshall et al., 2008). Parental support has been assessed in terms of emotional (e.g. 'How often to you encourage your child to do physical activity?') and practical support (e.g. 'How often do you take your child to a place where they can be physically active?') One frequently used measure of parental support for physical activity is a five-item scale developed by Trost and colleagues, which has demonstrated good internal consistency and test-retest reliability (Trost et al., 2003).

Parental feeding practices have received considerable research attention, largely as a separate research area rather than a part of the home environment. Many researchers measuring the home environment in childhood have considered at least some aspect of parental feeding to be a feature of the social home food environment. Two extensively used measures in the parent feeding literature are the Child Feeding Questionnaire (CFQ) (Birch et al., 2001), and the Parental Feeding style Questionnaire (PFSQ) (Wardle, Sanderson, Guthrie, Rapoport, & Plomin, 2002). Parental feeding practices assessed in the CFQ include 'Monitoring' (keeping track of the child's eating), 'Restriction' (limiting the child's access to foods), and 'Pressure to eat' (pressurising the child to eat more, particularly at meal times). Confirmatory factor analyses identified the subscales in three separate samples and internal consistencies for the subscales were above 0.70. Restriction and pressure to eat correlated with child weight in the expected directions (positively and negatively, respectively), providing some support for validity (Birch et al., 2001). The PFSQ comprises four subscales assessing 'emotional feeding' (using food as a response to the child's emotional state), 'instrumental feeding' (using food as a reward), 'encouragement to eat', and 'control over eating'. Internal consistencies for the subscales were moderate to high (α = 0.65 – 0.85); test-retest reliability was good (r = 0.76 – 0.83) (Wardle et al., 2002).

The use of rules or household routines, sometimes referred to as 'parental policies', is another form of social influence. Examples of household routines include the frequency of family mealtimes, whether the child eats while watching TV, and household rules around media use. In the context of the home media environment, parental rules can take various forms, such as limit-setting on the amount or content of TV viewed, when children can watch TV, and whether or not viewing is used as a reward or punishment (Nathanson, 2001). Researchers have assessed parental rules in terms of simple presence (e.g. 'do you have family rules about time spent on TV or video games?' (Hearst, Sevcik, et al., 2012)) or the frequency with which rules are used (e.g. 'how often does a parent put limits on how much time you may watch TV?' (Gentile, Nathanson, Rasmussen, Reimer, & Walsh, 2012)).

1.3.5 Multi-component measures: incorporating physical and social aspects

Several research groups have developed comprehensive, multi-component measures of the home environment based on socio-ecological models of health (see **Table 1.1** for details of the measures described). For example, Gattshall and colleagues developed the Home Environment Survey (HES) to assess a breadth of home environment variables including availability, accessibility, parental role modelling, and parental policies related to food, physical activity, and media resources in families with overweight children aged 8 to 12 years (Gattshall et al., 2008). Items were developed for the study (based on a review of the literature) or taken from previously validated scales, where available. Items within each of the subscales were scored from 0 to 4 and then averaged to create summary scores, with higher scores reflecting healthier home environments. Internal consistency of the subscales was moderate to high, except for fat and sweet snack accessibility (α = 0.59), and fruit and vegetable accessibility was reduced to a single item due to poor reliability. Test-retest reliability was moderate to high for most items, while inter-rater reliability was much more variable, suggesting caregivers report some differences in the home environment. Criterion validity was not assessed but construct validity was good.

To assess the home environments of younger children, Spurrier and colleagues developed The Physical and Nutritional Home Environment Inventory (Spurrier et al., 2008). Items were developed for the survey on the basis of hypothesised associations between the home environment and EBBs. Half the items were assessed by direct observation, the rest were measured by parent report. Although the survey showed good construct validity, no other psychometric properties were reported. Another multi-component measure of the home environment, the Healthy Home Survey (HHS), was administered as a telephone interview to parents with at least one child aged 3 to 8 years (Bryant et al., 2008). Items were generated after a review of the literature and then circulated to five experts in the child obesity field for feedback on their relevance. Another strength of the HHS is that home visits were conducted to assess criterion validity, which few studies have done. However, items related to household routines, such as mealtime frequency, could not be validated in a single observation episode. Test-retest reliability and criterion validity estimates were generally moderate to high. Reliability estimates were lower for the variety, quantity, and display of fresh fruit and also for more subjective questions (e.g. 'When eating in front of your child, do you try to eat healthy: a) all of the time; b) most of the time; c) some of the time; d) rarely; e) never?') Validity estimates were lower for the variety and quantity of fresh fruit and snacks, the visibility of fruit, and the accessibility of snacks, confectionery, and sugar-sweetened fizzy drinks. It may be difficult to accurately assess quantity by telephone; the HHS derived quantity from general package sizes (small, medium, and large), which may have affected the reliability and validity estimates. Low estimates for food availability (and possibly the display of fruit) may also reflect natural changes due to consumption or purchase. With regard to accessibility, the authors suggested that parents may have believed their child could not physically access food or drink items because they had never done so or because they were not permitted to do so. Internal consistency was not assessed.

The most recent inclusive measure of the home food, activity, and media environment relevant to child obesity is the Comprehensive Home Environment Survey (CHES) (Pinard et al., 2013), which has been administered to low-income families of children aged 5 to 17 years. As in the HHS, items were generated using the literature and then circulated to four experts to confirm their relevance. The CHES is somewhat lengthy, comprising 18 subscales, but unlike some of the other comprehensive measures, it has a total scoring procedure; the subscales are rescaled to range from 0 to 1 and then summed, with higher scores representing homes that are more supportive of healthy eating and physical activity behaviour. The subscales demonstrated adequate internal consistency, high test-retest reliability, interrater reliability, and convergent validity. Criterion validity was not assessed.

Other researchers have developed short 'screeners' to capture a snapshot of the home environment. For example, the Family Nutrition and Physical Activity (FNPA) screening tool is a 21-item measure based on constructs identified by an evidence analysis project supported by the American Dietetic Association (ADA) (Ihmels, Welk, Eisenmann, & Nusser, 2009). The FNPA assesses parental modelling of food intake, physical activity, and media use, TV availability, and child EBBs, including food intake, physical activity, and media use. While short screeners may be particularly beneficial for studies with limited time or money, comprehensive measures yield a large amount of information and may be particularly insightful.

1.4 Summary

The home environment is thought to play a key role in early weight trajectories, incorporating various physical and social aspects hypothesised to relate to food and beverage intake, physical activity, and sedentary behaviour. Many measures have been used to capture the home environment; few have reported psychometric testing, and most have focused on a particular aspect or domain (food, physical activity, or media). In order to provide further insight into the role of the home environment, it seems important to use comprehensive, psychometrically tested measures, which can capture a more realistic picture of the family setting.

Table 1.1. Description of multi-component home environment measures

Author name and year	Sample	Measure	Constructs assessed	Reliability	Validity
Golan & Weizman, (1998)	**N, age** 40 mothers of children aged 6 – 11 years (20 had an obese child; 20 had a normal weight child). And 60 parents of obese children aged 6 – 11 years in a clinical weight-based intervention[1] **SES** The children in sample 2 were from the public school system of a middle-class town in Israel **Nationality/ethnicity** Ethnicity not reported	**Name** The Family Activity and Eating Habits Questionnaire **Item generation** Literature review identified factors associated with obesity and weight loss in children. 10 experts gave feedback on the relevance of the questionnaire items **Completion method** Parent-completed questionnaire	**Food environment** *Physical aspects* Availability (presence) and accessibility (visibility) of snacks, sweets, cakes and ice-cream *Social aspects* Parental boundaries on child's ability to buy or take snacks, sweets, cakes, and ice-cream, parental feeding practices, parental eating behaviour **Activity environment** *Physical aspects* Not assessed *Social aspects* Parental activity level **Media environment** *Physical aspects* Not assessed *Social aspects* Parental sedentary behaviour	**Test-retest** Individual items: r = 0.78 – 0.90 Total: r = 0.84 **Inter-rater** Subscales: r = 0.81 – 0.94 **Internal consistency** Subscales: α = 0.78 – 0.88	**Criterion** Not assessed **Construct** Subscale scores significantly differed between obese and normal weight children; child weight loss sig correlated with improvement in questionnaire score **Factorial** Not assessed
Ihmels, Welk, Eisenmann, & Nusser, (2009)	**N, age** 854 parents of children aged 6 – 7 years **SES** 44% of mothers and 55% of	**Name** The Family Nutrition and Physical Activity Screening Tool (FNPA) **Item generation**	**Food environment** *Physical aspects* Not assessed *Social aspects* Parental modelling of healthy eating and feeding practices	**Test-retest** Not assessed **Inter-rater** Not assessed	**Criterion** Not assessed **Construct** Sig positive associations between total score and SES,

Author name and year	Sample	Measure	Constructs assessed	Reliability	Validity
	fathers with high school education or less; 34% with a family income < $25,000 pa **Nationality/ethnicity** USA 68% White, 12% African American, 12% Hispanic, 5% Asian	Systematic literature review identified factors associated with overweight and obesity. Experts in diet and exercise behaviour (no. not reported) reviewed and refined the survey **Completion method** Parent-completed questionnaire	**Activity environment** *Physical aspects* Not assessed *Social aspects* Parental modelling of PA **Media environment** *Physical aspects* Presence of TV in child's bedroom *Social aspects* Parental monitoring of screen time	**Internal consistency** α = 0.72 (0.70 when including 2 items that were later removed)	total score and child BMI **Factorial** 5 identifiable factors accounting for 5.7 – 17.1% of the variance
Boles, Scharf, Filigno, Saelens, & Stark, (2013)	**N, age** 82 families of children aged 2 – 5 years (35 obese children with at least one obese carer; 47 normal-weight children with no obese carers) **SES** 75% had a family income ≥ $50,000 pa; 13% had a family income < $50,000 pa **Nationality/ethnicity** USA 91% White	**Name** Home Health Environment Instrument (HHE) **Item generation** Items were based on a review of the literature and taken from an existing inventory that had demonstrated construct validity and adequate test-retest reliability. Experts in assessing and treating pediatric obesity were consulted to refine the items (no. not reported)	**Food environment** *Physical aspects* Unhealthy food/drink, fruit, and vegetable availability (variety) and accessibility (within reach and readiness to be eaten) *Social aspects* Not assessed **Activity environment** *Physical aspects* Availability (variety) of PA equipment *Social aspects* Not assessed	**Test-retest** Not assessed **Inter-rater** All but 12 items had Kappa values > 0.60 **Internal consistency** Not assessed	**Criterion** No assessed **Construct** Home observations discriminatively characterised the home environments of obese and normal-weight preschoolers **Factorial** Not assessed

Author name and year	Sample	Measure	Constructs assessed	Reliability	Validity
		Completion method Parent-completed questionnaire tested as an observation tool	**Media environment** *Physical aspects* Availability of media equipment (number of TVs, computers, games consoles); presence of a TV in the child's bedroom *Social aspects* Not assessed		
Bryant et al. (2008)	**N, age** 85 parents of children aged 3 – 8 years **SES** 11% low income families (< $19,000 pa) **Nationality/ethnicity** USA 73% White, 24% African American	**Name** Healthy Home Survey (HHS) **Item generation** Literature review identified confirmed or hypothesised associations between aspects of the home environment and child weight. 5 experts in the field gave feedback on the relevance of the items **Completion method** Telephone interview	**Food environment** *Physical aspects* Fruit, vegetable, sweet snack, salty snack, confectionery, and sugar-sweetened fizzy drink availability (presence, variety, quantity) and accessibility (visibility of fruit, readiness of vegetables to be eaten, snacks/soda within child's reach) *Social aspects* Parental feeding practices **Activity environment** *Physical aspects* Availability (proximity to outdoor and indoor recreation facilities; garden, garden size, share garden, play equipment in garden; bike or riding toy; adequate indoor place space) *Social aspects*	**Test-retest** ICC = 0.22 – 0.91; % agreement = 51.2 – 97.8 **Inter-rater** Not assessed **Internal consistency** Not assessed	**Criterion** ICC = 0.30 – 0.88 % agreement = 43.0 – 98.7 **Construct** Not assessed **Factorial** Not assessed

Author name and year	Sample	Measure	Constructs assessed	Reliability	Validity
			Parental restriction of indoor and outdoor play; parental exercise **Media environment** *Physical aspects* Availability (number of TVs, DVD players, computers, games consoles, DVDs ; cable TV; TV, computer, games console in child's bedroom) *Social aspects* Parental restriction of TV, computer, games console use; parental use of TV, computer, games console to reward behaviour		
Crawford et al. (2012)	**N, age** 491 parents of children aged 5 – 12 years living in socio economically disadvantaged suburbs **SES** 24% of parents with a low education level **Nationality/ethnicity** Australia Ethnicity not reported	**Name** No name **Item generation** Some items taken from existing measures; others created for the study **Completion method** Parent-completed questionnaire	**Food environment** *Physical aspects* Not assessed *Social aspects* Maternal self-efficacy for child eating healthily, use of food as a reward, beliefs/feelings about food enjoyment **Activity environment** *Physical aspects* Child's access to PA equipment (11 items) *Social aspects* Maternal self-efficacy for child	**Test-retest** Kappa = 0.46 – 0.64 (estimates for pre-existing measures not included here) **Inter-rater** Not assessed **Internal consistency** α = 0.69 – 0.90	**Criterion** Not assessed **Construct** Sig associations with child BMI (β = -0.04 – 0.24) **Factorial** Not assessed

Author name and year	Sample	Measure	Constructs assessed	Reliability	Validity
			PA, support for PA, beliefs about PA importance **Media environment** *Physical aspects* Child's access media equipment (6 items), TV in child's bedroom *Social aspects* Parental use of media as a reward for behaviour, rules around sedentary behaviour (time limits, supervision during media use, eating while watching TV)		
Gattshall et al. (2008)	**N, age** 219 parents of children aged 8 – 12 years and with a BMI ≥85th percentile **SES** 36% of parents at grade or basic high school education level **Nationality/ethnicity** USA 61% White, 24% Latino, 6% Black, 4% American Indian, 3% Asian	**Name** The Home Environment Survey (HES) **Item generation** Items were developed for the Family Connections study (a randomised controlled trial examining parental interventions to support child weight management) or taken from validated scales, where available **Completion method** Parent-completed questionnaire	**Food environment** *Physical aspects* Fruit/vegetable/fat/ sweet availability (variety) and accessibility (visibility) *Social aspects* Parental modelling of healthy eating, parental policies to support healthy eating **Activity environment** *Physical aspects* PA equipment availability (variety) and accessibility (visibility, physical accessibility to child) *Social aspects* Parental modelling of PA, parental policies to support PA	**Test-retest** ICC = 0.43 – 0.99 **Inter-rater** ICC = -0.29 – 1.00 **Internal consistency** α = 0.59 – 0.84	**Criterion** Not assessed **Construct** Sig associations with intake and activity outcome variables (r = 0.14 – 0.36) **Factorial** Not assessed

Author name and year	Sample	Measure	Constructs assessed	Reliability	Validity
			Media environment *Physical aspects* Not assessed *Social aspects* 2 items on parental modelling of sedentary behaviour; 2 items on TV eating		
Pinard et al., (2013)	**N, age** 150 parent-child dyads; children aged 5 – 17 years **SES** 38% low income families (≤ $10,000 pa) **Nationality/ethnicity** USA 44% White, 48% Black, 5% Mixed Race, 1% Asian, 1% American Indian, 2% Other	**Name** The Comprehensive Home Environment Survey (CHES) **Item generation** The HES was used as a starting point and other hypothesised factors were incorporated. 4 child obesity experts were consulted to review the items **Completion method** Parent- and child-completed questionnaire	**Food environment** *Physical aspects* Fruit/vegetable/fat/ sweet availability (variety) and accessibility *Social aspects* Parental modelling of healthy eating, parental policies to support healthy eating **Activity environment** *Physical aspects* PA equipment availability (variety) and accessibility *Social aspects* Parental modelling of PA, parental support of PA **Media environment** *Physical aspects* Media equipment availability (variety) *Social aspects* Parental modelling of screen time, parental policies to monitor media use	**Test-retest** Pearson's r = 0.59 – 0.97 **Inter-rater** Pearson's r = 0.42 – 0.91 **Internal consistency** α = 0.74 – 0.92	**Criterion** Not assessed **Construct** Sig associations with intake, activity, and sedentary behaviour outcome variables (r = 0.19 – 0.55) **Factorial** Not assessed

Author name and year	Sample	Measure	Constructs assessed	Reliability	Validity
Spurrier et al. (2008)	**N, age** 280 parents of children aged 4.1 – 5.4 years **SES** 8% low income families (< $20,000 pa) **Nationality/ethnicity** Australia Ethnicity not reported	**Name** The Physical and Nutritional Home Environment Inventory **Item generation** Items were included if they had previously been (or were hypothesised to be) associated with child dietary intake, physical activity, sedentary behaviour, or weight **Completion method** Parent-completed questionnaire and direct observation	**Food environment** *Physical aspects* Fruit/vegetable/fruit juice/dairy/savoury snack/sweet snack/confectionery/carbonated drink/cordial availability (quantity) *Social aspects* Parental policies around food/drink access/intake **Activity environment** *Physical aspects* Availability of PA equipment (garden size, variety of outdoor play equipment) *Social aspects* Parental modelling and support of PA **Media environment** *Physical aspects* Media equipment availability (no. of TVs, presence of computer, internet, games console) *Social aspects* Parental modelling and policies around media use (frequency TV is left on in home, parental	**Test-retest** Not assessed **Inter-rater** Not assessed **Internal consistency** Not assessed	**Criterion** Not assessed **Construct** Sig associations with intake, activity and sedentary behaviour outcome variables (ANOVA effect sizes not reported) **Factorial** Not assessed

Author name and year	Sample	Measure	Constructs assessed	Reliability	Validity
			rules around TV, parental limits on exposure to advertising)		

SES = socioeconomic status; PA = physical activity level.

[1] Two studies were used to assess reliability and validity of the measure. The first study assessed test-retest reliability and internal consistency in a sample of 40 mothers. The second study assessed inter-rater reliability and predictive validity in a sample 60 parents with children enrolled in a clinical intervention to treat childhood obesity.

Chapter 2: Associations between the obesogenic home environment, energy-balance behaviours, and weight

2.1 Characteristics associated with the obesogenic quality of the home environment

In addition to directly assessing associations between the home environment, energy-balance behaviours (EBBs), and weight, identifying other characteristics associated with the obesogenic quality of the home environment can provide further insight into its role in early weight trajectories, with implications for weight-management strategies. Some studies have examined characteristics associated with the obesogenic quality of the home environment, although these have focused on particular aspects of the home food, activity, or media environment, and have tended to consider characteristics in isolation, making it difficult to ascertain whether a characteristic is independently relevant to the home environment.

2.1.1 Demographic characteristics

Much of the existing research has focused on socioeconomic status (SES), showing that families differ on various aspects of the home environment according to their level of education or income. Compared to their higher SES counterparts, children from lower SES families eat fewer family meals (Neumark-Sztainer, Hannan, Story, Croll, & Perry, 2003; Videon & Manning, 2003), are more likely to have energy-dense foods at home (MacFarlane, Crawford, Ball, Savige, & Worsley, 2007), are more likely to have take-away food for a family meal (Campbell et al., 2002), have parents who eat fewer fruit and vegetables (Vereecken, Keukelier, & Maes, 2004), and have parents who are more likely to use food as a reward (Baughcum, Burklow, Deeks, Powers, & Whitaker, 1998) and use generally less authoritative feeding practices (Vereecken et al., 2004). In the activity and media domains, children from lower SES families have parents who are less likely to model physical activity behaviour and provide physical activity resources in the home or overall support for physical activity (Bauer, Neumark-Sztainer, Fulkerson, & Story, 2011), are more likely to have a TV in their bedroom (Barr-Anderson, Van Den Berg, Neumark-Sztainer, & Story, 2008), and are more likely to watch TV while eating (Campbell et al., 2002; MacFarlane et al., 2007). These findings suggest that higher SES families are more likely to live in an environment that is supportive of a balanced diet and physical activity, and limiting of sedentary behaviour.

Many of the studies reporting an association between SES and the home environment have used parental education level as the SES indicator, perhaps because income could be more liable to change (Liberatos, Link, & Kelsey, 1988), and because education has been more consistently related to weight status than income (Shrewsbury & Wardle, 2008). Nevertheless, both education and income are potentially relevant to the obesogenic quality of the home environment (Sobal, 1991); although the comparative strength of associations between the home environment and each SES indicator is unknown. Education level is associated with nutrition knowledge (Parmenter, Waller, & Wardle, 2000) and use of nutrition labels (Satia, Galanko, & Neuhouser, 2005), suggesting that less educated parents may be less able to make use of materials that provide health-related information, which in turn may influence the kinds of foods made available in the home. Low-income households typically reside in more economically deprived neighbourhoods, which may be less supportive of physical activity (Estabrooks, Lee, & Gyurcsik, 2003; Macintyre, 2007), with greater availability and accessibility of low-cost, energy-dense foods than nutritious foods (Cummins & Macintyre, 2006; Drewnowski & Darmon, 2005). The general level of health consciousness expressed within the social environment of less educated and more deprived communities may also be a mediating factor. Evidence suggests that lower SES adults, indexed by education level and occupation, are less likely to make a conscious effort to engage in health-promoting behaviours (Hearty, McCarthy, Kearney, & Gibney, 2007; Wardle & Steptoe, 2003).

Family structure may also be relevant to the obesogenic quality of the home environment, independent of SES. In addition to greater financial pressure, parents without a spouse or partner, and those with a large number of children, may have less support, time and energy to engage in creating a healthier home environment. Several studies have shown that mothers who have support from a partner, and those with fewer children are more likely to provide home environments that are supportive of their child’s cognitive, emotional, and social development (Baharudin & Luster, 1998; Belsky, 1984; Luster & Dubow, 1990). Larger family size and higher parental stress has been associated with higher levels of disorganisation within the home, as measured by the Confusion, Hubbub, and Order Scale (CHAOS) (Dumas et al., 2005), and recent research found that higher levels of work-life stress in parents was associated with fewer family meals, less time spent on food preparation, and greater parental consumption of fast food and sugar-sweetened drinks (Bauer, Hearst, Escoto, Berge, & Neumark-Sztainer, 2012). The presence of older children in the home may also shape the quality of the home environment due to changes in preferences and demands. For example, older children are more likely to have a TV in their bedroom than younger children (Ofcom, 2011), and there is some evidence that the presence of other children in the home is associated with earlier introduction of energy-dense, nutrient poor foods in young children, independent of SES (Koh, Scott, Oddy, Graham, & Binns, 2010; Schrempft, van Jaarsveld, Fisher, & Wardle, 2013).

Maternal age has also been identified as a potentially important determinant of parenting behaviours; the idea being that older mothers, with greater maturity and experience, can draw on more developed cognitive and emotional skills to create more supportive home environments (Belsky, 1984). A number of earlier studies reported positive associations between maternal age and the HOME inventory (Baharudin & Luster, 1998; Menaghan & Parcel, 1991), and a variety of other parenting outcomes, such as time spent with the child and the quality of parent-child interactions (R. A. Fox, Platz, & Bentley, 1995; Ragozin, Basham, Crnic, Greenberg, & Robinson, 1982). Within the context of risk for weight gain, younger maternal age has been associated with suboptimal feeding practices, such as shorter breastfeeding duration (Lande et al., 2003; Michaelsen, Larsen, Thomsen, & Samuelson, 1994) and earlier introduction of solid foods (Fewtrell, Lucas, & Morgan, 2003; Scott, Binns, Graham, & Oddy, 2009) in infancy, and earlier introduction of inappropriate foods in early childhood (Koh et al., 2010; Schrempft et al., 2013). Maternal age effects have been reported after adjusting for SES, and are often linear, contrasting with beliefs that adolescent and late childbearing are uniquely related to risk for poor parenting (Ragozin et al., 1982).

Ethnicity is another important factor to consider because parental attitudes and practices may be influenced by cultural values (Darling & Steinberg, 1993). Recent research has reported differences in the home food, activity, and media environments of Hispanic and African American families with preschool children, independent of employment status (Chuang, Sharma, Skala, & Evans, 2013; Skala et al., 2012). Specifically, Hispanic families were more likely to have fruit and vegetables available and to consume family meals than African American families, while African American families were more likely to use authoritarian feeding practices. Interestingly, Hispanic families were also more likely to have sugar-sweetened beverages available in the home, suggesting that being of a particular ethnicity may confer obesogenic risk in some senses but not others (Skala et al., 2012). Another study reported that Hispanic parents were more likely to have an outdoor play space and play equipment than African American parents, while African American parents had more TVs, were more likely to have a TV in their child's bedroom, more likely to permit their child to eat while watching TV, and less likely to regulate their child's TV time (Chuang et al., 2013). Using the HOME, Bradley and colleagues found that the home environments of European and Asian American families were overall more supportive than those of African American and Hispanic families, however, the effects were at least partly explained by poverty status (Bradley, Corwyn, McAdoo, & Coll, 2001). As for family structure and maternal age, ethnicity is confounded with SES, highlighting the need to take this into account when examining characteristics associated with the quality of the home environment.

2.1.2 Parental attitudes and traits

A number of studies have found that parental attitudes and concerns relate to various aspects of the home environment, independent of SES. For example, parental energy-balance knowledge has been associated with greater home availability of fruit and vegetables and reduced availability and accessibility of media equipment (Hendrie et al., 2012; Slater, Sirard, Laska, Pereira, & Lytle, 2011). Similarly, evidence suggests that mothers with greater investment in weight and eating-related issues are more likely to use restrictive feeding practices (Francis, Hofer, & Birch, 2001), are more likely to have fruit and vegetables in the home (Boutelle et al., 2007), and are less likely to have energy-dense snacks or drinks (MacFarlane, Crawford, & Worsley, 2010) compared to mothers with lower levels of concern. Research has also reported associations between higher parental concern around TV viewing and fewer sedentary items in the home, greater parental restriction of sedentary behaviours and parental tendency to offer sedentary activities as a reward for good behaviour in children (Pearson, Salmon, Crawford, Campbell, & Timperio, 2011); and parents who were concerned about their child's inactivity were more likely to restrict sedentary activity than unconcerned parents (Jackson, Crawford, Campbell, & Salmon, 2008).

In addition to attitudes and traits that seem directly relevant within the context of weight, research suggests that other psychological characteristics, specifically those related to parental well-being, may also be relevant to the obesogenic quality of the home environment. Parents with higher levels of well-being, as indicated by higher life satisfaction, higher self-esteem, and lower levels of stress and depression, may have better cognitive and emotional resources to draw upon to create healthier, more supportive home environments (Lovejoy, Graczyk, O'Hare, & Neuman, 2000). In line with this, higher maternal self-esteem has been associated with more supportive home environments, as indexed by the HOME inventory (Baharudin & Luster, 1998; Menaghan & Parcel, 1991), while higher levels of stress have been associated with less supportive, and more chaotic home environments (Dumas et al., 2005). Recent research found that parents living in obesogenic home environments, characterised by fewer positive family meal practices, fewer family rules, less physical activity equipment, less fruit and vegetable variety, and greater parental fast food consumption and TV viewing, had higher levels of depression than parents living in 'healthy consumer/salutogenic' home environments (Martinson et al., 2011). Moreover, there is some evidence that positive-psychology variables, such as subjective well-being and life satisfaction, are associated with positive health behaviours, such as regular physical activity and a prudent diet (Grant, Wardle, & Steptoe, 2009; Piqueras, Kuhne, Vera-Villarroel, Straten, & Cuijpers, 2011).

2.1.3 Early parenting practices

Parents who carry out non-recommended parenting practices early in their child's development may be prone to expose their child to other obesogenic influences, which further increase the risk for long-term overweight and obesity. Research suggests that aspects of the home environment, such as parental feeding practices and the frequency of family meals, are largely stable (Faith, Berkowitz, et al., 2004; Gable, Chang, & Krull, 2007), and non-recommended practices are associated with increased likelihood of other non-recommended practices later in life. For example, parents who breastfeed for 3 months or less are more likely to introduce their infant to solids foods before the recommended age, and those who introduce solid foods early are more likely to introduce non-recommended foods earlier in childhood, independent of various demographic characteristics (Koh et al., 2010; Schrempft et al., 2013). No studies have examined how early parenting practices relate to the obesogenic quality of the home environment later in life.

2.2 Associations between the home food environment, food and beverage consumption, and weight

2.2.1 Physical aspects

2.2.1.1 Food availability

Home food availability has been identified as a positive predictor of child and adolescent food intake (Patrick & Nicklas, 2005; Rasmussen et al., 2006; Van Der Horst, Oenema, et al., 2007). In a sample of around 4000 adolescents, fruit and vegetable availability was the strongest predictor of fruit and vegetable intake, even when taste preferences for these foods were low (Neumark-Sztainer, Wall, et al., 2003). Availability of various foods and beverages, including fruit and vegetables (Cullen et al., 2003; Hanson et al., 2005; Hearn et al., 1998; Pearson, Ball, & Crawford, 2011), energy-dense snacks (Campbell et al., 2007; Pearson, Ball, et al., 2011), dairy (Arcan et al., 2007; Hanson et al., 2005), fruit juice (Cullen et al., 2003; Nicklas et al., 2001), and sugar-sweetened beverages (Ezendam, Evans, Stigler, Brug, & Oenema, 2010; Grimm, Harnack, & Story, 2004), has been associated with their consumption. Most of the studies reporting an association between availability and intake have been cross-sectional; however, there is some longitudinal evidence (Ezendam et al., 2010; Pearson, Ball, et al., 2011). Moreover, change in the home food environment following nutrition or weight loss interventions has been associated with changes in intake in adult participants and their family members (Gorin et al., 2008).

While many studies have assessed the simple presence or frequency with which foods are available in the home, research suggests that the quantity and variety of foods available is also important. Storing large amounts of foods, referred to as stock piling, can increase consumption, particularly for convenience foods (Chandon

& Wansink, 2002) and foods stored in large package sizes. Serving large portions at meals or snacks leads to significant increases in energy intake; the effect on intake can be sustained for as long as 11 days (Rolls, Roe, & Meengs, 2007), is evident in preschool children as well as adults (Fisher, Rolls, & Birch, 2003; Rolls, Engell, & Birch, 2000), and may be particularly strong for energy-dense palatable foods. Increasing the variety of food can also increase the consumption volume of that food. Perceived variety may be just as powerful as actual variety. In one study, participants were given an assortment of confectionery in either seven or 10 different colours. Although the taste of the different colours was identical, those given the greater variety ate 43% more sweets over the course of an hour than those given fewer colours (Kahn & Wansink, 2004).

One reason why greater quantity or variety of a food can increase consumption is that it sets a higher consumption norm i.e. the amount or variety of foods available implicitly suggests a normal or acceptable amount to consume (Herman & Polivy, 2005; Wansink, Painter, & North, 2005). In line with this, individuals eat more from a half empty large packet of snacks than they do from a medium full packet of the same amount (Wansink, 1996). Similarly, people tend to eat less when offered multiple small packets than when offered a large packet of the same volume (Wansink, 2004). Physical or psychological effort may be another explanation. It is physically more effortful to open numerous smaller packets and these packets provide discrete stopping points for the individual to consider whether they want to continue eating. In terms of physiological processes, large portions or a variety of foods may cause sensations of satiety to be overridden. There is some evidence that, even when participants report increases in fullness and decreases in hunger, they continue to overeat when presented with large portions (Rolls, Roe, & Meengs, 2006). Tasting a variety of foods may delay habituation of the salivary response, which delays cessation of eating (Epstein, Rodefer, Wisniewski, & Caggiula, 1992).

Fewer studies have examined associations between home food availability and weight. Using household shopping receipts and diaries, one study found that overweight families (n = 75) purchased more energy-dense and high-fat foods than lean families (n = 139), even when adjusting for the number of individuals living in each household (Ransley et al., 2003). Other research found that overweight adults (n = 201) had fewer low-fat snacks, fruit, and vegetables and more high-fat snacks and spreads in their home than normal weight adults (n = 213) (Gorin, Phelan, Raynor, & Wing, 2011; Phelan et al., 2009). An early study found little evidence that heavier families stored more high calorie foods than less heavy families (Coates et al., 1978); however, this sample consumed 50% of their food intake outside the home, which may have been a more prominent influence on weight. It is also possible that the overweight families were already using strategies to avoid overconsumption; although this was not assessed. Although these studies highlight home food availability as a potentially important factor in weight trajectories, they cannot determine whether the differences in food storage are causes or consequences of the weight status of family members.

A handful of studies have examined associations between home food availability and weight in children. An Australian study found neither cross-sectional nor longitudinal associations (over 3 years) between home availability of energy-dense snack foods and BMI in 5 to 6-year-old ($n = 161$) or 10 to 12-year-old ($n = 132$) children (MacFarlane, Cleland, Crawford, Campbell, & Timperio, 2009). An American cross-sectional study found no association between fruit and vegetable or energy-dense food/beverage availability and BMI or body fat in a sample of adolescents ($n = 253$) (Bauer, Neumark-Sztainer, Fulkerson, Hannan, & Story, 2011); and a Canadian cross-sectional study also found no association between fruit and vegetable or energy-dense snack/beverage availability and BMI in a sample of 9 to 12-year-old children ($n = 201$) (Downs et al., 2009). When comparing the home environments of obese ($n = 35$) and normal-weight ($n = 47$) preschoolers, a recent study found no difference in the number of energy-dense snacks, sugar-sweetened drinks, or fruit; although obese homes had fewer fresh vegetables (mean (SD) = 2.5 (2.3) vs. 3.8 (1.9), $p < 0.005$) (Boles et al., 2013). Another study found that home vegetable availability was cross-sectionally associated with lower probability of being overweight in a sample of American-Indian preschool children ($n = 424$). However, the association was marginally significant ($p = 0.051$) and did not hold at two-year follow-up (Arcan et al., 2012).

Null associations between home food availability and child weight may partly be explained by limited power or measurement issues. If the effect of home food availability is small, larger sample sizes may be needed to detect it. All but two of the studies (Arcan et al., 2012; Boles et al., 2013) asked about the frequency with which fruit and vegetables and energy-dense snacks/beverages were usually available at home. Measures asking about current food variety are more detailed and may capture a more realistic picture. Another possibility is that home food availability may be a contributing factor to weight gain if the influence on intake is sustained over time.

2.2.1.2 Food accessibility

Experimental studies have shown that intake tends to be higher when foods are visible, in easy-to-reach locations, and in a form that encourages consumption. For example, adult office workers ate significantly more confectionery when they were closer or presented in transparent containers than when they were further away or placed in opaque jars (Wansink, Painter, & Lee, 2006). Similarly, individuals who were given sandwiches wrapped in transparent wrap ate more than those given them in opaque wrap (Johnson, 1974). On the other hand, locating cafeteria food even a small distance from the serving line can reduce intake (Meiselman, Hedderley, Staddon, Pierson, & Symonds, 1994; Rozin et al., 2011). Observational studies have found that child fruit and vegetable consumption tends to be higher when these foods are stored in accessible locations and in child-friendly sizes (Cullen et al., 2003; Hearn et al., 1998). Accessibility may be particularly important for children with low preferences for fruit and vegetables (Cullen et al., 2003).

The effects of proximity and visibility on consumption have been explained in terms of increased salience. Visible foods are more cognitively salient as they act as a reminder for consumption and they may also be more physiologically salient. Evidence suggests that the mere presence or smell of food can increase reported hunger (Bossert-Zaudig, Laessle, Meiller, Ellgring, & Pirke, 1991; Jansen & van den Hout, 1991; Klajner, Herman, Polivy, & Chhabra, 1981; Staiger, Dawe, & McCarthy, 2000), stimulate salivation (A. J. Hill, Magson, & Blundell, 1984; Rogers & Hill, 1989) and the release of dopamine (Volkow et al., 2002), which can influence consumption (Drewnowski & Bellisle, 2010; Nederkoorn & Jansen, 2002). Another factor that may explain the relationship is the amount of physical or psychological effort required to access the food. Such findings suggest that healthy foods should be stored in visible, accessible locations whereas less healthy foods should be kept out of reach and sight.

While research has reported associations between the physical accessibility of food and intake, there is very little evidence for associations with weight. In the study by Boles and colleagues, there were no differences between obese (n = 35) and non-obese (n = 47) households when examining the accessibility of fruit and vegetables; although this may have been due to limited power to detect an effect (Boles et al., 2013). Another study using in-home observations found that obese households (n = 8) had more visible foods than non-obese households (n = 8); however, this pattern was reversed at the second observation, suggesting that obese families reduced the number of visible foods (Terry & Beck, 1985). In any case, the robustness of the effect is questionable due to the very small sample size.

2.2.2 Social aspects

2.2.2.1 Parental modelling

Parental modelling is one of the most extensively examined correlates of child food intake (Van Der Horst, Oenema, et al., 2007). Much of the evidence for a modelling effect comes from parent-child resemblance in dietary intake, including intake of fruit and vegetables (Cooke et al., 2004; Fisher, Mitchell, Smiciklas-Wright, & Birch, 2002), fat (Feunekes, Stafleu, de Graaf, & van Staveren, 1997), snacks (Brown & Ogden, 2004), soft drinks (Grimm et al., 2004), and particular nutrients (Oliveria et al., 1992), even when controlling for demographics. Resemblance in dietary intake seems to be at least partly environmental as the effect exists among individuals living in the same household irrespective of their genetic relatedness (Pérusse et al., 1988; Vauthier, Lluch, Lecomte, Artur, & Herbeth, 1996). Some research has reported stronger associations between mother-child dyads than father-child dyads (Beydoun & Wang, 2009; Oliveria et al., 1992); although this differential effect has not always been reported (Feunekes et al., 1997; Patterson, Rupp, Sallis, Atkins, & Nader, 1988). Much of the research has been cross-sectional, although there is some evidence that parental intake predicts child intake over time (Fisher, Mitchell, Smiciklas-Wright, Mannino, & Birch, 2004). In the latter study, the association between maternal modelling and child intake was mediated by home food availability. As noted by Ventura and Birch, the effects of modelling and availability are difficult to separate in observational studies as they naturally co-occur (Ventura & Birch, 2008). Experimental studies have provided evidence for a causal role, with consistent reports that the presence of a peer or adult model facilitates young children's acceptance of new foods as indicated by their intake and preferences (Addessi, Galloway, Visalberghi, & Birch, 2005; Harper & Sanders, 1975; Hendy, 2002; Jansen & Tenney, 2001). Parental behaviours may influence the child's behaviour unconsciously or consciously via attitudes, subjective norms, imitation, awareness, and involvement (Kremers et al., 2006).

Fewer studies have examined associations between parental modelling and child weight. One cross-sectional study with a sample of 9 to 11-year-old Mexican children (n = 108) found no association between parental modelling of 'healthful food behaviours' and child BMI (Matheson, Robinson, Varady, & Killen, 2006). However, very limited information was provided about the modelling measure, making it difficult to draw firm conclusions about the findings. In an American sample of 92 parent-child dyads (children aged 3 to 5 years), parental disinhibition (defined as the tendency to overeat in the presence of palatable food cues, or other disinhibiting stimuli, such as emotional stress) was associated with increases in child body fat over a period of 6 years (Hood et al., 2000). The association may partly be explained by a modelling effect, although this was not directly assessed. Other research has shown that child weight loss interventions are more likely to succeed if the child's parent makes changes to their own diet (Sato et al., 2010) and loses weight (Boutelle, Cafri, & Crow, 2012), suggesting that simple encouragement may be insufficient to improve child eating habits. A randomized controlled weight loss trial including 8 to 12-year-old children and their parents found that parental modelling of healthy eating habits independently predicted 24-month child percentage overweight change (Wrotniak, Epstein, Paluch, & Roemmich, 2005); and in a sample of preschool children in primary care, a family-based behavioural weight control program predicted 6-month weight loss (Quattrin et al., 2012), with parental modelling of healthy mealtime behaviours as one of the intervention's components.

2.2.2.2 Parental feeding practices

Parental feeding practices have received considerable research attention. In particular, restricting access to well-liked foods has generally been viewed as having adverse consequences for eating behaviour and weight. According to Birch and colleagues, maternal restriction interferes with the child's ability to regulate their intake, as they have greater reliance on external rather than internal cues for consumption (Faith, Scanlon, et al., 2004). Support for this notion comes from a series of experimental studies by Birch and colleagues (Fisher & Birch, 1999a, 1999b), which found that restricting access to a palatable food increased young children's behavioural response to the food (as indexed by the number of positive comments about the food, requests for the food, and attempts to obtain the food) and their subsequent selection and intake of the food when compared to periods in which the food was freely available. Some cross-sectional and prospective observational studies have provided further support for this notion, reporting a positive association between parental restriction and child BMI (Birch & Fisher, 2000; Faith, Scanlon, et al., 2004; Faith, Berkowitz, et al., 2004; Fisher & Birch, 2002). However, a number of studies have not replicated the effects reported by this research group, with some finding no association with weight (K. A. Brown, Ogden, Vögele, & Gibson, 2008; Carnell & Wardle, 2007; T. N. Robinson, Kiernan, Matheson, & Haydel, 2001), and others suggesting that some form of parental restriction may have favourable consequences for dietary intake and weight. For example, higher levels of parental permissiveness has been associated with greater fat, sweet, snack, and soft drink consumption in younger children and adolescents (De Bourdeaudhuij, 1997; Vereecken et al., 2004), while greater parental control has been associated with higher intake of soft drinks and snack foods (R. Brown & Ogden, 2004; De Bourdeaudhuij & Oost, 2000). Restriction of energy-dense snacks has also been associated with lower BMI at three-year follow-up in an Australian sample of 204 5 to 6-year-olds (Campbell et al., 2010); while another study found that restriction during infancy was associated with lower weight at 2 years in a UK sample of 62 mother-child dyads (Farrow & Blissett, 2008).

There are a number of possible reasons for these findings. First, researchers have used various measures of parental feeding practices, including standardised measures such as the Child Feeding Questionnaire (Birch et al., 2001) and the Parental Feeding Style Questionnaire (Wardle et al., 2002), and unstandardised measures that have been created for the particular study. It is possible that the construct of parental control is complex. Existing measures may capture some aspects that are detrimental to child eating behaviours and some that are beneficial, and there might be non-linear effects. For example, excessive restriction may adversely affect eating behaviour and weight, whereas moderate levels of restriction may have a beneficial effect. The parenting context may also play an important role. For example, restriction combined with coercive and chaotic parenting styles has been associated with children's disinhibited eating whereas higher levels of supportiveness reduced the association (Joyce & Zimmer-Gembeck, 2009). The form of control seems to be another important factor. Ogden and colleagues found that covert control (management of a child's eating environment that may not be recognised by the child) was negatively related to snack intake, whereas overt control (explicit management of the child's intake that is recognised by the child) was positively associated with snack intake (Ogden, Reynolds, & Smith, 2006).

In addition to measurement, associations between parental feeding practices and child weight may be influenced by the predispositions of the child. Positive associations between restrictive feeding practices and excessive eating or weight over time have been shown in 'at risk' individuals, such as those with a high BMI or low inhibitory control, but to a lesser extent or not at all in those of lower risk (Anzman & Birch, 2009; Birch, Fisher, & Davison, 2003; Faith, Berkowitz, et al., 2004). Other longitudinal studies have found that heavier child weight predicts parental use of controlling feeding practices (Rhee et al., 2009; Rifas-Shiman et al., 2011; Webber, Cooke, Hill, & Wardle, 2010b), and a mediation analysis found that parents restricted their child's intake because they were concerned about their weight or eating behaviour (Webber, Hill, Cooke, Carnell, & Wardle, 2010). It is feasible that restrictive feeding practices further increase the internal salience of foods in susceptible individuals, prompting weight gain. However, review studies have highlighted a need for more longitudinal research, and the inclusion of standardised measures assessing a variety of parental feeding practices (Faith, Scanlon, et al., 2004; Hurley, Cross, & Hughes, 2011; Wardle & Carnell, 2007).

2.2.2.3 Family meals

Eating more meals together as a family tends to be associated with healthier eating patterns, such as higher consumption of fruit, vegetables, and dairy foods, lower glycaemic load, more fibre and micronutrients from food; and fewer unhealthy eating patterns including less fried foods, sugar-sweetened drinks, saturated fat, a reduced tendency to skip breakfast, and less binge eating (Gillman et al., 2000; Hammons & Fiese, 2011; Neumark-Sztainer, Eisenberg, Fulkerson, Story, & Larson, 2008; Neumark-Sztainer, Wall, Story, & Fulkerson, 2004; Videon & Manning, 2003). Much of the research on family meals and diet quality has been cross-sectional; although some research found that having more family meals in adolescence was associated with higher diet quality (Larson, Neumark-Sztainer, Hannan, & Story, 2007) and less disordered eating behaviour (Neumark-Sztainer et al., 2008) in early adulthood. Suggested mechanisms for associations between family meals and diet quality include parental awareness and control of their child's intake, parental modelling of intake, and family-connectedness, which may establish positive attitudes towards food. Some research has shown that the association between frequency of family meals and eating patterns holds when adjusting for family-connectedness (Neumark-Sztainer et al., 2008, 2004), suggesting that there may be other explanatory factors. Associations could be explained by some other familial indicator, such as the degree of household 'chaos' (Dumas et al., 2005; Matheny Jr., Wachs, Ludwig, & Phillips, 1995), although this has not been directly examined. There is some evidence that families of a higher SES have more family meals than those of a lower SES (Neumark-Sztainer, Hannan, et al., 2003; Videon & Manning, 2003); although studies reporting an effect of family meals have typically adjusted for SES, suggesting that there are other mediating variables involved. Further research is needed to understand moderators and mediators, such as the quality of the mealtime interaction and the foods provided.

Associations between family meals and weight have been examined, mainly in American and adolescent samples. Two studies found that eating more meals as a family was associated with reduced odds of adolescent overweight in cross-sectional analyses (n = 1710 and 14, 486, respectively), but associations did not hold at one-year and five-year follow-up (n = 806 and 11,403, respectively) (Fulkerson, Neumark-Sztainer, Hannan, & Story, 2008; Taveras, Rifas-Shiman, et al., 2005). Another study found that more frequent family dinners was associated with reduced odds of becoming overweight and increased odds of ceasing to be overweight over a three-year period in white adolescents (n = 2089) but not black or Hispanic adolescents (n = 1685) (Sen, 2006). The same moderating effect of ethnicity was reported in another US-based sample of 6 to 11-year-olds (n = 16, 770) (Rollins, Belue, & Francis, 2010). Ethnic differences in the caloric content or portion size of food served at family meals may explain these findings as non-white ethnicity has been associated with more frequent fast food consumption (Pereira et al., 2005) and there is some evidence for ethnic differences in home food availability (Franco et al., 2009; Skala et al., 2012). Among younger children, a cross-sectional study found that not eating dinner as a family at least 6 days per week was associated with increased likelihood of being obese at age four (n = 8550) (S. E. Anderson & Whitaker, 2010); and a longitudinal study of 8000 5-year-olds found that fewer family meals was associated with increased likelihood of persistent overweight over a three-year period (Gable et al., 2007). It is possible that the critical time period for family meal influences on weight occurs earlier in childhood, although further research in non-American samples is needed.

2.3 Associations between the home activity environment, physical activity, and weight

2.3.1 Physical aspects

2.3.1.1 Availability of physical activity equipment and facilities

A recent review focusing on preschool-aged children identified several outdoor activity variables, including having an open space, having a large open space, and having fixed equipment and wheeled toys, as significant positive correlates of overall physical activity (De Craemer et al., 2012). Home availability of physical activity equipment has been associated with higher levels of both reported and accelerometer-measured physical activity in older children and adolescents, but findings have been inconsistent (Davison & Lawson, 2006; Maitland, Stratton, Foster, Braham, & Rosenberg, 2013; Van Der Horst, Paw, Twisk, & Van Mechelen, 2007). Ethnicity may be a moderating factor as studies reporting no association used ethnically diverse samples (e.g. Sallis et al., 1993; Trost et al., 1997; Trost, Pate, Ward, Saunders, & Riner, 1999). Findings from longitudinal analyses suggest that home availability of activity equipment may not predict physical activity over time (Crawford et al., 2010; Hearst, Patnode, Sirard, Farbakhsh, & Lytle, 2012). As with home food availability, the availability of physical activity equipment may act as a temporary environmental cue and may be necessary but insufficient for behaviour.

There is some evidence that overweight adults (n = 201) have less exercise equipment in their home than normal-weight adults (n = 213) (means (SDs) for total exercise items = 11.1 (5.5) vs. 13.0 (6.0), p = 0.004) (Gorin, Phelan, Raynor, & Wing, 2011; Phelan et al., 2009). Another study reported a similar (albeit small) effect when comparing the home environments of obese (n = 35) and non-obese (n = 47) preschoolers (means (SDs) for total activity items = 6.7 (1.8) vs. 7.5 (2.0), $p < 0.05$) (Boles et al., 2013). However, studies examining associations between home availability of physical activity equipment and child or adolescent weight in the general population have generally reported a null result. There was no association with BMI in an Australian low-income sample of 491 5 to 12-year-olds (Crawford et al., 2012); with BMI or percent body fat in an American sample of adolescent girls (n = 253) (Bauer, Neumark-Sztainer, Fulkerson, Hannan, & Story, 2011); with BMI in an ethnically diverse American sample of adolescent boys (n = 1307) and girls (n = 1486) (Larson et al, 2013); or with BMI in an American sample of 5 to 11-year-old children (n = 116) and adolescents (n = 171) (Rosenberg et al., 2010). Two Australian studies found an inverse association with BMI over 3 and 5 years (adjusting for baseline BMI) in 10 – 12-year-old girls (n = 173 and 192, respectively), but not boys (Crawford et al., 2010; Timperio et al., 2008). However, the effects were small (B (95% CI), p value = -0.04 (-0.08 – -0.00), $p < 0.05$ and -0.05 (-0.08 – -0.01), 0.02, respectively), and there was no indication that statistical adjustment was made for multiple testing.

2.3.2 Accessibility of physical activity facilities

Although not a feature of the immediate home environment, the construct of neighbourhood satisfaction has been associated with many health outcomes and is thought to be important in determining whether or not individuals actually make use of the local amenities available to them (Carson, Kuhle, Spence, & Veugelers, 2010). This is particularly relevant given that a growing body of evidence suggests that the local neighbourhood environment may be an important factor contributing to childhood overweight and obesity. Several studies have found that child overweight and obesity was highest in neighbourhoods least favourable for physical activity, defined as having built environments least conducive to walking and limited access to parks or playgrounds (Dunton, Kaplan, Wolch, Jerrett, & Reynolds, 2009), in addition to those least conducive to healthy eating, defined as having poor proximity to supermarkets (Liu, Wilson, Qi, & Ying, 2007; Morland & Evenson, 2009) and high fast-food restaurant or convenience store density (Grafova, 2008; Jennings et al., 2011; Oreskovic, Kuhlthau, Romm, & Perrin, 2009). While many studies have been cross-sectional, there is some prospective evidence for associations between the built environment and child activity level and weight (Wolch et al., 2011). Moreover, a recent study found that various activity- (and eating-) related characteristics of the neighbourhood environment predicted child success across a variety of behavioural obesity treatments (Epstein et al., 2012). Associations between the neighbourhood environment and child weight status seems to hold even after controlling for parent weight status and a variety of neighbourhood, household, and individual demographics (Saelens et al., 2012).

2.3.3 Social aspects of the home activity environment

2.3.3.1 Parental modelling

Using both objective and self-report measures, researchers have identified parental physical activity as a significant positive correlate of child activity level (Oliver, Schofield, & Schluter, 2010); although not all studies have found an association (e.g. Dolinsky, Brouwer, Evenson, Siega-Riz, & Østbye, 2011; Jago, Fox, Page, Brockman, & Thompson, 2010). One review concluded that father’s physical activity had a stronger association with child physical activity than that of mothers (Ferreira et al., 2007); however, other research found that maternal rather than paternal physical activity was more strongly associated with that of the child (Spurrier et al., 2008). Much of the research reporting an association between parental and child physical activity has been cross-sectional, although there is some longitudinal evidence in both younger (Taylor et al., 2009) and older child samples (Cleland et al., 2011; Crawford et al., 2010).

Some studies have examined associations between parental physical activity level (parent-reported) and child weight, although findings have been inconsistent. For example, an American study found that fathers of obese children (n = 54) were significantly less active than fathers of non-obese children (n = 133) (Trost, Kerr, Ward, & Pate, 2001); another American study found that low levels of parental physical activity (combined with high levels of energy intake) was associated with greater increases in child BMI/skinfold thickness from 5 to 7 years (Davison & Birch, 2002); an Australian study found no association with maternal or paternal physical activity, but sibling physical activity was associated with three-year decreases in BMI in 10 – 12-year-old girls (n = 192) (but not boys) (Timperio et al., 2008); while another Australian study found no association with sibling activity but maternal physical activity was positively associated with BMI over 5 years in 10 – 12-year-old boys (n = 128) (but not girls) (Crawford et al., 2010). The unexpected result in the last study could be a chance finding, or it could be that boys with a higher BMI have mothers with a higher BMI, who may be engaging in more physical activity to manage their weight. Associations between parental physical activity and child weight may indeed reflect a modelling effect and/or they may reflect genetic influence on parent and child BMI.

2.3.3.2 Parental support

Review studies have identified parental support for physical activity as a key correlate of child and adolescent physical activity behaviour (Biddle, Atkin, Cavill, & Foster, 2011; Ferreira et al., 2007; Sallis, Prochaska, & Taylor, 2000; Van Der Horst, Paw, et al., 2007). Higher support for physical activity has been associated with smaller declines in physical activity among adolescent samples (Craggs, Corder, van Sluijs, & Griffin, 2011), and more time spent outdoors over 5 years in younger and older children (Cleland et al., 2010).

Little research has examined associations between parental support for physical activity and weight. An early observational study in the US found that parental encouragements for the child to be active correlated negatively with weight in a sample of preschool children (n = 30) (Klesges, Malott, Boschee, & Weber, 1986); and another American study found that overweight 12-year-olds (n = 84) reported overall less support for physical activity than normal-weight children (n = 80)

(Zabinski, Saelens, Stein, Hayden-Wade, & Wilfley, 2003). However, two longitudinal studies found no association between parental support of physical activity and BMI in 10 – 12-year-old Australian children (n = 128 – 192) (Crawford et al., 2010; Timperio et al., 2008). In these two studies, parental support was assessed at baseline only, suggesting that the results may have been affected by changes in parental support. Parental support may have an influential effect if it is sustained over time. Moreover, if the effect is small, larger sample sizes may be required to detect it. It is also possible that parents are more supportive of physical activity in children who show a preference for engaging in physical activities, which may explain the evidence for cross-sectional but not longitudinal associations.

2.4 Associations between the home media environment, television viewing, and weight

2.4.1 Physical aspects

2.4.1.1 Availability of media equipment

Children and adolescents who live in homes with more media equipment, including TV sets, VCR/DVD players, computers, and games consoles are consistently found to spend more time in sedentary behaviours (Maitland et al., 2013; Pate, Mitchell, Byun, & Dowda, 2011). For example, having multiple TVs and cable or satellite in the home has been associated with higher levels of TV viewing in children and adolescents (Jago et al., 2012; Jordan et al., 2010; Van Zutphen, Bell, Kremer, & Swinburn, 2007). Randomized controlled trials have found that TV limiting devices reduce TV viewing in children and adolescents (French, Gerlach, Mitchell, Hannan, & Welsh, 2011; T. N. Robinson & Borzekowski, 2006).

Some research found that overweight adults (n = 201) had more TVs in their home than normal-weight adults (n = 213) (means (SDs) = 3.3 (1.4) vs. 2.4 (1.2), $p < 0.001$) (Gorin et al., 2011; Phelan et al., 2009). In the general population, associations between home media equipment and child or adolescent weight have been inconsistent. Two cross-sectional studies (one American, one Australian) found no association between the number of media equipment and child or adolescent BMI (n = 491 5 to 12-year-olds; n = 116 8-year-olds & 171 15-year-olds, respectively) (Crawford et al., 2012; Rosenberg et al., 2010). Two prospective studies (both Australian) found that the number of media equipment was associated with increased BMI over 3 and 5 years in 10 – 12-year-old boys (n = 152 and 128, respectively), but not girls (Crawford et al., 2010; Timperio et al., 2008); although the effects were not strong (B (95% CI), p value = 0.11 (0.01 – 0.21), 0.037 and 0.09 (0.02 – 0.16), < 0.05, respectively), and there was no indication of statistical adjustment for multiple testing. It is feasible that the presence of media equipment in the home is more salient for boys as certain sedentary behaviours, such as electronic game use, are more common among this group (Salmon, Timperio, Telford, Carver, & Crawford, 2005). However, other research found an association between home video game equipment and weight in girls but not boys (Li, Dibley, Sibbritt, & Yan, 2008); and an American study reported a positive association between the number of media resources in the home and BMI and percent body fat in a sample of adolescent girls (n = 253) (Bauer, Neumark-Sztainer, Fulkerson, Hannan, & Story, 2011).

An obvious explanation for reported associations between the availability of home media equipment and weight is increased sedentary behaviour and reduced energy expenditure. However, in the study by Bauer and colleagues (Bauer, Neumark-Sztainer, Fulkerson, Hannan, & Story, 2011), the association between media equipment and weight was not mediated by TV viewing. The authors suggested that other behaviours, such as sleep, may mediate the association. Sleep duration has been independently associated with weight gain and increased incidence of obesity in numerous studies of children and adults (Patel & Hu, 2008), and the presence of a TV or computer in the bedroom has been associated with sleep duration and quality (Sisson, Broyles, Newton Jr., Baker, & Chernausek, 2011). Physiologic studies suggest that sleep duration may influence weight via appetitive, activity, and/or thermoregulation pathways (Klingenberg, Sjödin, Holmbäck, Astrup, & Chaput, 2012). On the other hand, it is possible that reported associations do not reflect a causal pathway whereby home media equipment influences weight.

2.4.1.2 Accessibility

Research has shown that children and adolescents who have a TV in their bedroom engage in higher levels of TV viewing (Anastassea-Vlachou, Fryssira-Kanioura, Papathanasiou-Klontza, Xipolita-Zachariadi, & Matsaniotis, 1996; Gorely, Marshall, & Biddle, 2004; Van Zutphen et al., 2007). The effect is less consistent in younger children (Hinkley, Salmon, Okely, & Trost, 2010; Hoyos Cillero & Jago, 2010); perhaps because young children are less likely to have a TV in their bedroom and they spend less leisure time in their bedroom. Having media equipment in the bedroom has also been associated with other EBBs such as less physical activity (Adachi-Mejia et al., 2006), and poor eating habits, including eating while watching TV (Saelens et al., 2002) and soft drink consumption (Cameron et al., 2013). No studies have yet tested whether removing TV sets or other media equipment from the bedroom reduces TV viewing time (Schmidt et al., 2012).

Several studies have reported that children and adolescents who have a TV in their bedroom are more likely to be overweight than those who do not, even when controlling for potential confounders including ethnicity, maternal education level, and maternal obesity. The association has been reported in a US sample of 9 to 12-year-olds (n = 2343) (Adachi-Mejia et al., 2006); a European sample of adolescents (n = 7234) (Cameron et al., 2013); a French sample of adolescents (n = 379) (Delmas et al., 2007); a US sample of low-income preschool children (n = 2761) (Dennison, Erb, & Jenkins, 2002); and an Australian sample of 4 to 12-year-olds (n = 1926) (Van Zutphen et al., 2007). In two studies, the association was partly mediated by TV viewing (Cameron et al., 2013; Delmas et al., 2007); although other studies found the association to be independent of TV viewing (Adachi-Mejia et al., 2006; Dennison et al., 2002; Van Zutphen et al., 2007), suggesting other potential explanatory mechanisms. Having a TV in the bedroom might influence several behaviours that contribute to child obesity; although causality cannot be inferred from the existing associations.

2.4.2 Social aspects of the home media environment

2.4.2.1 Parental modelling

A recent review of correlates of EBBs in preschool children aged 4 to 6 years identified higher parental TV viewing time as a significant correlate of child's screen viewing time (De Craemer et al., 2012); although just two studies met the review's inclusion criteria. In the study by Kourbala and colleagues, maternal TV viewing time was the first most important factor discriminating between 3 to 5-year-old children who watched ≥2 h/day and those who watched <2h/day (Kourlaba, Kondaki, Liarigkovinos, & Manios, 2009). More recently, another nationally representative study identified parental TV viewing time as a strong predictor of TV viewing time in children aged 5 years or younger (Bleakley, Jordan, & Hennessy, 2013). Similar results have been reported in older child and adolescent samples (Bleakley et al., 2013; Davison, Francis, & Birch, 2005; Hardy et al., 2006; Salmon et al., 2005).

No studies have examined the association between parental modelling of sedentary behaviour and weight in preschool children. However, higher parental TV viewing has been associated with a greater likelihood of being overweight in adolescent girls (Davison & Birch, 2002; Davison et al., 2005).

2.4.2.2 Parental rules and household routines

With regard to parental rules around media use, the majority of work to date has focused on rules around TV, with a particular focus on parental limits on the amount of TV watched. Studies have consistently found a negative association between parental use of time limits and the amount of TV the child views (Hinkley et al., 2010; Hoyos Cillero & Jago, 2010; Ramirez et al., 2011), particularly among younger children (Gentile & Walsh, 2002; Truglio, Murphy, Oppenheimer, Huston, & Wright, 1996; Van den Bulck & Van den Bergh, 2000). However, parental limits may have immediate but not long-term effects on children's media use as there is some evidence that the association does not hold over time (Lee, Bartolic, & Vandewater, 2009).

Unlike findings from the feeding literature, there is no evidence that restriction can have an adverse effect on sedentary behaviour and weight through increased liking of or desire to do the activity. On the contrary, one study found that children (aged 10 – 12 years) with low-restrictive parents were 3 times more likely to watch TV for more than 4 hours per day (than less than 2 hours per day) (Jago et al., 2011), while another study found that having rules around sedentary behaviour was negatively associated with five-year BMI change in children (aged 10 – 12 years at baseline) (Crawford et al., 2010). Whether parental use of sedentary time as a reward for good behaviour has an adverse effect on sedentary behaviour and weight is unclear. In the parental feeding literature, using food as a reward for good behaviour tends to increase preference for the reward foods (Birch, Marlin, & Rotter, 1984; Newman & Taylor, 1992). On the other hand, some researchers have promoted the use of screen time as a reward for physical activity behaviour in interventions for overweight children and adolescents. Although the interventions successfully increased physical activity in the short-term, the long-term effects of such techniques are not known (DeMattia, Lemont, & Meurer, 2007; Goldfield, Mallory, Prud'homme, & Adamo, 2008). It is possible that the effects of restriction and reward on behaviour are context-dependent.

Although not directly a rule, eating while watching TV has been identified as a household routine that could have both short and long-term consequences for child weight. Several studies have reported a positive association between eating while watching TV and overall TV viewing time in children (Saelens et al., 2002; Salmon et al., 2005; Van Zutphen et al., 2007); although the association may not be causal. Research more strongly indicates that eating while watching TV acts as a risk factor for weight gain via its influence on food intake. Experimental studies with adults (Bellisle, Dalix, & Slama, 2004) and older children (Bellissimo, Pencharz, Thomas, & Anderson, 2007) have shown increased food intake during TV viewing. Research with preschool children found that food intake increased or decreased during TV viewing, depending on the individual experience of the child (Francis & Birch, 2006). Specifically, only children who watched more daily hours of TV and had a higher frequency of meals eaten in front of the TV at home ate more in the TV condition. These findings suggest that TV can cue eating behaviour in those who habitually eat while watching TV. In terms of the types of foods consumed during TV viewing, research with children found no significant differences between the fat content and energy density of foods consumed during TV viewing and outside TV viewing hours.

However, snacks were consumed more frequently during TV viewing and the percentage of energy from vegetables consumed during TV viewing was significantly lower than that consumed at other times of the day (Matheson, Killen, Wang, Varady, & Robinson, 2004). Eating while watching TV has also been negatively associated with overall diet quality (Coon, Goldberg, Rogers, & Tucker, 2001; Liang, Kuhle, & Veugelers, 2009; Marquis, Filion, & Dagenais, 2005), and positively associated with weight status in children (Dubois, Farmer, Girard, & Peterson, 2008; Matheson et al., 2004), independent of the overall time spent watching TV (Liang et al., 2009).

One possible explanation for increased intake and body weight is that, while watching TV, people have limited attention and are less able to regulate the amount or type of foods consumed, perhaps through diminished responsiveness to internal cues for satiety. In line with this, one study found that intake was significantly greater in two different conditions of distraction: listening to an audiotaped story and watching TV (Bellisle et al., 2004). Another study found that TV watching increased the amount of food eaten, energy intake, and the time spent eating, but only when it required allocation of attention i.e. when TV was watched continuously rather than in repeated segments (Temple, Giacomelli, Kent, Roemmich, & Epstein, 2007). Recent experimental research found that just 9 minutes of watching a fast-paced TV programme was sufficient to impair executive function in preschool children (Lillard & Peterson, 2011), with other research showing a link between excessive eating and a disruption in brain regions involved in inhibitory control (Volkow, Wang, Fowler, & Telang, 2008). In a study that directly assessed the interaction between TV viewing and physiologic regulation of energy intake, boys had significantly higher intakes during TV viewing despite being given a glucose preload, suggesting a delay in satiation (Bellissimo et al., 2007). Other evidence has shown that habituation of the salivary response, which usually occurs after repeated tastes of a particular food/drink item and is an important mechanism involved in the cessation of eating, can be disrupted by a video game or TV watching in adults and children (Epstein et al., 1992; Epstein, Saad, Giacomelli, & Roemmich, 2005).

TV viewing itself may also act as a trigger for eating. This association may be established from a young age if, for example, parents place their child in front of the TV with a snack or meal while they do household chores (Lemish, 1987). People may also associate TV viewing with eating because the content of TV shows or adverts may trigger snacking. It is estimated that children may view as many as 40,000 advertisements for food each year, and 98% of these promote foods that are high in fat, salt, sugar, and energy-density, and low in nutrient-density (Powell, Szczypka, Chaloupka, & Braunschweig, 2007). Exposure to TV advertisements influences the type of food desired, requested and consumed (Dennison & Edmunds, 2008). The branding used in these adverts can have powerful effects on eating behaviours, as shown in laboratory studies (Keller et al., 2012). At a physiological level, recent experimental research with adults found that watching images of palatable foods increased plasma ghrelin concentrations (Kroemer et al., 2012) known to stimulate appetite and increase caloric intake in humans (Wren et al., 2001). Whether the effect of increased ghrelin extends to other non-food visual stimuli is unclear.

2.5 Conceptual issues

2.5.1 Examining the combined influence of multiple home environment variables

One possible reason why there is limited evidence for an association between the home environment and weight is that few studies have taken into account the combined influence of a range of home environment variables, which may act in synergistic ways to influence weight (Lake et al., 2010). Risk factors for obesity can cluster together but can also coexist with health-promoting behaviours. For example, several studies have found that intake of energy-dense foods increases with hours of TV viewing (Epstein, Roemmich, Paluch, & Raynor, 2005), while seemingly contrary physical activity and sedentary behaviours can also co-occur (Nelson, Gordon-Larsen, Adair, & Popkin, 2005; Owen, Leslie, Salmon, & Fotheringham, 2000). Similarly, recent research using latent class analysis identified ‘obesogenic’ and ‘healthy’ home environments but also ‘risky consumer’ homes, characterised by the highest variety of fruit and vegetables, the highest density of physical activity equipment, and the highest variety of snack foods and the highest density of media equipment (Martinson et al., 2011). These findings highlight the importance of considering multiple aspects of the home environment together when examining associations with EBBs and weight. Using appropriately aggregated composite measures rather than multiple tests of individual measures also reduces experiment wise error and is therefore likely to result in more reliable estimates of effects.

Pattern analytic techniques have been used to examine the combined effect of environmental variables on health outcomes (Grunseit, Taylor, Hardy, & King, 2011; Wall et al., 2012). In the study by Grunseit and colleagues, Principal Component Analysis (PCA) was used to determine the collective influence of the home environment on adolescent EBBs. Parental confidence about their child's soft drink intake, confidence about their child's physical activity participation, having rules about TV viewing, frequency of eating breakfast, and offering their child water to drink with meals loaded onto the first factor, which was labelled 'obesogenic control'. Soft drink availability at home, having a TV in the child's bedroom, fast food for family meals, eating dinner in front of the TV, and number of short car trips loaded onto the second factors, which was labelled 'obesogenic risk'. Although the authors argued against a unidimensional measure of home environment 'obesogenic risk', the relationships between the factors and EBBs were generally in line with a unidimensional model. Specifically, 'obesogenic control' was associated with intake of healthy foods, lower intake of unhealthy foods, higher physical activity, and less screen time, while 'obesogenic risk' was associated with lower adolescent intake of healthy foods, higher intake of unhealthy foods, lower physical activity, and more screen time.

Although this study was important, using factor analysis to derive a composite score is problematic as some variables may not load onto the latent factor(s) even though they are relevant to weight. Indeed, parental use of sweets to reward behaviour, (which has been associated with increased consumption of energy-dense foods and beverages (Benton, 2004)), was removed from the analysis as it did not load onto either of the latent factors (Grunseit et al., 2011). It is not necessarily expected that independent risk factors for obesity will be related even if they are each relevant to weight.

Two American studies have created total scores by summing items in home environment measures, and examined associations with child BMI. One study found that total scores on the Family Nutrition and Physical Activity (FNPA) screening tool were associated with one-year BMI change, after adjusting for baseline BMI, parental BMI, and other demographic factors, in an American sample of 6 to 7-year-olds (n = 1030) (Ihmels, Welk, Eisenmann, Nusser, & Myers, 2009). However, the FNPA total score comprises the child's EBBs, which are not technically a part of the home environment, suggesting that the associations may have been driven by some other factor. More recently, another American study found that total scores on the Comprehensive Home Environment Survey (CHES) were associated with child BMI in a sample of 5 to 17-year-olds (n = 150); although the authors only presented the simple pearson's correlation ($r = 0.24$, $p < 0.05$) (Pinard et al., 2013).

Further research is needed to develop composite measures using a wide range of home environment variables, and, as existing studies have based their composite measures on older child or adolescent samples (in the US), developing a composite measure based on pre-school children's home environments will build upon these findings and inform early obesity prevention efforts.

2.5.2 Role of Gene-Environment interaction

In addition to potential measurement issues, another explanation why there is limited evidence for an association between the home environment and weight is that the home environment interacts with genetic predispositions to influence overweight and obesity.

A gene-environment interaction (G x E) refers to a phenotypic response to an environmental challenge that is significantly influenced by the genotype. In the presence of G x E, individuals with a 'sensitive' genotype are at greater risk to the predisposing environment than those with an 'insensitive' genotype (Moffitt, Caspi, & Rutter, 2006; Rutter, 2007). In the context of obesity, the behavioural susceptibility model proposes that genetically determined differences in appetitive traits confer differential susceptibility to obesogenic environments (Carnell & Wardle, 2008a). The importance of G x E is widely acknowledged and there have been an increasing number of studies attempting to detect evidence of environmental moderation on the genetic contribution to obesity.

Animal models are a powerful tool for the study of G x E as both genotype and environmental exposure can be experimentally controlled (Speakman, Hambly, Mitchell, & Król, 2007). Demonstrating G x E in humans, however, is more challenging. Due to the generally short-term, artificial nature of human experiments, the type of environmental exposure that can be manipulated is limited. The implementation of population-based twin studies, inclusion of measured environments, and advances in quantitative genetic modelling of twin data has made it possible to examine G x E outside of an experimental design (Dick, 2011). Various behaviour genetic studies have shown that the magnitude of genetic variance is not a static characteristic of a trait but can be moderated by particular environments (Rutter & Silberg, 2002; Turkheimer, Haley, Waldron, D'Onofrio, & Gottesman, 2003). In the context of obesity, existing research has focused on how behaviours such as physical activity and dietary intake moderate genetic influences on weight (Ahmad, Varga, & Franks, 2013). In particular, a number of twin studies have found the heritability of BMI to be lower among those who exercise frequently (McCaffery, Papandonatos, Bond, Lyons, & Wing, 2009; Mustelin, Silventoinen, Pietiläinen, Rissanen, & Kaprio, 2009; Silventoinen et al., 2009). Some other research has focused on the role of distal environmental exposures, such as income and education level, finding greater genetic variance in BMI among those with lower education and income (Johnson & Krueger, 2005; Johnson, Kyvik, Skytthe, Deary, & Sørensen, 2011). These findings suggest that environmental contexts may suppress or facilitate genetic expression.

No studies have used proximal measures of the environment when examining G x E in the context of obesity, despite recommendations to do so (Moffitt et al., 2006). It is possible that aspects of the home environment moderate the association between genetic risk for weight gain and actual weight gain. Indeed, research has shown that individuals respond differently to aspects of the home environment. For example, when presented with energy-dense palatable foods soon after consuming a filling meal, overweight children continued to eat while others showed disinterest (Jansen et al., 2003); greater parental restriction was associated with eating in the absence of hunger, and the association was particularly strong among girls who were already overweight at 5 years of age (Birch et al., 2003); obese individuals ate significantly more cookies than non-obese individuals when exposed to food commercials, with no difference in the amount consumed when viewing non-food commercials (Falciglia & Gussow, 1980); branding influenced young children's eating behaviour, particularly among those with a higher BMI (Keller et al., 2012); and exposure to fast food advertising was associated with BMI, but only in those at the upper end of the BMI spectrum (Andreyeva, Kelly, & Harris, 2011). Another study tracked childhood changes in BMI over time and found that, in families with lean parents, there were no differences in children's weight gain between high and low SES families. However, in families with obese parents, children from lower SES families gained significantly more weight than those from higher SES families, and many more became overweight (Semmler, Ashcroft, Jaarsveld, Carnell, & Wardle, 2009). These findings suggest that, while parental leanness confers protection to the development of overweight, even in the obesogenic environment, parental overweight is a risk factor, and is magnified by aspects of the obesogenic environment. Although the study did not directly explore proximal environmental mechanisms, there is evidence that aspects of the home environment vary according to SES (e.g. Barr-Anderson et al., 2008; Bauer, Neumark-Sztainer, Fulkerson, & Story, 2011; MacFarlane et al., 2007; Videon & Manning, 2003). Taken together, these studies highlight the importance of individual responsiveness to the home environment but none have used a genetically informed design, which can more directly assess the possibility of G x E.

2.6 Summary and aims of the present thesis

Overall, the existing evidence suggests that parents play a key role in creating the home environment, and various aspects of the home environment may play a role in childhood weight trajectories. Although previous research has provided insight into the role of the home environment, the current literature is limited in the following ways: (i) many studies have not reported the psychometric properties of their home environment measures, or provided limited information; (ii) few studies have focused on the preschool period, even though this is a time when the home environment may be particularly influential for establishing weight trajectories; (iii) few studies have taken into account the home environment as a whole, choosing instead to focus on a particular aspect or domain; and (iv) no studies have considered the role of genetic susceptibility to weight gain when examining associations between the home environment and weight. In addition, much of the existing research has taken place outside of the UK, where environments may differ.

The aims of this thesis are therefore as follows:

i. To develop a comprehensive measure of the home environment in early childhood, examine psychometric properties of the measure, and to create a composite score that reflects the overall obesogenic quality of the home environment, in addition to three separate composite scores for the home food, activity, and media domains.
ii. To examine the potential of a novel tool called 'SenseCam' to examine and validate aspects of the home environment.
iii. To identify family characteristics associated with the overall obesogenic quality of the home environment in early childhood.
iv. To examine associations between composite measures of the home environment and energy-balance behaviours in early childhood.
v. To examine associations between composite measures of the home environment and weight in early childhood.
vi. To investigate whether there is evidence for a gene-environment interaction in the context of the obesogenic home environment, using the twin design.

To achieve these aims, I use data from a UK population-based twin cohort called Gemini. The large sample size enables me to establish whether there is a reliable association between the home environment and weight; the young age of the sample enables me to examine potential associations at a time when the home environment is thought to be a particularly prominent influence on weight trajectories; and the twin design enables me to test the G x E hypothesis in the context of the obesogenic home environment. The Gemini sample and measures used in this thesis are described in the following chapter.

Chapter 3. Sampling and methodology

3.1 Overview of Gemini

Gemini is a population-based twin cohort study set up in 2007 by Professor Jane Wardle in the Department of Epidemiology and Public Health at University College London. The main aim of Gemini is to investigate genetic and environmental influences on childhood weight gain from birth, with a particular focus on infant appetite and the family environment. More specifically, the purpose of Gemini is as follows: '(i) to advance understanding of the genetic and environmental influences on weight gain, (ii) to identify modifiable determinants of excessive weight gain in early childhood, and (iii) to create a rich resource of data on early childhood exposures that can be used to assess the determinants of long-term health' (van Jaarsveld, Johnson, Llewellyn, & Wardle, 2010).

3.2 Sample and recruitment

All families with twins born in England and Wales between March and December 2007 (N = 6754) were contacted by the Office of National Statistics in January 2008 and asked whether they would consent to having their details sent to the Gemini research team. Data from the National Health Service Central Registry was used to verify that the mother and both twins were alive. There were 3435 families (51%) who agreed to be contacted; these families were sent a consent form and baseline questionnaires between February and April 2008. Of those contacted, 2402 (70%) returned completed consent forms and baseline questionnaires. The response rate of families was considered acceptable given that they had been approached when their twins were on average 8 months old and they were asked to complete two long questionnaires. Parents provided informed consent for their family to participate in the study and ethical approval was granted by the University College London Committee for the Ethics of non-National Health Service Human Research. The geographical distribution of participating families reflects the UK population density and the cohort is representative of national twin statistics for sex, zygosity, birth weight, and gestational age at birth (van Jaarsveld et al., 2010). **Table 3.1** shows characteristics of twins in the total Gemini sample compared to national statistics.

As shown in **Table 3.2**, mothers in the Gemini sample are somewhat older and have a lower BMI than the national population. There is an overrepresentation of white parents in Gemini, as in some other cohort studies (e.g. Atherton, Fuller, Shepherd, Strachan, & Power, 2008; Heath et al., 2002; Trouton, Spinath, & Plomin, 2002). Married or cohabiting couples are also overrepresented but this is perhaps expected as the target sample was families of young children while the national statistic refers to all adults aged 16 and over. Finally, mothers and fathers in the Gemini cohort have a higher education level when compared to the national population. Similarly, some differences for education level are expected as the national statistics include adults as young as 16 years of age.

Table 3.1. Baseline characteristics of twins in the total Gemini sample and National statistics[1] (% (n), unless stated otherwise)

	Total Gemini Sample (N = 4804 twins)	**National statistics**
Age (years), mean (SD)[2]	8.18 (2.18)	-
Gestational age (weeks), mean (SD)	36.20 (2.48)	37[4]
Birth weight (kg), mean (SD)	2.46 (0.54)	2.50[4]
Sex of twin pair		
Male	32.7 (785)	32.1[4]
Female	33.3 (801)	32.8
Opposite sex	34.0 (816)	35.1
Zygosity[3]		
MZM	14.7 (352)	-[5]
DZM	17.0 (409)	
MZF	16.5 (397)	
DZF	16.3 (391)	
DZO	34.0 (816)	
Unknown	1.5 (37)	

[1] 2006 national statistics are presented as the Gemini twins were born around this time.
[2] Twins' age at the time the baseline questionnaire was completed.
[3] MZM = monozygotic male twin pairs; DZM = dizygotic male twin pairs; MZF = monozygotic female twin pairs; DZF = dizygotic female twin pairs; DZO = dizygotic opposite sex twin pairs.
[4] Birth Statistics Series FM1 no.35 (Office for National Statistics, 2006a). Numbers are for twin births in 2006.
[5] No published ONS statistics for these variables.

Table 3.2. Baseline characteristics of parents in the total Gemini sample and National statistics[1] (% (n), unless stated otherwise)

	Total Gemini Sample (N = 2402 families)	**National statistics**
Age at twin's birth (years), mean (SD)		
Mother	32.95 (5.19)	29.5[2]
Father	35.73 (6.20)	-
BMI, mean (SD)		
Mother	25.10 (4.76)	26.9[3]
Father	26.38 (3.92)	27.2
Marital status		
Married or cohabiting	94.8 (2276)	77[4]
Divorced or separated	1.3 (31)	9
Single	3.9 (93)	11
Unknown	0.1 (2)	-
Mother's ethnicity		
White	92.9 (2231)	88.2[5]
Non-White	7.0 (169)	11.8
Unknown	0.1 (2)	-
Father's ethnicity		
White	87.5 (2101)	87.5[5]
Non-White	6.7 (162)	12.5
Unknown	5.8 (139)	-
Mother's education		
Low	21.6 (518)	32[6]
Intermediate	36.6 (878)	39
High	41.9 (1006)	28
Father's education		
Low	30.1 (722)	29[6]
Intermediate	30.9 (742)	43
High	33.8 (812)	28
Unknown	5.2 (126)	-
Household gross annual income		
<£15,000	8.4 (202)	[7]
£15,000 – £30,000	24.0 (577)	
£30,000 – £45,000	22.5 (539)	
£45,000 – £60,000	16.7 (401)	
£60,000 – £75,000	9.4 (226)	
>£75,000	15.4 (369)	
Unknown	3.7 (88)	-

[1] Where possible, 2008 national statistics are presented as demographic characteristics of Gemini parents were collected then.
[2] Characteristics of mother 1, England and Wales, 2008 (Office for National Statistics, 2009a).

[3] Health Survey for England, (2008a).
[4] General Lifestyle Survey (Office for National Statistics, 2008a). Statistics are based on families with dependent children.
[5] Population Estimates by Ethnic Group (Office for National Statistics, 2008b).
[6] Labour Force Survey (Office for National Statistics, 2006b). Statistics are based on males and females of working age (16-64 and 16-59, respectively). Education level categorised as: low (no qualifications or basic high-school education, intermediate (vocational or advanced high-school education), and high (university-level education).
[7] Although not equivalent, the Office for National Statistics, (2009b) presented household gross income by quintile group, which provides a useful comparison: lowest quintile = £7592 (p.a.), second quintile = £16120, third quintile = £27456, fourth quintile = £42952, highest quintile = £91364. Statistics are based on household members in Great Britain and Northern Ireland.

3.3 Data collection

All data in Gemini are parent reported, with the main method of data collection being questionnaires. Questionnaires are completed either online or by hand as a paper-based version. Measures that are developed or modified for use in the Gemini sample are piloted in parents of young children (singletons and twins). All other measures are based on validated questionnaires. DNA was collected from the twins when they were approximately 30 months old using self-administered cheek swabs. Height charts and Tanita digital weighing scales were sent to parents between March and May 2009 so they could continue to record their twins' heights and weights following the regular health checks that occur until one year of age.

Table 3.3 provides an overview of the measures and assessment points in Gemini. The current thesis uses data from the questionnaires administered when the twins were on average 8 months old, 15 months old, 24 months old, from the home environment interview (HEI) administered when the twins were on average 4 years old, and from the latest Gemini questionnaire at 5 years. The measures from the 8-month, 15-month, 24-month, and 5-year questionnaires that are used in the current thesis are described below; the full questionnaires are included in **Appendices 3.1 – 3.4**. The HEI is described in Chapter 4.

Parents were sent two baseline questionnaires when their twins were on average 8 months old; one focusing on the family; the other focusing on the twins. At 15 months, parents were sent one questionnaire that included further questions about their twins. At 24 months, parents were sent two questionnaires; one for the respondent to complete and one for their partner to complete, if applicable. Parents also received two questionnaires at 5 years (one focusing on the family and the other focusing on the twins).

3.3.1 Twin zygosity

To determine twin zygosity, parents were asked at baseline whether their twins were the opposite or same sex. Opposite-sex twins were classified as dizygotic (DZ). Parents of same-sex twins were asked to complete a 20-item validated zygosity questionnaire (Price et al., 2000). The questions assess the twins' physical likeness (e.g. 'are there differences in the colour of your twins' eyes?') and blood type, how easily friends and family members can tell the twins apart (e.g. 'when looking at a new photograph of your twins, can you tell them apart (without looking at their clothes or using any other clues)?') and the opinion of the parents and health professionals on the twins' zygosity (e.g. 'have you ever been told by a health professional (e.g. doctor, nurse, consultant) that your twins are identical or non-identical?') Zygosity was determined using three methods. First, twins with discordant blood types were classified as DZ. In other cases, specific questionnaire items with a high weighting were used to determine zygosity. For example, twins described as being as physically alike as 'two peas in a pod' could be classified as MZ, while those described as 'not looking much alike at all' could be classified as DZ. In cases where responses to the questionnaire items were conflicting, a third classification system was used. A total score was calculated by summing the responses to each item and dividing by the maximum possible score based on the number of questions answered. A total score of 0 represented maximal similarity; a total score of 1 represented maximal dissimilarity. Twin pairs with a total score ≤ 0.64 were classified as MZ; those with a total score ≥ 0.70 were classified as DZ. Twin pairs with a total score > 0.64 and < 0.70 were classified as having unknown zygosity, as instructed by Price and colleagues. Cases with missing data on 50% or more of the questionnaire items were also classified as having unknown zygosity.

The questionnaire has previously been validated against polymorphic DNA markers in 18 month old twins, with 95% agreement, and 96% agreement when the questionnaire was re-administered at 3 years of age (Price et al., 2000). To check the validity of the questionnaire in the Gemini sample, it was re-administered when the twins were around 3 years old, and all families were invited to provide DNA samples for their twins. DNA analysis was carried out on 81 randomly selected twin pairs (43 MZ twins; 38 DZ twins) at the Institute of Psychiatry, King's College London. There was 100% agreement between the questionnaires and DNA samples.

3.3.2 Anthropometrics

At baseline, parents were asked to provide the lengths, head circumferences, and weights of their twins at birth and around 6 weeks of age using their twins' health records. Parental heights and weights were also requested. Parents could report the height and weight measurements in metric or imperial units. Imperial units were converted to metric units for analyses. Parental body mass index (BMI) was calculated using the equation weight (kg) / height (m) ^{2}.

At 15 and 24 months, parents were asked to provide any length/height and weight measurements taken since the last point of contact, including the date they were taken, whether they were taken while the twins were lying down or standing up (15-month questionnaire only), and whether they were taken by a health professional or parent-reported.

Electronic weighing scales and height charts, along with instructions for their use, were sent to all families when the twins were 24 months old to collect parent-reported measurements at 3-month intervals. All families are sent a letter or email reminder shortly prior to each measurement interval. Families can provide their measurements online, by email, by post, or over the phone.

3.3.3 Age

At baseline, parents were asked to report their date of birth and that of their twins and partner, if applicable. Parental and twin age at the time of questionnaire completion was calculated using the parent's/twin's date of birth and the date of questionnaire completion. Parental age at the time of the twin's birth was calculated using the twin's date of birth and that of each parent.

3.3.4 Socioeconomic status

At baseline, parents were asked to report their highest education qualifications (response options: 'No qualifications', 'CSE, GCSE or O Level', 'Vocational qualification (GNVQ, BTEC)', 'A or AS Level', 'Higher National Certificate (HNC) or Diploma (HND)', 'Undergraduate degree', 'Postgraduate qualification (Masters, PhD)', 'Other, please describe'), their employment status (response options: 'On maternity leave' (if applicable), 'Full-time', 'Part-time', 'Unemployed', 'Stay at home to look after children') and job title, home ownership (response options: 'Own without mortgage', 'Own with mortgage', 'Rent privately', 'Rent from local authorities'), household gross annual income (response options ranged from 'Up to £15,000 per year' to 'More than £90,000 per year'), and the number of household bedrooms and cars. In this thesis, education level and household income were used as indicators of socioeconomic status (SES).

3.3.5 Household composition

At baseline, parents were asked to indicate their marital status ('married or cohabiting', 'divorced', 'widowed', 'separated', or 'single') and the number of other children living in the same home as their twins. This information was collected again in the HEI, when the twins were on average 4 years old.

3.3.6 Ethnicity

In the baseline questionnaire, parents were asked to report their ethnicity from 16 possible categories: 'White British', 'White Irish', 'Other White background', 'Caribbean', 'African', 'Other black background', 'Indian', 'Pakistani', 'Bangladeshi', 'Other Asian background', 'White and Black Caribbean', 'White and black African', 'White and Asian', 'Other mixed background', 'Chinese', 'Any other'. The categories were taken from the ONS's National Statistics interim standard classifications for presenting ethnic and national groups (Office for National Statistics, 2001).

3.3.7 Breastfeeding and solid food introduction

Breastfeeding duration was assessed using the following questions at baseline: 'Which feeding method did you use in the first 3 months' (response options: entirely breastfeeding, mostly breastfeeding with some bottle-feeding; equally breastfeeding and bottle-feeding; mostly bottle-feeding with some breastfeeding; almost entirely bottle-feeding; and entirely bottle-feeding); and 'If you are no longer breastfeeding, when did you stop' (response options: number of weeks after birth).

The age at which each twin first tried solid food was derived from responses to the baseline and 15-month questionnaires. Parents were asked whether their twins had tried each of a list of foods and, if so, the age at which they first tried them (in months). Where available, baseline responses to these questions were used. If responses were not available at baseline, responses provided at 15 months were used. This ensured that responses were given closer to the time of actual solid food introduction.

3.3.8 Parental feeding practices

At 15 months, parental feeding practices were assessed using adapted scales from several existing questionnaires. 'Encouragement to eat' (five items) e.g., 'I encourage my child to eat a wide variety of foods'; 'instrumental feeding' (four items) e.g. 'I reward my child with something to eat when he/she is well-behaved'; 'emotional feeding' (five items) e.g. 'I give my child something to eat to make him/her feel better when he/she is feeling upset'; and 'control' (five items) e.g. 'I decide how many snacks my child should have' were measured using items from the Parental Feeding Style Questionnaire (PFSQ) (Wardle et al., 2002). Modifications were made to the instrumental and emotional feeding scales to ensure they were appropriate for 15-month-old children. One item was removed from the instrumental feeding scale as it was considered unlikely that children of this age group would be able to understand action-consequence formulae sufficiently to have implications for their behaviour ('In order to get my child to behave him/herself I promise him/her something to eat'). For the emotional feeding scale, adjectives or phrases used to describe the child's mood state were adapted to be appropriate for 15-month-olds (the adapted adjectives or phrases are followed by the original versions in brackets): 'when s/he has hurt him/herself' ('when s/he has been hurt');

‘to occupy him/her, e.g. when in company, shopping, or travelling’ (‘if s/he is feeling bored’); ‘when s/he is grumpy’ (‘when s/he is feeling angry’); ‘when s/he is feeling irritable’ (‘when s/he is worried’). Each of the original scales have demonstrated adequate internal consistency (Cronbach’s $\alpha = 0.65 – 0.85$) and test-retest reliability (Pearson’s $r = 0.76 – 0.83$) (Wardle et al., 2002).

‘Pressure to eat’ (five items) e.g. ‘my child should always eat all of the food I give him/her’ and ‘monitoring’ (three items) e.g. ‘I keep track of the sugary foods that my child eats’ were measured using items from the Child Feeding Questionnaire (CFQ) (Birch et al., 2001). The factor structure of these subscales has been confirmed previously (C. B. Anderson, Hughes, Fisher, & Nicklas, 2005; Birch et al., 2001; Corsini, Danthiir, Kettler, & Wilson, 2008); and each factor has shown adequate internal consistency (Cronbach’s alpha = 0.70 for Pressure; 0.92 for monitoring (Birch et al., 2001)). The CFQ also assesses the feeding practice parental restriction; however, the measure is limited in several ways. First, there is evidence that restriction is a separate construct from using food as a reward for behaviour (Anderson et al., 2005; Corsini et al., 2008); second, the measure refers to restriction of the child’s favourite foods, which could be healthy or unhealthy; third, the measure does not capture portion sizes. Restriction was therefore assessed using a four-item scale designed to measure restricted access to, and portion sizes of, sugary and high-fat foods e.g. ‘I limit the portion sizes of high fat foods that I give to my child’.

‘Modelling’ was measured using the four-item modelling scale from the Comprehensive Feeding Practices Questionnaire (CFPQ) (Musher-Eizenman & Holub, 2007) e.g. ‘I model healthy eating for my child by eating healthy foods myself’. The factor structure and internal consistency of the modelling scale has been demonstrated previously (Cronbach’s alphas = 0.77, 0.80, and 0.84 in separate samples) (Musher-Eizenman & Holub, 2007). ‘Covert restriction’ was measured using a four-item scale adapted from that developed by Ogden and Colleagues, which demonstrated factorial validity (Ogden et al., 2006). Two items (‘I avoid buying sweets and crisps and bringing them into the house’ and ‘I avoid buying biscuits and cakes and bringing them into the house’) were combined into one (‘I avoid buying unhealthy foods and bringing them into the house’) to shorten the scale. One item was added to the scale to capture an additional behaviour considered to relate to covert control ('I ask other people not to feed my child unhealthy foods').

Parental feeding practices were assessed again in the latest Gemini questionnaire (T7), when the twins were on average 5 years old. The items per scale were the same as those included in the 15-month questionnaire, but without the modifications that were made to accommodate the younger age of the children at 15 months.

All parental feeding items were scored on a 5-point scale (1 = never; 5 = always), except for restriction, which was measured on a 7-point scale (1 = not at all; 7 = strictly). A mean score was calculated for each scale, with higher scores indicating higher levels of the particular feeding practice. The internal consistency of each parental feeding scale (for the study sample) is reported in Chapter 4.

3.3.9 Parental eating traits

The 24-month questionnaire included a slightly shorter version of the Dutch Eating Behaviour Questionnaire (DEBQ) (van Strien, Frijters, Bergers, & Defares, 1986) to assess the eating traits of each parent. This shortened version has five items per subscale, each of which has correlated highly (all r's > 0.90) with the corresponding full scales using data from the National Diet and Nutrition Survey (NDNS) and the Twins Early Development Study (TEDS) (unpublished findings). The restraint subscale assesses the extent to which the individual restricts their food intake (e.g. 'how often do you refuse food or drink because you are concerned about your weight?'); the emotional eating subscale assesses the extent of eating in response to arousal states, such as anger or anxiety (e.g. 'do you have a desire to eat when you are feeling lonely?'); and the external eating subscale assesses the extent of eating in response to food-related stimuli regardless of the individual's internal state of hunger or satiety. The factorial validity and internal consistency has been established in previous research (van Strien et al., 1986; Wardle, 1987). The internal consistency of each subscale (for the study sample) is reported in Chapter 6.

3.3.10 Parental happiness

Parental global well-being was assessed in the 24-month questionnaire using the Subjective Happiness Scale (Lyubomirsky & Lepper, 1999). The scale includes four items, each measured on a 7-point scale (e.g. 'in general, I consider myself a happy person' (response options: 1 = not a very happy person; 7 = a very happy person)) and has demonstrated excellent psychometric properties (Lyubomirsky & Lepper, 1999). The internal consistency of the scale (for the study sample) is reported in Chapter 6.

Table 3.3. Overview of the measures and assessment points in Gemini (adapted from van Jaarsveld et al., 2010)

	Child age in months (measurement point)							
	8 (T0)	**15 (T1)**	**20 (T2)**	**24 (T3)**	**30 (T4)**	**36 (T5)**	**48 (T6)**	**60 (T7)**
Child variables								
Anthropometrics	X	X		X		X	X	X
Appetite	X	X						X
Food preferences, sensory experiences		X				X		
Activity behaviour	X	X					X	X
Activity preferences							X	
TV watching		X					X	X
Sleep behaviour		X					X	X
Birth complications/illnesses/medical conditions	X	X		X				X
Introduction of solid foods	X	X						
3-day diet diary			X					
Temperament								X
DNA collection using cheek swab					X			
Family variables								
Parental feeding style	X	X						X
Demographics, anthropometrics, health behaviours of both parents	X			X				X
Parental eating behaviour				X				
Parental activity behaviour				X				
Parental sleep behaviour								X
Parental diet								X
Parental illnesses/medical conditions	X							X
Environmental confusion/'chaos'								X
Home environment							X	

Chapter 4. Development of the Home Environment Interview (HEI)

4.1 Background

The literature review in Chapter 2 indicated that multiple aspects of the home environment may be implicated in childhood weight trajectories. However, most studies have tended to focus on one or two factors in isolation and there are few comprehensive, psychometrically tested measures of the home environment. Moreover, although various aspects of the home environment may influence child weight, evidence suggests that existing effects are small (they only account for a small proportion of variance in weight). It is possible that effects may be better detected when considering various aspects of the home environment together, as a composite score.

4.2 Aim

The aim of this study was as follows: (i) to develop a comprehensive measure of the home environment, (ii) to assess test-retest reliability of the measure, and (iii) to develop a composite scoring procedure that would quantify the overall level of obesogenic risk in the home environment. There are two sections in this chapter. The first describes the variables included in the HEI, data collection procedures, and the descriptive statistics for and test-retest reliability of the individual variables. The second section describes the development of the home environment composite scores.

4.3 Part 1: variables included in the HEI

4.3.1 Selection of survey

The Healthy Home Survey (HHS) (Bryant et al., 2008) was selected as a basis for the Gemini home environment measure. A review of the literature identified the HHS as the most comprehensive existing measure that had undergone psychometric testing. The HHS demonstrated generally moderate to high reliability and validity, and had already been carried out with parents of preschool children in the general population. It was designed to be conducted as a telephone interview rather than a paper-based questionnaire, which was considered suitable for the Gemini study. Piloting showed that the interview was quicker to complete when administered by telephone rather than a paper questionnaire. The interview was 44 pages when printed, which may have overwhelmed participants and reduced response rates. Moreover, it is possible that participants completing a paper version would not have completed it in one sitting due to its length, which was important as some questions needed to be answered in one sitting. Data were entered online, directly into the database, which meant manual data entry was not needed, a particular advantage given the large sample size. There were virtually no missing values; paper-based questionnaires tend to have more (Feveile, Olsen, & Hogh, 2007; Harris, Weinberger, & Tierney, 1997), which could compromise the meaning of composite scores. Finally, a telephone interview allowed verbal contact with participants; prior to that all data collection had been by paper-based questionnaires. The interviewers could respond immediately to any queries or ambiguity around the HEI, as well as other queries about the Gemini study in general, which parents appreciated.

4.3.2 Adaptation of the HHS

Adaptation of the HHS was informed by discussion with the researchers who developed the survey. Several amendments were made to the HHS; these are detailed below, along with descriptions of the unchanged measures.

4.3.2.1 Home environment measures

The full HEI is included in **Appendix 4.1**.

4.3.2.1.1 Food availability

Food availability was assessed in terms of presence (e.g. ‘do you have any fresh fruit in your home now?’) and variety (e.g. ‘what types of fresh fruit do you have in your home now?’). The questions on variety were open-ended; prompts were used to ensure participants answered as accurately as possible (e.g. ‘Have you remembered fresh fruit in your fridge, in a fruit bowl, and in your cupboards?’) Interviewers referred to pre-defined lists of foods to confirm the relevance of participants’ responses to each food category (see **Appendix 4.2** for food lists). As in the HHS, the HEI assessed the availability of fruit (fresh, tinned, dried, and frozen), vegetables (fresh, tinned, and frozen), savoury snacks, sweet snacks, confectionery, and sugar-sweetened drinks. Additionally, the HEI included questions on the availability of other non-alcoholic drinks in the home, such as milk, fruit juice and sugar-free (or artificially-sweetened) drinks. Questions on the quantity of food and drink in the home were not included in the HEI because it is difficult to accurately complete a food inventory by telephone.

4.3.2.1.2 Food accessibility

The HHS assessed the physical accessibility of savoury snacks, sweet snacks, confectionery, and sugar-sweetened drinks (e.g. ‘would it be possible for your twins to get any confectionery by themselves, without your help?’). To distinguish between families who had some form of restriction on their child’s food and drink access and those who had no restrictions, the HEI also assessed whether the child was allowed access to food and drink (e.g. ‘are your twins allowed to get any confectionery by themselves, without asking you first?’). While the HHS only assessed the accessibility of sweet snacks, savoury snacks, confectionery, and sugar-sweetened drinks, the HEI included questions on the accessibility of fruit and vegetables and all non-alcoholic drinks.

4.3.2.1.3 Family meals

The HHS assessed mealtime structure for breakfast but not for other meals. To assess mealtime structure for all meals, parents who completed the HEI were asked how many days per week their twins ate breakfast, lunch, dinner and snacks at home, and how many days per week their twins ate each meal as a family. ‘As a family’ was defined as occasions where at least one parent was eating with the twins; presence of older siblings or other adults, such as nannies, were not included. The mean number of days the twins ate breakfast, lunch and dinner as a family was calculated to indicate overall level of family meal consumption.

4.3.2.1.4 Parental feeding practices

The HHS included items to assess parental modelling of food intake, restriction, pressure, and instrumental feeding. Parental feeding practices have been extensively examined at other time points in the Gemini study; therefore the HEI did not include the shorter feeding items from the HHS. Parental feeding practice data were taken from the five-year Gemini questionnaire, where available, as this was closest to the time of the HEI. If data were unavailable at 5 years, scale scores were taken from the 15-month Gemini questionnaire.

4.3.2.1.5 Availability of physical activity facilities

Parents were asked whether they had a garden or outdoor space, how big they perceived their garden or outdoor space to be (response options: small, medium, large), whether they had any usable play equipment in their garden, such as swings and climbing frames, and whether their twins had a usable tricycle, bike, scooter, or wheeled toy. To assess parental limits on physical activity, parents were asked how often their twins were allowed to play actively in the garden or outdoor space and inside the home (response options: 1 = never; 5 = all of the time). ‘Actively’ or ‘active play’ was defined as anything that involves physically moving about during playing such as running, jumping, or climbing on things.

Parents were asked whether there were any parks/outdoor recreation areas and indoor recreation centres (such as a gym or indoor soft play) close to their home. ‘Close’ was defined as what parents believed to be within a reasonable walking distance or short drive away from their home so as not to constrain their perception of accessible facilities.

The HEI also included an adapted version of the Neighbourhood Satisfaction Scale (NSS) (Saelens, Sallis, Black, & Chen, 2003; Zaleski, Sallis, Saelens, & Black, 2003) to give a global index of parents’ satisfaction with the neighbourhood that their twins were growing up in. Unlike other measures of neighbourhood satisfaction, the NSS captures the multidimensional nature of neighbourhood satisfaction and has shown good to acceptable psychometric performance (Saelens et al., 2003; Zaleski et al., 2003). The original NSS includes 18 items that assess satisfaction with various aspects of the physical and social neighbourhood environment; the mean scale score is used as an indicator of global neighbourhood satisfaction. The HEI included 12 items that incorporated satisfaction with safety, walkability, access to destinations, and the level of traffic in the neighbourhood. As previously suggested, participants answered the questions using their perception of their neighbourhood, rather than a pre-defined area (Walton et al., 2008). This subjective approach allowed participants to answer the questions without making them consider a definition of neighbourhood that may be narrower or wider than their own conception. Items were measured on a 5-point scale (1 = strongly dissatisfied; 5 = strongly satisfied).

4.3.2.1.6 Parental modelling and support of physical activity

To build on the HHS, the HEI included a measure of parental support of physical activity, a five-item scale that has been extensively used in previous research and has shown good test-retest reliability (Trost et al., 2003). Parental modelling of physical activity was measured with three questions, used during the assessment of the Change for Life (C4L) campaign. These questions demonstrated adequate test-retest reliability during pilot testing (Croker et al, unpublished). Each question was framed to include the partner (if applicable) e.g. ‘How often do you or your partner do physical activity or play sports with your twins?’ Items were scored on a 5-point scale (1 = never; 5 = very often) and mean scale scores were calculated.

4.3.2.1.7 Availability of media equipment

Parents were asked about the number of working TVs, VCR/DVD players, computers or laptops, and games consoles in the home, and whether they had cable or satellite TV.

4.3.2.1.8 Accessibility of media equipment

To assess the physical accessibility of media equipment, parents were asked whether their twins had a working TV, computer/laptop or games console in their bedroom. Parental rules around media use were assessed using the question: ‘Do you have any rules around TV or computer use for your twins?’

4.3.2.1.9 Parental modelling of sedentary behaviour

Questions on maternal and partner (where applicable) TV viewing were used to assess parental modelling of sedentary behaviour. The questions were adapted from those used by Anderson and colleagues (Anderson, Field, Collins, Lorch, & Nathan, 1985), and previously correlated well with viewing diaries (r = 0.60), which reflected the actual viewing time of 5-year-olds (D. R. Anderson et al., 1985). Weekend and weekday TV viewing were included e.g. ‘On average, how long do you watch TV during the following times of a typical weekday (Monday to Friday) at this time of year?’ Each time of day (morning (6 am to 12 noon; afternoon (12 noon to 6 pm); evening (6 pm to midnight)) was read aloud. Responses were recorded in hours and minutes. Maternal and partner weekly TV viewing were calculated (the total number of hours spent watching TV in an average week).

4.3.2.1.10 Eating while watching TV

As in the HHS, parents were asked how often their twins ate each meal (breakfast, lunch, and dinner) and snacks while watching TV e.g. ‘How many days per week do your twins eat breakfast while watching TV?’ Response options: 0 – 7 days per week. The mean number of days each twin ate a meal or snack while watching the TV was calculated to represent overall level of eating while watching TV.

4.3.2.2 Additional questions

4.3.2.2.1 General information

Parental demographic information had been collected at baseline and was to be collected again in the follow-up 5-year Gemini questionnaire. Questions on the current home address, whether the parent was living with a partner, and the number of children in the home were included in the HEI.

4.3.2.2.2 Household shopping

As in the HHS, the HEI asked parents how frequently they shopped for food, whether the last shop they completed was small or big, and how many days it had been since they last shopped for food. For each food category, parents were also asked how typical the amount they had in their home was (e.g. ‘Would you say that the amount of fruit you have in your home now is more than usual, less than usual, or about the same?’) These factors were taken into account when assessing the reliability of food availability variables in the HEI.

4.3.3 Formatting

Changes were also made to the wording and format of questions in the HHS so they were consistent with the Gemini project. For example, each question was adapted to include each twin. Some questions were framed for both twins (e.g. ‘on average, how often do you encourage your twins to do physical activity?’) and some questions were asked separately for each twin (e.g. ‘do you think your first born twin gets enough physical activity?’). Where the questions were framed to include both twins, prompts were used at the end of these questions to ensure parents were not mistakenly giving one response for both twins (i.e. ‘is that for your first born twin, your second born, or both?). The language used in the HHS was also adapted to make it UK specific. For example, the word ‘yard’ was replaced with ‘garden’, and ‘candy’ with ‘confectionery’.

4.3.4 Recruitment

Data collection for the HEI began in October 2010 and ended in March 2012. Participants were informed about the upcoming HEI in the preceding Gemini questionnaire, sent when the twins were 3 – 4 years old. At the time of the preceding questionnaire, telephone numbers were available for only 30% of the total Gemini sample, therefore participants were asked to provide this information. In total, 1337 participants completed the questionnaire; and only 7 participants did not provide a telephone number. Therefore, at the time of the HEI, telephone numbers were available for approximately 60% of the total Gemini sample. All participants who were contactable by telephone were contacted. In cases where the telephone number was out of use or the participant had moved, an email or letter was sent asking for an updated number. An email was sent if a working address was available, otherwise a letter was sent. Of those participants contacted, 14 did not want to complete the telephone interview and 14 withdrew from the Gemini study.

4.3.4.1 Procedures

The HEI was administered as a computer-assisted telephone interview. The number of call attempts before interview completion and interview duration was recorded (mean interview duration = 36 minutes; SD = 6.8; range = 25 – 60 minutes). Participants completed the interview while at home and were prompted to check their food stores to ensure accurate responding. At the end of the interview, parents were asked to provide the most recent height and weight measurements for their twins taken using the Gemini growth chart and weighing scales. If there were no recent measurements, parents were asked to measure and weigh their twins at the time of the interview or to provide some after the interview. Parents were reminded that they could provide the measurements by email, letter, telephone, or enter them online using the Gemini website. New growth charts and scales were sent to parents if needed. Data were collected by a team of 3 researchers (SS, LM, and AR)[1], who were trained to administer the telephone interview.

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[1] SS developed the HEI and carried out the data collection with LM and AR.

A convenience sample of 44 mothers completed a second telephone interview 7 – 19 days (mean = 9.6, SD = 3.4) after the first interview to assess test-retest reliability of the measure. All but one of the 45 families asked to complete a second interview did so. Data from the first interview were used in the analyses.

4.3.4.2 Statistical analysis

4.3.4.2.1 Sample characteristics

To check for response bias, baseline characteristics of families who completed the HEI were compared to those of the total baseline Gemini sample. Independent t-tests were used for continuous dependent variables; chi-square tests were used for categorical dependent variables. Characteristics of families who completed the test-retest were also compared to those of the total HEI sample.

4.3.4.2.2 Creation of summary variables

Analyses were performed using SPSS version 18.0 and Stata version 11.0. To control for clustering, one twin from each family was selected at random to be included in the analyses. Scale scores were calculated for each parental feeding practice (restriction, instrumental feeding, emotional feeding, covert restriction, pressure, control, monitoring, and encouragement), parental modelling and support of physical activity, and neighbourhood satisfaction, which have pre-existing scoring procedures. Summary scores were also calculated to create the total number of fruit types in the home (the sum of fresh, dried, tinned, and frozen fruits), the total number of vegetable types in the home (the sum of fresh, tinned, and frozen vegetables), the total number of energy-dense snack types in the home (the sum of savoury snacks, sweet snacks, and confectionery items), whether there were any energy-dense snacks displayed in the open, the child’s access to energy-dense snacks (whether they were allowed access to savoury snacks, sweet snacks, or confectionery), meals eaten at a table as a family (the mean number of days per week the child eats breakfast, lunch, and dinner at a table as a family), the number of media equipment in the home (the sum of TVs, DVD/VCR players, games consoles, and the presence of satellite TV), and eating while watching TV (the mean number of days per week the child eats breakfast, lunch, dinner, and snacks while watching TV). Descriptive statistics (means (SDs) for continuous variables; % (N) for categorical variables) were calculated for the HEI variables (individual-item and summary variables).

4.3.4.2.3 Reliability

Cronbach's alpha was used to measure the internal consistency of established scales; values ≥ 0.70 were considered acceptable (Cronbach, 1951). Percent agreement, Kappa statistics, and proportion of positive and negative agreement were used to assess test-retest reliability of categorical items. Single measure Intraclass correlation coefficients (ICC) were used to assess test-retest reliability of continuous items. As recommended, Kappa coefficients were defined as: 0.00 – 0.20 = slight, 0.21 – 0.40 = fair, 0.41 – 0.60 = moderate, 0.61 – 0.80 = substantial and 0.81 – 1.00 = almost perfect (Landis & Koch, 1977); ICC values were categorised as: <0.40 = poor, 0.40 – 0.75 = fair to good agreement and >0.75 = excellent (Fleiss, 1986). Weighted Kappa was used for items with more than two ordered response options (Fleiss & Cohen, 1973). As Kappa values are affected by the proportion of responses in each item category, items with Kappa > 0.6 and/or percent agreement ≥ 60% were considered to have acceptable reliability. The proportion of positive and negative agreement were calculated to distinguish between the proportion of agreement for 'yes' responses and the proportion of agreement for 'no' responses across the two assessment points. Agreement for 'yes' responses could be high but the chance of participants responding 'no' at test and retest could be lower (or vice versa); this could be obscured by single estimates such as Kappa.

4.3.5 Results

4.3.5.1 Sample characteristics

In total, 1119 participants in the Gemini study completed the HEI. Due to technical difficulty, 6 participants had incomplete data, which were excluded from analyses, leaving a total of 1113 participants (46% of the total Gemini sample). Almost all participants (97%) were mothers of the twins, 3% were fathers of the twins, and one participant was the nanny. All participants were main caregivers of the twins and were in a position to answer questions about the home environment. Socio demographic characteristics of families who completed the HEI and those who completed test-retest are shown in **Table 4.1**; characteristics of twins in the total HEI sample are shown in **Table 4.2**.

Mothers of families who completed the HEI were on average 34 years old when their twins were born, while fathers had an average age of 36 years. Mothers had a mean BMI of 24.84; the upper end of the range for normal weight status. Fathers had a mean BMI of 26.29; just above the range for normal weight status. Most parents were married or cohabiting (97%), 2% were single, and 1% were divorced or separated. Most mothers (95%) and fathers (92%) were white; 4% of fathers had unknown ethnicity. Almost half (48%) of mothers and 40% of fathers had a high education level; 44% of mothers and just over half (53%) of fathers were in higher professional or managerial occupations.

Twins were on average 4 years old when their parents completed the HEI. More than two-thirds (69%) were same sex twin-pairs; 31% were opposite sex twin-pairs. The mean gestational age at birth was 36.22 weeks and the mean birth weight was 2.46 kg, as expected for a twin population. Around a third (34%) were identical (MZ) twins; 65% were non-identical (DZ) twins; 1% had unknown zygosity.

Compared to the total Gemini sample, mothers and fathers of families who completed the HEI were significantly older ($t(3505) = -4.939$, $p < 0.001$ and $t(3305) = -2.637$, $p = 0.03$, respectively), had a higher education level (48% vs. 42% university educated mothers; 41% vs. 36% university educated fathers) ($\chi^2(2) = 21.08$, $p < 0.001$ and $\chi^2(1) = 11.07$, $p = 0.004$, respectively), and fewer were non-white (5% vs. 7% non-white mothers; 4% vs. 7% non-white fathers) ($\chi^2(1) = 4.22$, $p = 0.04$ and $\chi^2(1) = 10.00$, $p = 0.002$, respectively). There were no significant differences when comparing the BMI of mothers ($t(3432) = 1.545$, $p = 0.122$) and fathers ($t(3171) = 0.582$, $p = 0.560$) in completing families to the BMI of mothers and fathers in the total Gemini sample.

These findings are generally expected as age, ethnicity, and education level are characteristics associated with on-going participation in cohort studies (Tambs et al., 2009; Young, Powers, & Bell, 2006).

Mothers from families who completed test-retest had a significantly higher BMI than that of the total HEI sample ($t(1138) = -2.426$, $p = 0.015$). There was no significant difference between the BMI of fathers in families who completed test-retest and the BMI of the total HEI sample ($t(1067) = 0.354$, $p = 0.724$). There were no significant differences between the age of mothers and fathers who completed test-retest and the age of mothers and fathers in the total HEI sample ($t(1153) = -1.387$, $p = 0.166$ and $t(1103) = -1.335$, $p = 0.182$ respectively). The proportions of white and non-white mothers and fathers did not significantly differ between families who completed test-retest and the total HEI sample ($\chi^2(1) = 0.755$, $p = 0.385$ and $\chi^2(1) = 1.936$, $p = 0.164$, respectively). Similarly, there were no significant differences between the samples in terms of maternal and paternal education level ($\chi^2(2) = 2.464$, $p = 0.292$ and $\chi^2(1) = 1.63$, $p = 0.449$, respectively).

Table 4.1. Characteristics of families in the total Gemini sample compared to those who completed the HEI and those who completed test-retest (% (n), unless stated otherwise)

	Total Gemini sample (N = 2402)	HEI sample (N = 1113)	Test-retest sample (N = 44)
Age at twin's birth (years), mean (SD)[1]			
Maternal	32.95 (5.19)	33.86 (4.75)	34.86 (4.24)
Paternal	35.73 (6.20)	36.32 (5.80)	37.52 (5.28)
BMI, mean (SD)[2]			
Maternal	25.10 (4.76)	24.84 (4.58)	26.58 (6.49)
Paternal	26.38 (3.92)	26.29 (3.75)	26.09 (3.52)
Marital status			
Married or cohabiting	94.8 (2276)	96.5 (1074)	97.7 (43)
Divorced or separated	1.3 (31)	1.0 (11)	2.3 (1)
Single	3.9 (93)	2.4 (27)	0
Unknown	0.1 (2)	0.1 (1)	-
Maternal ethnicity			
White	92.9 (2231)	94.8 (1055)	97.7 (43)
Non-White	7.0 (169)	5.2 (58)	2.3 (1)
Unknown	0.1 (2)	-	-
Paternal ethnicity			
White	87.5 (2101)	91.6 (1020)	97.7 (43)
Non-White	6.7 (162)	4.1 (46)	2.3 (1)
Unknown	5.8 (139)	4.2 (47)	-
Maternal education level			
Low	21.6 (518)	15.5 (173)	20.5 (9)
Intermediate	36.6 (878)	36.2 (403)	43.2 (19)
High	41.9 (1006)	48.2 (537)	36.4 (16)
Paternal education level			
Low	30.1 (722)	26.7 (297)	34.1 (15)
Intermediate	30.9 (742)	29.8 (332)	31.8 (14)
High	33.8 (812)	40.0 (445)	31.8 (14)
Unknown	5.2 (126)	3.5 (39)	2.3 (1)
Household gross annual income			
<£15,000	8.4 (202)	4.9 (55)	2.3 (1)
£15,000 – £30,000	24.0 (577)	21.4 (239)	27.3 (12)
£30,000 – £45,000	22.5 (539)	23.0 (256)	20.5 (9)
£45,000 – £60,000	16.7 (401)	19.3 (214)	11.3 (5)
£60,000 – £75,000	9.4 (226)	10.6 (118)	18.2 (8)
>£75,000	15.4 (369)	17.8 (197)	20.5 (9)
Unknown	3.7 (88)	3.1 (34)	-

Education level categorised as: low (no qualifications or basic high-school education, intermediate (vocational or advanced high-school education), and high (university-level education).
[1] Data were missing for 1% (n = 2) of mothers and 5% (n = 51) of fathers.
[2] Data were missing for 2% (n = 17) of mothers and 5% (n = 86) of fathers.

Table 4.2. Characteristics of twins from families who completed the HEI compared to the total Gemini sample (% (n), unless stated otherwise)

	Total Gemini sample (N = 4804)	**HEI sample (N = 2226)**
Age (years), mean (SD)[1]	-	4.17 (0.40)
Gestational (weeks), mean (SD)	36.20 (2.48)	36.22 (2.54)
Birth weight (kg), mean (SD)	2.46 (0.54)	2.46 (0.54)
Sex of twin pair		
Male	32.7 (785)	33.7 (750)
Female	33.3 (801)	35.0 (778)
Opposite sex	34.0 (816)	31.4 (698)
Zygosity		
MZM	14.7 (352)	16.1 (358)
DZM	17.0 (409)	17.1 (380)
MZF	16.5 (397)	17.6 (392)
DZF	16.3 (391)	16.8 (374)
DZO	34.0 (816)	31.4 (698)
Unknown	1.5 (37)	1.1 (24)

[1] Twins' age at time of interview completion.

4.3.5.2 Test-retest reliability

4.3.5.2.1 Home food environment variables

Results for the test-retest reliability of home food environment variables are shown in **Table 4.3**. For food availability (yes/no), percent agreement was high for all items (79.5 – 100%). Kappa scores were more variable (0.39 – 0.76), but generally moderate to substantial, with the lowest score for fruit juice and the highest score for sugar-free drinks. Kappa could not be calculated for fresh fruit availability due to cell counts equalling zero. Specifically, at the first measurement point (T1), all but one person said that fresh fruit was available, while at test-retest (T2), everyone said that fresh fruit was available. Kappa scores were not calculated for milk, dried fruit, and sweet snacks availability as these variables had 100% agreement. The proportion of positive agreement ranged from 0.76 to 0.99, while the proportion of negative agreement ranged from 0.00 to 0.93. For food and drink variety, ICCs ranged from 0.47 to 0.92, with the lowest scores for variety of sweet and savoury snacks, and the highest score for frozen vegetables. For total snack variety, the ICC was higher (0.66 (0.45 – 0.80)).

As the ICCs for savoury and sweet snack variety were low, the data were split into those who reported that the amount of snacks (savoury or sweet) they had in their home was consistent across T1 and T2 i.e. less, the same, or more than usual on both occasions, and those who reported that the amount of snacks they had in their home was different across T1 and T2 e.g. parents may have said that they had the same amount as usual at T1 but more at T2. For savoury snacks, 34 parents (77%) said that they had the same amounts of savoury snacks in their home at T1 and T2, while 10 parents (23%) said that they had different amounts of sweet snacks across time points. The ICC for those who reported the same amounts of savoury snacks across time points was slightly higher than the ICC for the total sample (0.65 (0.40 – 0.81) vs. 0.47 (0.21 – 0.61). For sweet snacks, 26 parents (59%) reported that they had the same amounts of sweet snacks in their home at T1 and T2, while 18 parents (41%) said that they had different amounts of sweet snacks at T1 and T2. The ICC for those who reported the same amounts of sweet snacks across time points was slightly higher than the ICC for the total sample (0.58 (0.26 – 0.79) vs. 0.47 (0.21 – 0.68); the confidence intervals were still wide.

Percent agreement for the display of food and drinks was high for all items (77.3 – 100%). Again, Kappa scores were more variable (0.29 – 0.85), with the lowest score for the display of sugar-sweetened drinks and the highest score for the display of sweet snacks. Kappa could not be calculated for the display of fruit due to empty cells. Specifically, all but one parent said that fruit was displayed at T1, while everyone said that fruit was displayed at T2. The proportion of positive agreement ranged from 0.33 to 0.86, while the proportion of negative agreement ranged from 0.81 to 0.99. Kappa was not calculated for the display of fruit juice and milk as percent agreement was 100% for these variables. Lower Kappa scores, but high percent agreement, were noted for sugar-sweetened drinks and confectionery. These findings were due to most responses to these variables being no and, where there were yes responses, these were generally not consistent across T1 and T2. The proportion of positive agreement was lowest for these variables (0.33).

For the physical accessibility of food and drink, percent agreement was generally high (70.5 – 95.5%). Kappa scores ranged from 0.33 to 0.73 but were generally at least moderate. Kappa could not be calculated for the physical accessibility of sugar-sweetened drinks due to some empty cells. Specifically, at T1, all parents said their child could not physically access sugar-sweetened drinks, while at T2 two parents said their child could physically access sugar-sweetened drinks. The proportion of positive agreement ranged from 0.00 to 0.96; the proportion of negative agreement ranged from 0.67 to 0.98.

Variables assessing whether the child was allowed access to food and drink generally had high percent agreement (73.7 – 100%); Kappa ranged from 0.29 to 0.85, with the lowest score for whether the child was allowed access to sugar-free drinks and the highest score for savoury snacks. Sugar-free drinks access had high percent agreement but a low Kappa score due to most parents responding no and little consistency between T1 and T2 when parents responded yes. Kappa scores were not calculated for confectionery and sugar-sweetened drinks as these had 100% agreement. The proportion of positive agreement ranged from 0.33 (for sugar-free drinks) to 0.86; the proportion of negative agreement ranged from 0.50 to 0.95.

Internal consistency was high for parental restriction (0.87), emotional feeding (0.80), and modelling (0.78); acceptable for covert restriction (0.69), monitoring (0.67), and instrumental feeding (0.67); and slightly lower for pressure (0.64), control (0.63), and encouragement (0.58).

Table 4.3. Single measure Intraclass correlation coefficients (and 95% confidence intervals), percent agreement, Kappa values (and 95% confidence intervals), proportion of positive agreement, and proportion of negative agreement for home food environment variables

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)	Ppos	Pneg
Availability (Yes/No)					
Fresh fruit	-	97.7	+	0.99	0.00
Tinned fruit	-	86.4	0.71 (0.52 – 0.90)	0.89	0.82
Dried fruit	-	100	-	-	-
Frozen fruit	-	88.6	0.69 (0.41 – 0.97)	0.76	0.93
Fresh vegetables	-	95.5	0.48 (-0.18 – 1.14)	0.98	0.50
Tinned vegetables	-	81.8	0.40 (0.03 – 0.76)	0.89	0.50
Frozen vegetables	-	97.7	0.66 (-0.06 – 1.38)	0.99	0.67
Savoury snacks	-	93.2	0.73 (0.47 – 1.00)	0.96	0.77
Sweet snacks	-	100	-	-	-
Confectionery	-	86.4	0.54 (0.22 – 0.87)	0.92	0.63
Sugar sweetened drinks	-	79.5	0.58 (0.34 – 0.83)	0.76	0.82
Sugar-free drinks	-	90.9	0.76 (0.55 – 0.97)	0.94	0.82
Fruit juice	-	81.8	0.39 (0.06 – 0.73)	0.89	0.50
Milk	-	100	-	-	-
Variety					

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)	Ppos	Pneg
Total fruit	0.83 (0.71 – 0.90)	-	-	-	-
Fresh fruit	0.70 (0.51 – 0.82)	-	-	-	-
Tinned fruit	0.70 (0.51 – 0.82)	-	-	-	-
Dried fruit	0.80 (0.66 – 0.87)	-	-	-	-
Frozen fruit	0.86 (0.76 – 0.92)	-	-	-	-
Total vegetables	0.76 (0.59 – 0.86)	-	-	-	-
Fresh vegetables	0.72 (0.54 – 0.84)	-	-	-	-
Tinned vegetables	0.72 (0.54 – 0.84)	-	-	-	-
Frozen vegetables	0.92 (0.85 – 0.95)	-	-	-	-
Total snacks	0.66 (0.45 – 0.80)	-	-	-	-
Savoury snacks	0.47 (0.21 – 0.67)	-	-	-	-
Sweet snacks	0.47 (0.21 – 0.68)	-	-	-	-
Confectionery	0.72 (0.54 – 0.84)	-	-	-	-
Total drinks	0.81 (0.67 – 0.89)	-	-	-	-
Sugar sweetened drinks	0.61 (0.38 – 0.76)	-	-	-	-
Sugar free drinks	0.68 (0.49 – 0.81)	-	-	-	-
Fruit Juice[1]	-	-	-	-	-
Milk[2]	0.79 (0.65 – 0.88)	-	-	-	-

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)	Ppos	Pneg
Displayed (Yes/No)					
Any fruit	-	97.7	+	0.99	0.00
Any vegetables	-	77.3	0.52 (0.28 – 0.77)	0.71	0.81
Any snacks	-	84.1	0.51 (0.22 – 0.80)	0.59	0.90
Savoury snacks	-	93.2	0.54 (0.05 – 1.02)	0.57	0.96
Sweet snacks	-	97.7	0.85 (0.50 – 1.19)	0.86	0.99
Confectionery	-	90.9	0.31 (-0.23 – 0.84)	0.33	0.95
Any drinks	-	79.5	0.53 (0.27 – 0.78)	0.67	0.85
Sugar sweetened drinks	-	90.9	0.29 (-0.25 – 0.83)	0.33	0.95
Sugar free drinks	-	79.5	0.41 (0.08 – 0.74)	0.53	0.87
Fruit juice	-	100	-	-	-
Milk	-	100	-	-	-
Physically accessible (Yes/No)					
Any fruit	-	93.2	0.73 (0.39 – 1.06)	0.96	0.67
Any vegetables	-	84.1	0.68 (0.47 – 0.89)	0.84	0.84
Any snacks		75.0	0.48 (0.20 – 0.76)	0.79	0.69
Savoury snacks	-	81.8	0.62 (0.36 – 0.88)	0.78	0.85

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)	Ppos	Pneg
Sweet snacks	-	75.0	0.49 (0.27 – 0.70)	0.70	0.78
Confectionery	-	77.3	0.43 (0.10 – 0.77)	0.58	0.84
Any drinks		75.0	0.50 (0.27 – 0.73)	0.74	0.76
Sugar sweetened drinks	-	95.5	+	0.00	0.98
Sugar free drinks	-	81.8	0.46 (0.15 – 0.76)	0.56	0.89
Fruit juice	-	75.0	0.39 (0.13 – 0.65)	0.56	0.83
Milk	-	70.5	0.33 (0.02 – 0.65)	0.55	0.78
Allowed access (Yes/No)					
Any fruit	-	80.6	0.47 (0.09 – 0.84)	0.86	0.53
Any vegetables	-	73.7	0.36 (-0.00 – 0.73)	0.67	0.50
Any snacks	-	84.1	0.49 (0.16 – 0.82)	0.59	0.90
Savoury snacks	-	92.9	0.85 (0.49 – 1.21)	0.71	0.73
Sweet snacks	-	84.6	0.64 (-0.02 – 1.29)	0.67	0.57
Confectionery	-	100	-	-	-
Any drinks	-	81.8	0.52 (0.26 – 0.78)	0.64	0.88
Sugar sweetened drinks	-	100	-	-	-
Sugar free drinks	-	90.9	0.29 (-0.21 – 0.79)	0.33	0.95
Fruit juice	-	86.4	0.50 (0.20 – 0.80)	0.57	0.92

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)	Ppos	Pneg
Milk	-	81.8	0.33 (-0.00 – 0.66)	0.43	0.89
Family meals (days per week)					
Total family meals	0.89 (0.81 – 0.94)	-	-	-	-
Breakfast	-	56.8	0.69 (0.56 – 0.82)[w]	-	-
Lunch	-	50.0	0.64 (0.49 – 0.79)[w]	-	-
Dinner	-	65.9	0.75 (0.64 – 0.86)[w]	-	-

Ppos = proportion of positive agreement; Pneg = proportion of negative agreement.
[1] Fruit juice variety was not assessed.
[2] The maximum variety for milk drinks was 3 (i.e. skimmed, semi or full-fat milk).
- Not applicable.
+ Kappa values could not be calculated due to cell counts equalling zero.
[w] Weighted Kappa for items with 3 or more ordered response options.

4.3.5.2.2 Home activity environment variables

Test-retest results for the home activity environment variables are shown in **Table 4.4**. Percent agreement was high for all variables (81.8 – 100%), but lower for how often the child was allowed outdoors (63.6). Kappa scores were moderate to high for all variables (0.52 – 0.94). Kappa scores were not calculated for whether there was a garden, whether there were parks close to the home, and whether the child had a wheeled toy as percent agreement was 100% for these variables. The proportion of positive agreement ranged from 0.82 to 1.00; the proportion of negative agreement ranged from 0.63 to 0.96. ICCs for parental modelling of physical activity and neighbourhood satisfaction were high (0.78 and 0.86 respectively); the ICC for parental support of physical activity was slightly lower (0.68). Internal consistency was high for parental modelling of physical activity and neighbourhood satisfaction (α = 0.80 and 0.81 respectively); parental support of physical activity had lower internal consistency (α =0.54).

Table 4.4. Single measure Intraclass correlation coefficients (and 95% confidence intervals), percent agreement, Kappa values (and 95% confidence intervals), proportion of positive agreement, and proportion of negative agreement for home activity environment variables

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)	Ppos	Pneg
Parks	-	100	-	-	-
Indoor recreation	-	84.1	0.53 (0.24 – 0.82)	0.91	0.63
Garden	-	100	-	-	-
Garden size	-	95.5	0.94 (0.86 – 1.03)[w]	-	-
Garden Equipment	-	97.7	0.85 (0.55 – 1.14)	1.00	0.86
Tricycle	-	100	-	-	-
Adequate outdoors	-	72.7	0.68 (0.50 – 0.87)[w]	-	-
Adequate indoors	-	72.7	0.68 (0.54 – 0.81)[w]	-	-
Allowed outdoors	-	63.6	0.55 (0.37 – 0.73)[w]	-	-
Allowed indoors	-	81.8	0.52 (0.31 – 0.73)[w]	-	-
Parental support of PA	0.68 (0.48 – 0.81)	-	-	-	-
Parental modelling of PA	0.78 (0.62 – 0.87)	-	-	-	-
Neighbourhood satisfaction	0.86 (0.76 – 0.92)	-	-	-	-

Ppos = proportion of positive agreement; Pneg = proportion of negative agreement; PA = physical activity.
- Not applicable.
[w] Weighted Kappa for items with 3 or more ordered response options.

4.3.5.2.3 Home media environment variables

Results for the test-retest reliability of the home media environment variables are shown in **Table 4.5**. ICCs were almost perfect for all continuous variables (0.90 – 0.98). Percent agreement was high for all categorical variables (75 – 100%) but lower for the number of days the child ate snacks while watching TV (61.4%). Kappa scores were moderate to high for all variables (0.56 – 0.82). Scores could not be calculated for whether the child had a computer or console in their bedroom as there were some empty cells. Specifically, at T1, two children reportedly had a computer in their bedroom, while at T2 no children reportedly had a computer in their bedroom. For games consoles, one person said their child had one on their bedroom, while at T2 no one said their child had one in their bedroom. Whether the child had a TV in their bedroom had 100% agreement therefore Kappa was not calculated. The proportion of positive agreement ranged from 0.00 to 0.92; the proportion of negative agreement ranged from 0.72 to 0.99.

Table 4.5. Single measure Intraclass correlation coefficients (and 95% confidence intervals), percent agreement, Kappa values (and 95% confidence intervals), proportion of positive agreement, and proportion of negative agreement for home media environment variables

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)	Ppos	Pneg
Total media equipment		-	-	-	-
Number of TVs	0.97 (0.95 – 0.99)	-	-	-	-
Number of VCR/DVD players	0.91 (0.84 – 0.95)	-	-	-	-
Number of computers	0.97 (0.94 – 0.98)	-	-	-	-
Number of games consoles	0.98 (0.96 – 0.99)	-	-	-	-
Caregiver TV watching (hours per week)	0.90 (0.83 – 0.95)	-	-	-	-
Partner TV watching (hours per week)	0.94 (0.90 – 0.97)	-	-	-	-
TV bedroom	-	100	-	-	-
Computers bedroom	-	95.5	+	0.00	0.98
Console bedroom	-	97.7	+	0.00	0.99
TV rules	-	84.1	0.61 (0.36 – 0.86)	0.89	0.72
Reward TV	-	93.2	0.63 (0.17 – 1.09)	0.67	0.96
Reduce TV	-	88.6	0.77 (0.55 – 0.99)	0.87	0.89
Eat TV	-	90.9	0.81 (0.62 – 1.00)	0.92	0.89
Days eat TV per week	0.93 (0.87 – 0.96)	-	-	-	-

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)	Ppos	Pneg
Breakfast TV	-	86.4	0.82 (0.67 – 0.97)[w]	-	-
Lunch TV	-	84.1	0.80 (0.67 – 0.93)[w]	-	-
Dinner TV	-	75.0	0.74 (0.50 – 0.94)[w]	-	-
Snacks TV	-	61.4	0.56 (0.39 – 0.78)[w]	-	-

Ppos = proportion of positive agreement; Pneg = proportion of negative agreement.
- Not applicable.
+ Kappa could not be calculated due to cell counts equalling zero.
[w] Weighted Kappa for items with 3 or more ordered response options.

4.3.5.3 Descriptive statistics

4.3.5.3.1 Home food environment

Descriptive statistics for the home food environment variables are shown in **Table 4.6**. All but one parent reported that they had some kind of fruit available at home. Fresh fruit was the most common kind of fruit reported to be available (99%); frozen fruit was the least common to be reported (31%). All parents reported that there was some kind of vegetable available at home. Again, fresh vegetables were reportedly the most common vegetable type at home (98%); availability for the other vegetable types was also high. Most parents (99%) also said there was some kind of energy-dense snack food available at home; sweet snacks were the most commonly available energy-dense snack type (95%). All but four parents said that there were non-alcoholic drinks other than water available in the home; milk was the most commonly available (99%); sugar-sweetened drinks were the least commonly available (39%). Of those who had milk in their home, most had skimmed milk; almost half (46%) had full-fat milk. In terms of variety, parents reported an average of 8 kinds of fruit available in the home. There was most variety for fresh fruit (around 5 kinds), and least variety for frozen fruit (around 1 kind). For vegetables, parents reported an average of 10 kinds at home; again most variety was for fresh vegetables (around 7 kinds), and tinned vegetables had the least variety (around 2 kinds). On average, parents reported 5 kinds of energy-dense snack at home and 4 kinds of non-alcoholic drink other than water. The highest variety was for sweet snacks (around 2 kinds) and sugar-free drinks (around 2 kinds).

Most parents (94%) reported that fruit was displayed in the open; approximately half (54%) reported that there were ready-to-eat vegetables in the fridge or on the kitchen counter; 20% reported that there was some kind of energy-dense snack displayed in the open; and 25% reported that there was some kind of drink displayed in the open, with sugar-free drinks being the most commonly reported type (18%).

In terms of accessibility, most parents (88%) reported that fruit was physically accessible to their child; approximately half (53%) said that vegetables were accessible. A fairly large proportion (58%) reported that energy-dense snacks were accessible, with 43% reporting savoury snacks as the most common type of accessible snack; 44% said that non-alcoholic drinks were physically accessible, with milk being the most commonly reported (27%) and sugar-sweetened drinks being the least commonly reported (6%). Approximately half of the sample said that their child was allowed access to fruit; 29% reported that their child was allowed access to vegetables; 9% reportedly allowed their child access to some kind of energy-dense snack, with confectionery being the least commonly reported (2%); 17% said their child was allowed access to non-alcoholic drinks other than water, with milk being the most commonly reported (9%).

Parental feeding data were available for 778 (restriction), 779 (monitoring, covert restriction, pressure, modelling, and emotional feeding), and 780 (encouragement, instrumental feeding, and control) cases at the time of the latest follow-up questionnaire. There were an additional 291 (restriction), 292 (encouragement, monitoring, covert restriction, instrumental feeding, pressure, and control), and 293 (modelling and emotional feeding) cases with parental feeding data from the 15-month questionnaire. Total parental feeding data comprised 1069 (restriction), 1071 (monitoring, covert restriction, and pressure), and 1072 (encouragement, instrumental feeding, control, modelling, and emotional feeding) cases. For parental control, encouragement, monitoring, modelling, restriction, and covert restriction, each had an average score above the mid-point of the scale. For parental emotional feeding, instrumental feeding, and pressure, each had an average score below the mid-point of the scale.

Parents reported that their child consumed any meals at a table as a family on average 4 days per week. Breakfast and dinner were the meals most frequently consumed at a table as a family (4 days per week), while lunch was slightly less frequently consumed at a table as a family (3 days per week).

Table 4.6. Descriptive statistics for home food environment variables (% (n) who responded yes, unless stated otherwise)

	N = 1113
Physical Aspects	
Availability (Yes/No)	
Any fruit	99.9 (1112)
Fresh fruit	99.4 (1106)
Tinned fruit	51.9 (578)
Dried fruit	90.5 (1007)
Frozen fruit	31.4 (349)
Any vegetables	100 (1113)
Fresh vegetables	97.5 (1085)
Tinned vegetables	94.6 (1053)
Frozen vegetables	94.4 (1051)
Any energy-dense snacks	99.3 (1105)
Savoury snacks	88.9 (989)
Sweet snacks	95.1 (1059)
Confectionery	83.1 (925)
Any non-alcoholic drinks	99.6 (1109)
Sugar sweetened drinks	38.8 (432)
Sugar free drinks	79.3 (883)
Fruit Juice	74.9 (834)
Milk	98.5 (1096)
Skimmed	74.3 (827)
Semi-skimmed	16.9 (188)
Full-fat	46.1 (513)
Variety, mean (SD)	
Total fruit	7.75 (3.23)
Fresh fruit	4.52 (1.73)
Tinned fruit	0.90 (1.12)
Dried fruit	1.83 (1.32)
Frozen fruit	0.49 (0.92)
Total vegetables	10.78 (3.75)
Fresh vegetables	6.53 (3.05)
Tinned vegetables	1.83 (1.14)
Frozen vegetables	2.42 (1.55)
Total energy-dense snacks	5.23 (2.10)
Savoury snacks	1.65 (1.09)
Sweet snacks	2.26 (1.10)
Confectionery	1.33 (0.76)
Total drinks	3.80 (1.23)
Sugar sweetened drinks	0.52 (0.72)
Sugar free drinks	1.87 (0.92)
Juice drinks[1]	-
Milk drinks	1.41 (0.59)

Displayed (Yes/No)	
Any fruit	93.5 (1041)
Any ready-to-eat vegetables	54.0 (601)
Any energy-dense snacks	20.4 (227)
Savoury snacks	6.5 (72)
Sweet snacks	9.8 (109)
Confectionery	8.3 (92)
Any drinks	24.7 (275)
Sugar sweetened drinks	6.6 (74)
Sugar free drinks	18.2 (203)
Fruit juice	2.8 (31)
Milk	0.3 (3)
Physically accessible (Yes/No)	
Any fruit	88.4 (984)
Any vegetables	52.7 (587)
Any energy-dense snacks	57.6 (641)
Savoury snacks	43.4 (483)
Sweet snacks	35.0 (389)
Confectionery	26.3 (293)
Any non-alcoholic drinks	43.8 (487)
Sugar sweetened drinks	6.3 (70)
Sugar free drinks	20.9 (233)
Fruit juice	23.5 (262)
Milk	27.0 (301)
Social Aspects	
Allowed access (Yes/No)[2]	
Any fruit	53.5 (596)
Any vegetables	28.6 (318)
Any energy-dense snacks	8.7 (97)
Savoury snacks	6.8 (76)
Sweet snacks	3.6 (40)
Confectionery	2.3 (26)
Any non-alcoholic drinks	16.9 (188)
Sugar sweetened drinks	1.8 (20)
Sugar free drinks	6.6 (74)
Fruit juice	8.2 (91)
Milk	9.2 (102)
Parental feeding practices,[3] mean (SD)	
Restriction[4]	5.19 (1.12)
Monitoring[5]	3.66 (0.96)
Covert restriction[5]	3.02 (0.83)
Pressure[5]	2.61 (0.71)
Encouragement[6]	4.12 (0.54)
Instrumental[6]	2.18 (0.66)
Control[6]	4.25 (0.45)
Modelling[6]	3.62 (0.75)

Emotional[6]	1.80 (0.62)
Family meals, mean (SD)	
Any family meals	3.83 (1.62)
Breakfast	4.36 (2.69)
Lunch	2.87 (1.93)
Dinner	4.26 (2.52)

[1] Fruit juice variety was not assessed.
[2] This question was skipped if the participant answered no to whether the particular food or drinks were physically accessible to the child therefore data were missing as follows: 11.6 (129) for fruit, 47.3 (526) for vegetables, 56.6 (630) for savoury snacks, 65 (724) for sweet snacks, 73.7 (820) for confectionery, and 56.2 (626) for each of the non-alcoholic drinks other than water.
[3] Parent feeding practice variables were taken from the five-year and 15-month Gemini questionnaires.
[4] Data were available for 1069 families (44 missing cases).
[5] Data were available for 1071 families (42 missing cases).
[6] Data were available for 1072 families (41 missing cases).

4.3.5.3.2 Home activity environment

Descriptive statistics for the home activity environment variables are shown in **Table 4.7**. Almost all parents (97%) said that there were parks or outdoor play areas close to their home, while 80% said that there were indoor recreation centres close to their home. Almost all parents reported that they had a garden or outdoor play area where their child could be physically active (99%). Of those who had a garden, nearly half said that it was medium (46%) and most said that there was useable play equipment in their garden (87%). Almost all children reportedly had a wheeled toy (99%). The average neighbourhood satisfaction score (48.5, SD = 6.5) was high when compared to the total possible score of 65. The average scores for parental support and parental modelling of physical activity were above the mid-point of each scale.

Table 4.7. Descriptive statistics for home activity environment variables (% (n) who responded yes, unless stated otherwise)

	N = 1113
Physical Aspects	
Neighbourhood satisfaction, mean (SD)	48.45 (6.46)
Parks	96.7 (1076)
Indoor recreation centres[1]	80.0 (890)
Garden/outdoor space	98.7 (1098)
Garden Size[2]	
Small	19.4 (216)
Medium	46.4 (516)
Large	32.9 (366)
Garden play equipment[2]	86.5 (963)
Tricycle/bike/wheeled toy	98.7 (1098)
Adequate indoor space (0 = strongly disagree; 1 = strongly agree), mean (SD)	0.83 (0.22)
Adequate outdoor space (0 = strongly disagree; 1 = strongly agree), mean (SD)[2]	0.86 (0.23)
Social Aspects	
Allowed to play indoors (0 = never; 1 = all of the time), mean (SD)	0.93 (0.15)
Allowed to play outdoors (0 = never; 1 = all of the time), mean (SD)[2]	0.84 (0.19)
Parental modelling of physical activity, mean (SD)	3.94 (0.75)
Parental support of physical activity, mean (SD)	3.99 (0.57)

[1] Data were missing for 3 participants as they didn't know whether there were any indoor recreation centres close to their home.
[2] Data were missing for 15 participants as they didn't have a garden or outdoor space.

4.3.5.3.3 Home media environment

Descriptive statistics for the home media environment variables are shown in **Table 4.8**. Around two thirds (68%) of families had cable or satellite TV at home. On average, families had two TV sets, two VCR or DVD players, two computers and one games console at home. On average, children ate snacks more frequently than meals while watching TV (3 days vs. less). Breakfast was more frequently eaten while watching TV than other meals (1 day vs. less). TV was the most common form of media equipment in the child's bedroom (12%); 2% had a computer in their bedroom and 2% had a games console in their bedroom. On average, parents and their partners watched TV for a very similar number of hours per week (16.21 and 16.28, respectively). Two thirds (66%) of parents reported that they had some form of rules around TV and computer use, half (51%) said that they reduced TV or computer time if their child misbehaved, while fewer (14%) said that they used TV or computer as a reward for good behaviour.

Table 4.8. Descriptive statistics for home media environment variables (% (n) who responded yes, unless stated otherwise)

	N = 1113
Physical Aspects	
Number of TVs, mean (SD)	2.27 (1.25)
Number of DVD/VCR players, mean (SD)	1.67 (0.90)
Cable or satellite	68 (757)
Number of computers, mean (SD)	1.92 (1.05)
Number of games consoles, mean (SD)	1.30 (1.45)
Total media equipment, mean (SD)	5.93 (2.89)
TV in child's bedroom	11.8 (131)
Computer in child's bedroom	1.9 (21)
Games console in child's bedroom	2.2 (25)
Child eats while watching TV	70.5 (785)
Child eats breakfast while watching TV (days per week), mean (SD)	1.32 (2.50)
Child eats lunch while watching TV	0.51 (1.30)
Child eats dinner while watching TV	0.89 (1.91)
Child eats snacks while watching TV	2.54 (2.63)
Social aspects	
Main caregiver TV watching (hours per week), mean (SD)	16.21 (9.39)
Partner TV watching (hours per week), mean (SD)[1]	16.28 (8.98)
Any rules around TV/computer	66.4 (739)
Use TV/computer as a reward	13.8 (154)
Reduce TV/computer if child misbehaves	50.8 (565)

[1] Data were missing for 7% (n = 77) of the total sample.

4.4 Part 2: Development of the home environment composite scores

4.4.1 Methods

4.4.1.1 Variable inclusion

Although the variable selection for the HEI was research-based, the literature review in Chapter 2 indicated that the existing evidence is not always strong. To ensure that the home environment composites included variables relevant to childhood weight gain, a panel of experts were consulted using a Delphi method. The Delphi method is one of several consensus methods used to obtain a level of agreement on controversial topics in a systematic manner. Experts are invited to provide an opinion on a scientific matter, responding individually and anonymously, usually via a self-administered questionnaire. There may be several rounds for expert feedback, depending on the needs of the investigator, and the final group consensus is reported back to the experts (Fink, Kosecoff, Chassin, & Brook, 1984; Jones & Hunter, 1995).

Fifty-five experts in the child obesity field were contacted by email. The email contained a link to an online survey, which presented the list of home environment variables and asked the experts to indicate whether they thought each variable was associated with increased or decreased risk for weight gain in childhood. The list of home environment variables comprised all those included in the HEI (in addition to the parental feeding practice variables), except for the following variables where responding was substantially skewed (i.e. fewer than 5% of the sample responded in one of the response categories): whether the child had a bicycle or wheeled toy (only 1% (n = 15) responded no); whether there were any parks or outdoor recreation areas close to the home (3% (n = 37) responded no); whether the child had a computer in their bedroom (2% (n = 21) responded yes); and whether the child had a games console in their bedroom (2% (n = 25) responded yes). Although fewer than 5% of the sample said that their child was allowed to help themself to sugar-sweetened drinks (2% (n = 20) responded yes), and that they did not have a garden or outdoor space that their child could play in (1% (n = 15) responded no), these variables were still included in the list on the basis that they had been highlighted consistently in the literature as particularly relevant to risk for weight gain. There was an option for the experts to select ‘not sure’ and a free text box for additional comments. A variable was included in the composite if the majority (60% or more) of experts identified it as being associated with increased or decreased risk for weight gain.

The contents of the email and survey sent to the expert panel are included in **Appendix 4.3**.

4.4.1.2 Aggregation of variables

There are numerous ways to create composite scores (Nardo et al., 2008). One approach, outlined in Chapter 2, is the use of factor or cluster analytic techniques, which reduce a set of variables to a smaller number of factors or clusters, on the basis of the associations between the variables (e.g. Grunseit et al., 2011; Wall et al., 2012). When the degree of association between variables is high, they are said to load onto the same factor (or cluster together). The factor or cluster scores represent the final composite. The potential disadvantage of factor and cluster analytic techniques can be the somewhat unspecific nature of the factor or cluster composite. Taking into account the aims of the current thesis, a major limitation of factor or cluster analytic techniques is that variables that do not load onto a factor or form a cluster would be excluded from the composite, even though they may be relevant to risk for weight gain.

An alternative and perhaps the simplest approach is the summing of categorical variables, which may represent presence or absence of particular risk factors. In the developmental psychology literature, several studies have used this approach to create composite measures of environmental risk that relate to outcomes including emotional and behavioural disturbance (Rutter, 1979; Williams, Anderson, McGee, & Silva, 1990), and intelligence (Sameroff, Seifer, Baldwin, & Baldwin, 1993). However, in many cases, including a large proportion of variables collected as part of the HEI, an objective categorical definition of risk is not available, and the researcher must choose more arbitrary cut-offs, such as assigning those with scores in the top quartile to the high risk group. More generally, this approach is limited in that it loses variation in the data.

When there is a mixture of categorical, ordinal, and continuous variables to be aggregated (as in the HEI), defining a common metric is necessary; otherwise the variables make unequal contributions to the composite score. There are several standardisation procedures, which retain a greater level of variation in the data (Nardo et al., 2008). One such procedure is rescaling, whereby the variables to be included in the composite are recoded so they all have identical ranges (0 – 1) (e.g. Pinard et al., 2013). However, a problem with this approach is that the extreme values (minimum and maximum) may be erroneous, creating a distortion effect on the transformed variable. Extreme values can arise in open-ended questions, such as the food availability questions in the HEI. An alternative, more commonly-used procedure is standardisation using Z-scores. This procedure transforms all variables to a common scale with an average of 0 and a standard deviation of 1. The resultant Z-scores are the number of standard deviation units an individual's score is above or below the average score. The Z-score transformation procedure has been used to create composite scores in various research contexts, often (but not exclusively) to assess some form of cognitive functioning (e.g. Andres, Finison, Conlon, Thibodeau, & Munsat, 1988; Cutter et al., 1999; Moller et al., 1998).

Summing the standardised scores on variables has been described as simple or unit weighting (Bobko, Roth, & Buster, 2007). Researchers can also apply differential weights to the variables within a composite; an approach that is used when there is reason to believe that some variables are more or less important than others, and therefore should make specific contributions to the overall composite score. Weights may be assigned based on theoretical expectations or the statistical quality of the data. Methods to determine differential weights include statistical techniques such as linear regression, where the strength of the relationship between each variable and a criterion determines the weight to apply, and expert judgements, where a panel of experts rank the importance of each variable (Bobko et al., 2007). Although it is 'intuitively reasonable that (differential) weighting should make a difference' (Aiken, 1966), research has shown that the predictive efficiency of unit versus differential weights is very similar, especially for composites with a large number of variables (Ree, Carretta, & Earles, 1998; Wainer, 1976; Wilks, 1938).

Taking into account the strengths and limitations of the different approaches, standardisation using Z-scores was deemed the most appropriate for the HEI composite scores. First, variables identified as being associated with decreased risk for childhood weight gain were reverse scored so that a higher total score on each composite would reflect ‘higher risk’ for weight gain. Each variable was then standardised to have a mean of 0 and a standard deviation of 1. Before standardising the food and drink availability variables, specifically fruit, vegetable, and energy-dense snack variety, and the presence of sugar-sweetened drinks, a series of linear regression analyses were carried out to examine potential relationships with how typical the reported availability was, and the number of days since the participant last shopped for food/drink. In each regression model, the particular food/drink availability was the dependent variable (DV) and how typical the reported availability was and the days since last shopping were the independent variables (IVs). If only one of the IVs was significantly associated with food/drink availability, the model was re-run to include just the significant variable and the standardised residuals for the model were saved to be used in the composite. To create the standardised energy-dense snack variety variable, the standardised residuals for savoury snack, sweet snack, and confectionery variety were summed. This variable was then standardised again to have a mean of 0 and a standard deviation of 1. The standardised variables (Z-scores) were then summed to create three composites: one to represent the home food environment (the sum of the food environment variables), one to represent the home activity environment (the sum of the activity environment variables), and one to represent the media environment (the sum of the media environment variables). The food, activity, and media composites were then summed to create an overall home environment composite, dividing by the number of variables per composite so that each composite contributed equally to the overall one (food composite/20 + activity composite/6 + media composite/6).

4.4.1.3 Sensitivity and test-retest reliability analyses

To assess the robustness of composite measures, it is important to carry out sensitivity analyses. One approach is to create new composites by systematically including and excluding particular variables; and then seeing how these composites relate to the original versions. A further check would be to repeat future analyses with the composites using different versions to see if the results vary according to the composite type used. For this thesis, new composites were created based on the experts' feedback. In the first set of variations, a variable was included if 50% or more of the experts identified it as being associated with increased or decreased risk for weight gain, producing composites with a wider range of variables included than in the original versions. In the second set of variations, a variable was included if 85% or more of the experts identified it as being associated with increased or decreased for weight gain, producing composites with a narrower range of variables included than in the original versions. Associations between the composite variations were examined using Pearson correlations. Effect sizes were defined as: small ($r = 0.1$), medium ($r = 0.3$), and large ($r = 0.5$) (J. Cohen, 1988). Single measure Intraclass correlation coefficients (ICCs) with 95% confidence intervals (CIs) were used to assess test-retest reliability of each home environment composite. ICC values were categorised as: <0.40 = poor, 0.40 – 0.75 = fair to good agreement and >0.75 = excellent (Fleiss, 1986).

4.4.2 Results

4.4.2.1 Variable inclusion

Twenty-eight (50%) of the experts contacted completed the survey; another two experts part-completed the survey. The results of the survey are shown in **Tables 4.9 – 4.11**. Variables identified by the majority (60% or more) of experts are highlighted in bold.

Overall, thirty-two (65%) of the home environment variables were identified by the majority as being associated with increased or decreased risk for weight gain; thirty-six (73%) were identified by 50% or more of the experts; and fifteen (31%) were identified by 85% or more of the experts. For the remaining twelve variables, there was less than 45% consensus among the experts.

Of the home food environment variables, twenty (63%) were identified by the majority as being associated with increased or decreased risk for weight gain; twenty-four (75%) were identified by 50% or more of the experts; and just eight (25%) were identified by 85% or more of the experts. For the remaining eight variables, there was less than 45% consensus (see **Table 4.9**).

Of the home activity environment variables, six (67%) were identified by the majority as being associated with increased or decreased risk for weight gain; seven (78%) were identified by 50% or more of the experts; and just three (33%) were identified by 85% or more of the experts. For the remaining two variables, there was less than 45% consensus (see **Table 4.10**).

Of the home media environment variables, six (75%) were identified by the majority as being associated with increased or decreased risk for weight gain; and four (50%) were identified by 85% or more of the experts. For the remaining two variables, there was less than 30% consensus (see **Table 4.11**).

Table 4.9. Experts' categorisation of the home food environment variables (% (n))

	Probably/definitely INCREASED risk	**Probably/definitely DECREASED risk**	**Not sure**
More types of energy-dense snack in the home	**96.7 (29)**	0.0 (0)	3.3 (1)
Sugar-sweetened drinks in the home	**96.7 (29)**	0.0 (0)	3.3 (1)
Energy-dense snacks on display (visible)	**93.3 (28)**	0.0 (0)	6.7 (2)
Maternal modelling of healthy eating	6.7 (2)	**93.3 (28)**	0.0 (0)
Family meals at the table	6.9 (2)	**93.1 (27)**	0.0 (0)
Child is allowed to help themself to energy-dense snacks	**90.0 (27)**	0.0 (0)	10.0 (3)
Sugar-sweetened drinks on display (visible)	**90.0 (27)**	0.0 (0)	10.0 (3)
Child is allowed to help themself to sugar-sweetened drinks	**90.0 (27)**	0.0 (0)	10.0 (3)
More types of vegetable in the home	0.0 (0)	**83.3 (25)**	16.7 (5)
More types of fruit in the home	0.0 (0)	**80.0 (24)**	20.0 (6)
Ready-to-eat vegetables in the fridge or on the kitchen counter	0.0 (0)	**79.3 (23)**	20.7 (6)
Child is allowed to help themself to vegetables	3.4 (1)	**75.9 (22)**	20.7 (6)
Parental restriction of unhealthy foods	10.7 (3)	**75.0 (21)**	14.3 (4)

	Probably/definitely INCREASED risk	Probably/definitely DECREASED risk	Not sure
Parental use of food to make the child feel better	**75.0 (21)**	0.0 (0)	25.0 (7)
Parental use of food as a reward	**72.0 (18)**	0.0 (0)	28.0 (7)
Parental encouragement for the child to eat fruit and vegetables	0.0 (0)	**71.4 (20)**	28.6 (8)
Parental monitoring of the child's unhealthy food intake	0.0 (0)	**71.4 (20)**	28.6 (8)
Parental covert restriction of the child's unhealthy food intake	10.7 (3)	**71.4 (20)**	17.9 (5)
Child is allowed to help themself to fruit	0.0 (0)	**70.0 (21)**	30.0 (9)
Fruit on display (visible)	6.7 (2)	**63.3 (19)**	30.0 (9)
Full-fat milk in the home	55.2 (16)	3.4 (1)	41.4 (12)
Skimmed milk in the home	0.0 (0)	55.2 (16)	44.8 (13)
Child is allowed to help themself to fruit juice	51.7 (15)	10.3 (3)	37.9 (11)
Parental control of the child's food intake	25.0 (7)	50.0 (14)	25.0 (7)
Parental pressure for the child to eat	44.4 (12)	7.4 (2)	48.1 (13)
Fruit juice on display (visible)	41.4 (12)	13.8 (4)	44.8 (13)
Fruit juice in the home	36.7 (11)	13.3 (4)	50.0 (15)
Semi-skimmed milk in the home	3.4 (1)	34.5 (10)	41.4 (12)

	Probably/definitely INCREASED risk	Probably/definitely DECREASED risk	Not sure
Child is allowed to help themself to milk	17.2 (5)	24.1 (7)	58.6 (17)
Sugar-free drinks in the home (excluding water)	20.0 (6)	16.7 (5)	63.3 (19)
Sugar-free drinks (excluding water) on display (visible)	20.0 (6)	16.7 (5)	63.3 (19)
Child is allowed to help themself to sugar-free drinks (excluding water)	16.7 (5)	16.7 (5)	66.7 (20)

Table 4.10. Experts' categorisation of the home activity environment variables (% (n))

	Probably/definitely INCREASED risk	Probably/definitely DECREASED risk	Not sure
Parental support of physical activity	0.0 (0)	**100.0 (28)**	0.0 (0)
Parental modelling of physical activity	0.0 (0)	**92.9 (26)**	7.1 (2)
Greater frequency that the child is allowed to play actively in the garden/yard	0.0 (0)	**92.6 (25)**	7.4 (2)
Play equipment in the garden/yard	0.0 (0)	**77.8 (21)**	22.2 (6)
Garden/yard that the child can play in	0.0 (0)	**70.4 (19)**	29.6 (8)
Greater frequency that the child is allowed to play actively inside the home	3.7 (1)	**66.7 (18)**	29.6 (8)
Larger garden/yard that the child can play in vs. smaller garden/yard	0.0 (0)	55.6 (15)	44.4 (12)
Parental satisfaction with their home neighbourhood	0.0 (0)	44.4 (12)	55.6 (15)
Indoor recreation centres close to the home	0.0 (0)	37.0 (10)	63.0 (17)

Table 4.11. Experts' categorisation of the home media environment variables (% (n))

	Probably/definitely INCREASED risk	Probably/definitely DECREASED risk	Not sure
TV in the child's bedroom	**96.4 (27)**	0.0 (0)	3.6 (1)
Child eats while watching TV	**92.9 (26)**	3.6 (1)	3.6 (1)
Greater amount of media equipment in the home (i.e. TVs, DVD players, games consoles)	**85.7 (24)**	0.0 (0)	14.3 (4)
Greater maternal TV watching	**85.2 (23)**	0.0 (0)	14.8 (4)
Greater paternal TV watching	**82.1 (23)**	0.0 (0)	17.9 (5)
Parental rules around media use	0.0 (0)	**82.1 (23)**	17.9 (5)
Parental use of TV/computer time as a reward	29.6 (8)	3.7 (1)	66.7 (18)
Parental limits on TV/computer time if the child misbehaves	14.8 (4)	11.1 (3)	74.1 (20)

4.4.2.2 Aggregation of variables

The regression analyses showed significant positive associations between how typical the reported amount of fruit was and the variety of fruit in the home (B (95% CI) = 1.25 (0.83 – 1.67), $p < 0.001$); how typical the reported amount of vegetables was and the variety of vegetables in the home (2.11 (1.65 – 2.56), $p < 0.001$); how typical the reported amount of savoury snacks was and the variety of savoury snacks in the home (0.60 (0.46 – 0.74), $p < 0.001$); how typical the reported amount of sweet snacks was and the variety of sweet snacks in the home (0.62 (0.49 – 0.75), $p < 0.001$); how typical the reported amount of confectionery was and the variety of confectionery in the home (0.47 (0.40 – 0.55), $p < 0.001$); and how typical the reported amount of drinks was and the presence of sugar-sweetened drinks in the home (0.13 (0.04 – 0.22), p = 0.004). There were no significant associations between the number of days the participant last shopped for food/drink and the variety of fruit (0.01 (-0.07 – 0.09), p = 0.819); vegetables (-0.03 (-0.12 – 0.06), p = 0.526); savoury snacks (-0.01 (-0.03 – 0.02), p = 0.556); sweet snacks (-0.01 (-0.04 – 0.02), p = 0.442); confectionery (-0.01 (-0.03 – 0.01), p = 0.195); or the presence of sugar-sweetened drinks in the home (-0.00 (-0.01 – 0.01), p = 0.791).

Descriptive statistics for each composite and the standardised variables included in each composite are shown in **Table 4.12**. The standard deviations and ranges for each home environment composite indicated that there was considerable variation in scores. However, the theoretical ranges (based on the minimum and maximum scores on each variable in the data set) were wider. For all of the composites, the maximum possible score was much higher than the maximum actual score. For the home activity and media composites, the minimum possible score was reached.

Table 4.12. Descriptive statistics for each composite and the standardised variables included in each composite (N = 1113)

	Mean (SD)[1]	**Actual range**	**Theoretical range**[2]
Home food environment composite	0.00 (6.32)	-19.25 – 25.25	-32.27 – 59.50
More types of fruit in the home[3]	-	-5.56 – 2.54	-
More types of vegetable in the home[3]	-	-4.15 – 2.87	-
More types of energy-dense snack in the home	-	-2.59 – 4.38	-
Sugar-sweetened drinks in the home	-	-1.09 – 1.54	-
Fruit on display (visible)[3]	-	-0.26 – 3.80	-
Child is allowed to help themselves to fruit[3]	-	-0.93 – 1.07	-
Ready-to-eat vegetables in the fridge or on the kitchen counter[3]	-	-0.92 – 1.08	-
Child is allowed to help themself to vegetables[3]	-	-1.58 – 0.63	-

	Mean (SD)[1]	Actual range	Theoretical range[2]
Energy-dense snacks on display (visible)	-	-0.51 – 1.97	-
Child is allowed to help themselves to energy-dense snacks	-	-0.31 – 3.23	-
Sugar-sweetened drinks on display (visible)	-	-0.27 – 3.75	-
Child is allowed to help themself to sugar-sweetened drinks	-	-0.15 – 6.88	-
Family meals at the table[3]	-	-1.96 – 2.37	-
Maternal modelling of healthy eating[3, 4]	-	-1.83 – 3.50	-
Parental encouragement for the child to eat[3, 4]	-	-1.62 – 3.54	-
Parental use of food as a reward[4]	-	-1.80 – 3.07	-
Parental use of food to make the child feel better[4]	-	-1.29 – 4.17	-
Parental covert restriction of the child's unhealthy food intake[3, 5]	-	-2.38 – 2.42	-
Parental monitoring of the child's unhealthy food intake[3, 5]	-	-1.44 – 2.93	-
Parental restriction of unhealthy foods[3, 6]	-	-1.63 – 3.76	-
Home activity environment composite	0.00 (3.11)	-4.93 – 16.58	-4.93 – 29.48
Garden/yard that the child can play in[3]	-	-0.12 – 8.55	-
Play equipment in the garden/yard[3, 7]	-	-0.37 – 2.67	-
Greater frequency that the child is allowed to play actively in the garden/yard[3, 7]	-	-0.84 – 4.31	-
Greater frequency that the child is allowed to play actively inside the home[3]	-	-0.43 – 6.11	-
Parental support of physical activity[3]	-	-1.76 – 3.93	-

	Mean (SD)[1]	Actual range	Theoretical range[2]
Parental modelling of physical activity[3]	-	-1.40 – 3.91	-
Home media environment composite	0.00 (3.45)	-7.19 – 18.11	-7.19 – 28.01
Greater amount of media equipment in the home (i.e. TVs, DVD players, games consoles)	-	-1.70 – 5.21	-
TV in the child's bedroom	-	-0.37 – 2.74	-
Greater maternal TV watching	-	-1.72 – 6.63	-
Greater paternal TV watching[8]	-	-1.81 – 8.27	-
Rules around media use[3]	-	-0.71 – 1.41	-
Child eats while watching TV	-	-0.87 – 3.75	-
Overall home environment composite	0.00 (0.97)	-2.44 – 4.01	-3.64 – 12.55

[1] The mean (SD) for each home environment variable was 0 (1).
[2] Range based on the minimum and maximum scores on each variable in the data set.
[3] Variable was reverse scored as it was identified as being associated with decreased risk for weight gain.
[4] Variable had 41 missing cases (N = 1072), which were recoded to the mean value (0).
[5] Variable had 42 missing cases (N = 1071), which were recoded to the mean value (0).
[6] Variable had 44 missing cases (N = 1070), which were recoded to the mean value (0).
[7] Variable had 15 missing cases (N = 1098), which were recoded to the mean value (0).
[8] Variable had 76 missing cases (N = 1037), which were recoded to the mean value (0).

Figures 4.1 and 4.2 graphically display the distribution of scores for each home environment composite. A distribution is said to be normal when the data-points fall symmetrically around the mean. When displayed graphically, the normal distribution follows a bell-shaped curve, with 50% of the data falling below the mean and 50% falling above the mean. The extent of skewness refers to how much the data distribution deviates from symmetry. A positively-skewed distribution arises when the data are clustered (graphically) to the left and the tail points to the right, while a negatively-skewed distribution arises when data are clustered (graphically) to the right and the tail points to the left. The extent of kurtosis refers to how peaked the data is relative to a normal distribution. Distributions that are flattened in shape are said to be platykurtic; peaked distributions are said to be leptokurtic (A. Field, 2009). In addition to graphical displays, SPSS provides numerical values for the extent of skewness and kurtosis in the data. Although there is no definitive cut-off to indicate an unacceptable level of skewness and kurtosis, a conservative approach is to take values greater than 1.0 (or less than -1.0) as indicating that the data are not normally distributed (Bowen & Guo, 2011).

The home food composite was normally distributed (skew (standard error) = 0.30 (0.07); kurtosis (standard error) = 0.46 (0.15)). The home activity composite had a positively skewed (1.14 (0.07)), leptokurtic (2.43 (0.15)) distribution, indicating that most participants had lower risk scores, and there was a clustering of scores around the mean. The home media composite also had a positively skewed (1.04 (0.07)), leptokurtic (1.46 (0.15)) distribution, albeit to a lesser extent. The overall home environment composite was normally distributed (skew = 0.74 (0.07); kurtosis = 0.85 (0.15)).

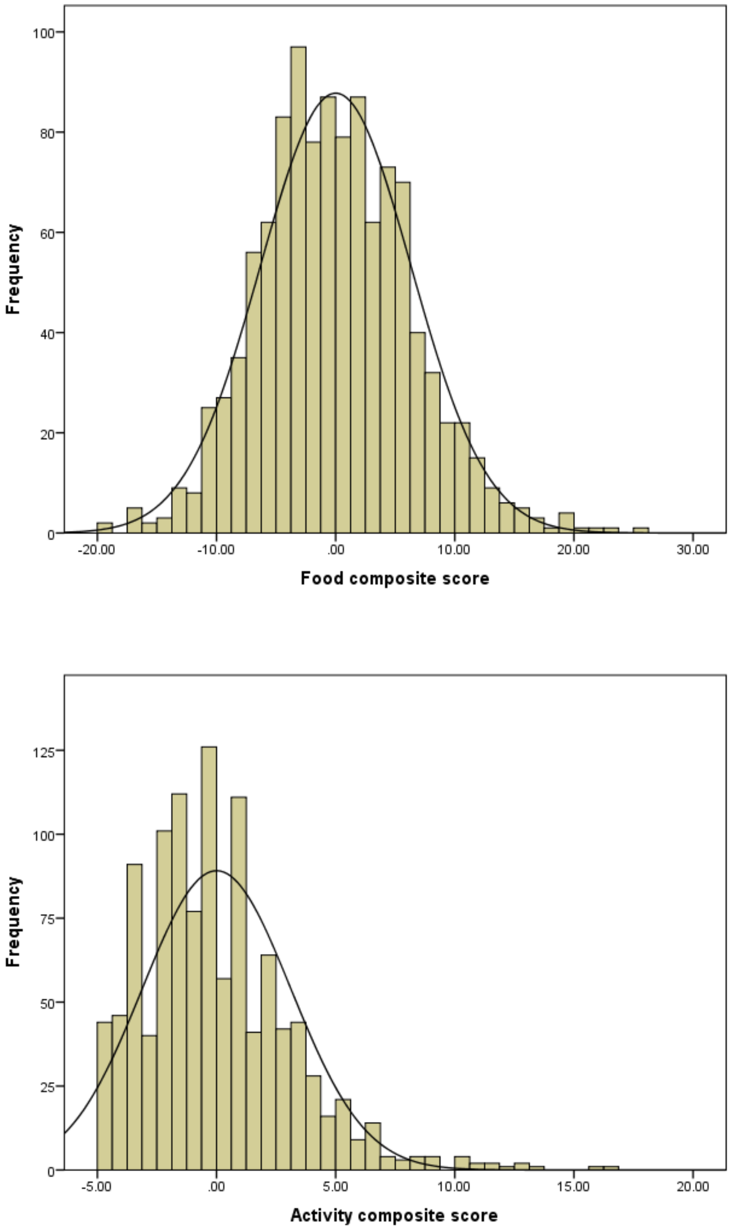

Figure 4.1. Distributions for the home food and activity environment composites

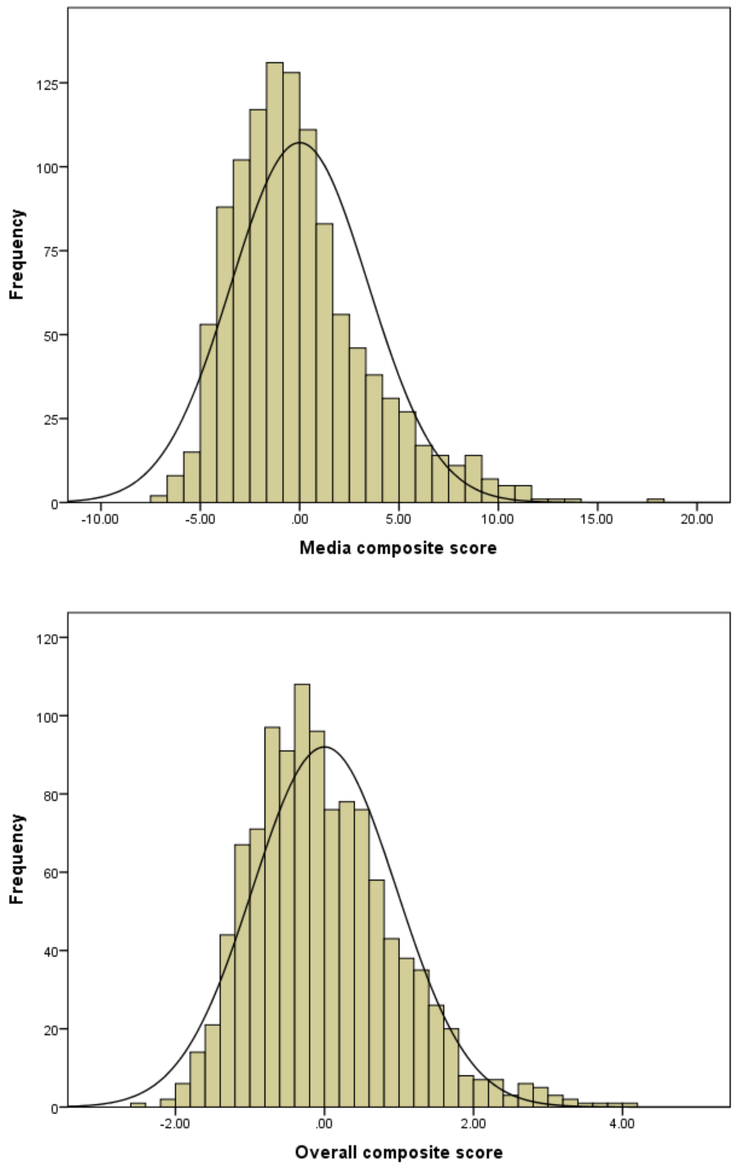

Figure 4.2 Distributions for the home media and overall environment composites

4.4.2.3 Test-retest reliability and sensitivity analyses

Test-retest reliability of each home environment composite was acceptable to high: food[2] original (0.65 (0.45 – 0.80)); activity original (0.80 (0.67 – 0.89)); media original (0.94 (0.89 – 0.96)); overall original (0.90 (0.83 – 0.95)); food variation 1 (0.70 (0.50 – 0.82)); activity variation 1 (0.86 (0.75 – 0.92)); media variation 1 (0.94 (0.89 – 0.96)); overall variation 1 (0.91 (0.83 – 0.95)); food variation 2 (0.57 (0.33 – 0.74)); activity variation 2 (0.80 (0.66 – 0.89)); media variation 2 (0.97 (0.94 – 0.98)); overall variation 2 (0.87 (0.78 – 0.93)). As shown in **Table 4.13**, there were significant positive associations between the food, activity, media, and overall composites. Associations were medium to large, except for that between the activity and media composites, which was non-significant (p = 0.054). As shown in **Table 4.14**, there were strong associations between the corresponding composite variations.

Table 4.13. Associations between the home environment composite scores

	Food composite	**Activity composite**	**Media composite**
Food composite	-	-	-
Activity composite	0.264**	-	-
Media composite	0.303**	0.058	-
Overall composite	0.650**	0.659**	0.726**

** Correlation is significant at the 0.01 level (2-tailed).

[2] The parent feeding variables, namely maternal modelling, encouragement, restriction, covert restriction, instrumental feeding, and emotional feeding, were not included in the test-retest analyses as these variables were assessed at separate time points.

Table 4.14. Associations between the home environment composite variations

	Food original composite	Food variation 1
Food original composite	-	-
Food variation 1	0.955**	-
Food variation 2	0.659**	0.655**
	Activity original composite	**Activity variation 1**
Activity original composite	-	-
Activity variation 1	0.960**	-
Activity variation 2	0.814**	0.783**
	Media original composite	**Media variation 1**
Media original composite	-	-
Media variation 1	1.000**	-
Media variation 2	0.925**	0.925**
	Overall original composite	**Overall variation 1**
Overall original composite	-	-
Overall variation 1	0.984**	-
Overall variation 2	0.871**	0.859**

** Correlation is significant at the 0.001 level (2-tailed).

4.5 Discussion

4.5.1 Study findings

This study described the development and evaluation of the HEI, one of few home environment measures that incorporate both physical and social aspects of the home hypothesised to influence food intake, physical activity, and sedentary behaviour in childhood. Building upon the HHS (Bryant et al., 2008), the HEI incorporated aspects of the home food, activity, and media domains and was completed by a large sample of families, demonstrating its potential usability in population-based cohort studies. Standardisation procedures were used to aggregate the HEI variables into composite scores, reflecting the overall obesogenic quality of the home environment in addition to separate food, activity, and media domains.

Consistent with the HHS, the test-retest reliability of the HEI was generally moderate to high, with lower reliability for some aspects of the home food environment. Although reliability results for the HEI were generally similar to those of the HHS, there were some differences. Reliability for fresh fruit variety was higher in the HEI (0.70) than the HHS (0.37), while savoury and sweet snack variety had lower reliability (both 0.47 vs. 0.86 and 0.65, respectively). These differences are possibly due to differences in the home food environments of the sample populations. Compared to the HHS sample, families who completed the HEI may have fruit and vegetables more consistently, and snacks less consistently in the home, due to cultural differences, differences in general health behaviours and concerns, or due to differences between the macro food environments of the UK and the US. Evidence suggests that home availability of energy-dense foods may be particularly high among black ethnic groups (Franco et al., 2009; Skala et al., 2012) and heavier individuals (Gorin et al., 2011; Phelan et al., 2009). These factors may partly explain the different findings as the HHS sample comprised a larger proportion of non-white caregivers (27% vs. 7%), 24% of whom were African American, and was overall heavier than the HEI sample (mean BMI = 26.58 vs. 24.84) (Bryant et al., 2008). It is also feasible that differences in findings may partly be due to differences in health behaviours and concerns. Although the UK environment is becoming increasingly similar to that of the US, it is generally less obesogenic (Rolls, 2003; Y. C. Wang et al., 2011).

More specifically, lower reliability results for savoury and sweet snack variety may be attributable to natural changes in food availability due to household purchase and consumption patterns. This possibility was explored by taking into account parent reports of how usual the amounts of snacks were across test and retest. Reliability was slightly higher for those who reported that the amount was consistent across time points, although the two groups were not directly compared to see whether differences were significant. How usual the amount of food/drink was in the home was also associated with the variety of each food type (fruit, vegetables, savoury snacks, sweet snacks, and confectionery) and the presence of sugar-sweetened drinks, so it was taken into account when creating the composite scores in an attempt to produce more accurate food availability scores.

Another possible reason for lower reliability is change in habits from test to retest. Simply talking about current habits may be sufficient to trigger behaviour change in those who are already in the early stages of behaviour change (Prochaska & Velicer, 1997). Although participants were not directly encouraged to reflect about their household routines, simply completing the HEI may have prompted reflection in some and caused them to modify some aspect of the environment. In line with this, several parents said at the end of the interview that answering the questions made them think about their home environment. At test-retest, one participant said that they had put a fruit bowl on display since the first interview as a way to encourage their child to eat fruit. Overall, although there were some lower reliability results, each variable had adequate reliability to be included in the composite scores.

The findings from the expert review were generally as expected from the existing literature. All of the variables identified by most experts (60% or more) as being associated with increased or decreased risk for weight gain have been associated with energy-balance behaviours (EBBs) in childhood, and some have been associated with weight. Of the home food environment variables, a majority of experts responded 'not sure' to the sugar-free drink variables, fruit juice variables, milk variables, parental pressure for the child to eat, and parental control of the child's food intake. Research has shown that home availability and accessibility of various beverages are associated with their consumption (Cullen et al., 2003; Grimm et al., 2004; Hanson et al., 2005). However, the role of sugar-free drink, fruit juice, and milk consumption in weight trajectories is unclear. Studies have reported positive (Berkey, Rockett, Willett, & Colditz, 2005; Dennison, Rockwell, & Baker, 1997; Giammattei, Blix, Marshak, Wollitzer, & Pettitt, 2003), negative (Barba, Troiano, Russo, Venezia, & Siani, 2005; de Ruyter, Olthof, Seidell, & Katan, 2012), and null (Newby et al., 2004; O'Connor, Yang, & Nicklas, 2006) associations between consumption of these beverages and child or adolescent weight. More research has focused on the role of sugar-sweetened beverages, with many (but not all) observational and experimental studies finding an association with weight (Malik, Pan, Willett, & Hu, 2013).

Findings from studies examining associations between parental feeding practices, eating behaviours, and weight have also been conflicting, particularly regarding the issue of control. One school of thought is that controlling feeding practices can have adverse effects on eating behaviour and weight (Birch et al., 2003; Faith, Scanlon, et al., 2004; Fisher & Birch, 1999b), while other research indicates that some form of control over feeding may protect against weight gain (De Bourdeaudhuij, 1997; Vereecken et al., 2004; Wardle et al., 2002). Parental pressure, control, restriction, covert restriction, and monitoring are all control-based practices; however, the first two reflect a control over any food intake, while the latter three are specifically concerned with the control of unhealthy food intake. This may explain why parental pressure and control were not identified by a majority of experts, but the other control-based practices were. There is some prospective evidence that practices limiting unhealthy food intake early in development protect against subsequent weight gain (Campbell et al., 2010; Farrow & Blissett, 2008). Other longitudinal research indicates that control-based practices are a response to rather than a cause of child weight (Rhee et al., 2009; Rifas-Shiman et al., 2011; Webber, Cooke, et al., 2010b). It is feasible that associations are bidirectional; however, more longitudinal research is needed to fully understand the role of different parental feeding practices in weight trajectories.

Of the home activity environment variables, presence of nearby indoor recreation centres, parental satisfaction with their neighbourhood, and a larger garden or outdoor space for the child to play in were variables classified by a majority of experts as ‘not sure’. Research showing associations between physical aspects of the neighbourhood environment and activity behaviour or weight has focused on recreational facilities in general (e.g. Gordon-Larsen, Nelson, Page, & Popkin, 2006; Kligerman, Sallis, Ryan, Frank, & Nader, 2007; Spence, Cutumisu, Edwards, & Evans, 2008), rather than specifically the presence of indoor facilities, which may explain the expert view. Neighbourhood satisfaction is more of a proxy measure of the environment and, while there is evidence for associations between aspects of the neighbourhood environment and weight (e.g. Dunton et al., 2009; Saelens et al., 2012; Wolch et al., 2011), less research has focused on this more subjective construct. A recent review of correlates of physical activity in preschool children did identify size of outdoor space as a relevant factor (De Craemer et al., 2012); more than half of the experts identified garden size as being associated with decreased risk for weight gain, therefore it was included in one of the composite variations.

Of the home media environment variables, a majority of experts responded ‘not sure’ to parental use of behaviour-contingent strategies to control their child’s media use. Unlike the parent feeding literature, there is little evidence examining the impact of such strategies on children’s sedentary behaviour and weight; existing research has focused on the impact of general time or content-based rules around media use (Hinkley et al., 2010; Hoyos Cillero & Jago, 2010).

The range of scores for each composite indicated that the obesogenic quality of homes within the sample was varied. However, the distributions for the activity and media composites were negatively skewed, with fewer families scoring at the upper tails. Scores on the food composite were normally distributed, with a slight skew for the overall composite. For all composites, the theoretical ranges indicated that the sample did not include the most extreme home environments in terms of obesogenic risk. This may be due to the nature of the Gemini sample, which comprises predominantly higher SES, white families, who may create less obesogenic home environments than lower SES (e.g. Barr-Anderson et al., 2008; Vereecken et al., 2004) and non-white groups (e.g. Chuang et al., 2013; Skala et al., 2012). Characteristics associated with the obesogenic quality of the home environment will be directly examined in Chapter 6. When looking at scores on individual aspects of the home environment, the findings were comparable to previous studies with similar samples. For example, average parental instrumental and emotional feeding scores (2.2 and 1.8, respectively) were very similar to those reported in another UK sample of families with 4-year-old twins (2.4 and 1.9) (Wardle et al., 2002); and the average total variety of fruit and vegetables (19) was comparable to that (22) reported in another higher SES sample of families with preschool children (Wyse, Campbell, Nathan, & Wolfenden, 2011). Differences were notable when comparing findings with those from lower SES and ethnically diverse preschool samples. For example, one study found that almost 40% of preschoolers had a TV in their bedroom (Dennison et al., 2002), while just 12% did in the present sample. Another study found that 10% of preschoolers had a video games console in their bedroom, compared to just 2% in this study, the average number of TVs per household was slightly higher than in this study (2.78 vs. 2.27, respectively), and the average number of computers was slightly lower (1.45 vs. 1.92, respectively) (Vandewater et al., 2007).

The small association between the home activity and media composites in the present study is in line with previous research showing that home environments may present risk for weight gain in some respects but not others (Martinson et al., 2011). For example, a home may have many TVs but also good access to physical activity facilities. The other home environment composites correlated positively with one another, suggesting that higher risk in one home environment domain is generally reflected in other domains. Taken together, the associations highlight the importance of adopting a comprehensive view of the home environment.

4.5.2 Limitations

The construction of composite indicators involves several stages where subjective judgement has to be made: selection of variables to be included, treatment of missing values, choice of aggregation method, and choice of weights to apply to each variable (Nardo et al., 2008). In the present study, the choice of variables to include in the composites was guided by feedback from an expert panel, and there were very few missing values to deal with. The aggregation method was selected as the most appropriate method as it standardised all variables while retaining a greater level of information than other methods would. In terms of weighting, there is currently insufficient information from the literature to determine differential weights for the home environment variables. While many previous studies have examined associations between aspects of the home environment and EBBs, the findings have not yet been systematically synthesised, and evidence for associations with weight is limited. Basing the weights on associations between aspects of the home environment and EBBs in this thesis would not have been appropriate as it is better practice to refer to meta-analyses, which provide effect sizes after taking into account a number of studies. It would also be important to include all EBBs relevant to each aspect of the home environment, which in practice may be difficult to achieve. In future research, it would be useful to see how differently weighted composites are related and how they each perform in classifying higher versus lower risk home environments. Existing research has shown that unit weighting produces composites that are highly correlated with, and perform as well as (if not better than), composites weighted by any other method, especially when the number of variables is large (Ree et al., 1998; Wainer, 1976; Wilks, 1938). As the home environment composites correlated highly with two different variations, this provided some support for their robustness. Subsequent analyses with the composites will be repeated using the composite variations as a further robustness check.

Although the HEI was comprehensive in that it assessed various physical and social aspects of the food, activity, and media domains, some potentially relevant variables were not included. For example, the quantity of food and drink in the home environment is an important aspect to consider (Wansink, 2004), but this was not assessed due to the anticipated difficulty in carrying out a food inventory by telephone, particularly given the sample size of Gemini. The reliability and validity results for the quantity of food and drink in the HHS were low to moderate (Bryant et al., 2008), suggesting that it may be difficult to accurately assess quantity by telephone. If quantity were to be included in composite indicators of the home environment, it may be better assessed using home visits; although this would be costly and labour-intensive with large sample sizes. Other variables potentially relevant to risk for childhood weight gain, namely whether the child had a wheeled toy, and other media equipment in their bedroom, were not included in the composites due to limited variation in responding.

Another possible limitation is the classification of energy-dense savoury snacks. As in the HHS, energy-dense savoury snacks were those typically regarded as ‘unhealthy’, including crisps, cheesy crackers, pretzels, and peanuts. ‘Healthier’ snacks such as rice cakes and plain crackers were not included due to their generally lower energy-density. However, ‘good junk foods’ may be processed, energy-dense, nutrient-poor products, with modest reductions of fat or portion size. The satiety value of such snack foods is arguably small, and could still promote overeating (Drewnowski, 1998; Rolls, Bell, Castellanos, et al., 1999). Future research could ask about all savoury snacks in the home and then examine associations with weight using different snack classifications. Although time-consuming, it may be useful to ask about specific brands of snacks in the home to obtain more detailed information.

While parental modelling of ‘healthy’ eating and physical activity were assessed using existing modelling scales, parental TV viewing behaviour was used as an indicator of parental modelling of sedentary behaviour. Although researchers have inferred that associations between child and parental behaviour reflect modelling (e.g. Davison et al., 2005; Kourlaba et al., 2009; Salmon et al., 2005), in hindsight, it would have been better to specifically ask about parental TV viewing in front of the child. Moreover, partner modelling of healthy eating and physical activity were not assessed in the HEI. Previous research indicates that maternal modelling may be particularly relevant to child weight trajectories (e.g. Kourlaba et al., 2009; Oliveria et al., 1992; Spurrier et al., 2008); although modelling by other caregivers and siblings may also be important (e.g. Crawford et al., 2010; Ferreira et al., 2007; Timperio et al., 2008). Future research using the home environment measure might therefore assess modelling by all adults and siblings living in the child's home.

Another limitation is that parental rules around media use were assessed in terms of simple presence or absence. In hindsight, it may have been better to use a more detailed measure of rules around media use. Some research has shown that children with parents who are more consistent in applying media rules watch less TV than those with parents who are inconsistent in their rule implementation (Gentile & Walsh, 2002). It would be useful to determine whether media-related rules are more or less influential when they are implicit or explicit, as there is no known research on this issue.

Child eating while watching TV was included as an aspect of the home media environment; however, it could be argued that this would be better placed as an aspect of the home food environment, as it is hypothesised to relate to child food and beverage consumption. More generally, child eating while watching TV is not strictly environmental, and might be better considered as an eating practice rather than an aspect of the home environment (although the same could be said for family mealtimes). Due to the uncertainty about the placement of child eating while watching TV, subsequent analyses will be repeated using a food composite that includes child eating while watching TV, and using a media composite that excludes this variable.

The home environment composites in this study were based on parent reports of the home environment, which may be prone to bias. There is some evidence that caregivers are more likely to report greater availability of fruits and vegetables in the home and that self-reported intake is more likely to relate to child report, suggesting parent response bias (Cullen et al., 2003; De Bourdeaudhuij et al., 2005). Although attempts were made to reduce bias, specifically by asking participants to answer honestly and affirming the anonymity of their responses, there is evidence that social desirability bias may be more pronounced when using telephone interviews than self-administered paper-based questionnaires (Aquilino & Sciuto, 1990; Bowling, 2005; Fowler, 2009; Hochstim, 1967; Wiseman, 1972). Future research could attempt to adjust for social desirability using a scale that measures the tendency to respond in a socially desirable way, such as the Marlow-Crowne Scale (Crowne & Marlowe, 1960). However, as research suggests that such measures cannot fully address the issue of social desirability (Nederhof, 1985), it would also be useful to see how composites based on objective measurement of the home the environment compare to those based on parent reports.

Although the present study examined test-retest reliability, other psychometric properties such as inter-rater reliability and convergent validity were not assessed. The CHES, another comprehensive measure of the home environment, reported adequate inter-rater reliability and convergent validity (Pinard et al., 2013), providing some support that comprehensive measures are robust in this sense. Perhaps the most important psychometric property to test is criterion validity. The HHS did provide evidence for the criterion validity of various aspects of the home environment, although some aspects could not be validated (Bryant et al., 2008). The following study will examine the utility of a novel tool called 'SenseCam' to examine and validate aspects of the home environment, including those that cannot be captured in standard home visits.

4.5.3 Conclusion

This study developed a comprehensive measure of the home environment in early childhood, along with a composite scoring procedure to quantify the extent to which the home environment presents risk for childhood weight gain.

Chapter 5. Using a wearable camera to validate aspects of the Home Environment Interview

5.1 Background

Chapter 4 described the development of the Home Environment Interview (HEI). Consistent with the Healthy Home Survey (HHS) (Bryant et al., 2008) items within the HEI showed generally moderate to high test-retest reliability. As discussed in Chapter 1, a strength of the HHS development is that the authors also assessed criterion validity (the extent to which a measure relates to concrete criteria in the 'real world'), which few others have done (Pinard et al., 2012). Demonstrating the criterion validity of parent- or self-reported measures (which are prone to social-desirability and recall biases) is important to ensure that the results of studies using these measures are largely unattributable to measurement error. In the case of the home environment, measurement error may explain the inconsistent associations with child weight.

Validity estimates for the HHS were varied, with lower results for aspects of the home food environment including the variety of fresh fruit and energy-dense snacks (Bryant et al., 2008) Moreover, behavioural and social aspects of the HHS, such as mealtime structure and parental TV viewing, could not be validated using single home visits. Although multiple home visits can provide further insight (e.g. Sisk, Sharkey, McIntosh, & Anding, 2010), they are costly and labour intensive.

5.1.1 Introducing SenseCam

In addition to self-report measures and home visits, there are a variety of technologies that can be used to objectively examine aspects of the home food, media and activity environments. Accelerometers measure the degree of motion at the hip and have been extensively used as an objective measure of physical activity and sedentary behaviour in children and their parents (Reilly et al., 2008; Ruiz, Gesell, Buchowski, Lambert, & Barkin, 2011); Geographic Information Systems (GIS), which analyse various geographic data, have been used to objectively measure neighbourhood access to physical activity facilities (Witten, Hiscock, Pearce, & Blakely, 2008); and Global Positioning Systems (GPS), satellite-based global navigation systems, have been used in conjunction with accelerometers and GIS to determine individuals' locations during their activity routines (Maddison & Mhurchu, 2009). While these technologies have been insightful, particularly for measuring activity level and the neighbourhood environment, they cannot visually capture the immediate home environment.

In the food domain, some researchers have used disposable cameras to capture intake (Dodson et al., 2009) and the home food environment from the child's perspective (Briggs & Lake, 2011). Video recording has long been used by developmental researchers to assess child-parent interactions, including those at mealtimes (e.g. Crittenden & Bonvillian, 1984; Gunning et al., 2004; Wilson et al., 2011). Although insightful, standard picture or video cameras are limited in the extent to which they can capture the wider home environment. Standard picture cameras do not permit continuous recording; image capture is completely reliant upon the action of the user. Although video cameras allow continuous recording and require little user intervention, they do not capture events from the first-person perspective (unless carried by the person of interest, which is not practical for research requiring on-going recording), which would provide a more detailed and naturalistic account of an individual's surroundings and how they interact with their surroundings.

Visual 'life-logging' refers to the passive digital capture of everyday activities from the first-person perspective. Researchers in the computing and engineering domains have developed numerous devices designed for visual life-logging (Bell & Gemmell, 2007). In 2003, Microsoft developed a wearable digital camera called SenseCam[3], designed to take pictures automatically (approximately every 20 seconds) when triggered by sensors that log temperature, light, acceleration, and passive infrared data (Hodges et al., 2006). The advantage of SenseCam is that it is straight forward to use, has a long battery life (up to 16 hours), a large storage capacity (over one week's worth of images), and does not record sound. When worn, SenseCam is reasonably close to the wearer's eye line and has a wide-angle lens to capture everything within the wearer's view (see **Figure 5.1**). Each image is time-stamped so duration of specific events or activities can be deduced.

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[3] Commercially known as the Vicon Revue: http://viconrevue.com/

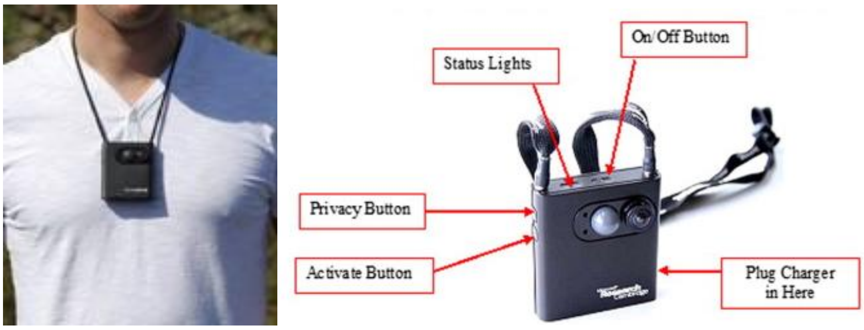

Figure 5.1. Wearing SenseCam (left) and SenseCam features (right)
Sources: http://www.clarity-centre.org/sensecam2010/; Doherty et al., 2011

SenseCam has predominantly been used in memory research as a rehabilitation tool for those with cognitive impairments, with positive results (e.g. Berry et al., 2009; Pauly-Takacs, Moulin, & Estlin, 2011). More recent applications include memory support in healthy participants (Doherty et al., 2012), language learning (Hou, Ogata, Li, & Uosaki, 2012), market research (Hughes, Newman, Smeaton, & O'Connor, 2012), and social sharing of everyday images in school (Fleck & Fitzpatrick, 2009) and family contexts (Lindley, Glancy, Harper, Randall, & Smyth, 2011). In the food and activity domains, researchers have started to explore how SenseCam can be used to assess dietary intake, physical activity, and sedentary behaviour[4]. Recent research has compared SenseCam images with self-reported travel diaries (P. Kelly et al., 2011, 2012) and food diaries (O'Loughlin et al., 2013), highlighting the utility of a wearable camera to validate self-report measures. No studies have used a wearable camera to examine the obesogenic home environment.

[4] http://sensecam2012.dph.ox.ac.uk/programme-1

5.2 Aim

To use a device called ‘SenseCam’ in an exploratory study to validate aspects of the HEI.

Two primary questions will be investigated:

i. Which aspects of the home environment does SenseCam capture?

   The study will examine the kind of information captured by SenseCam during the wearing period and how this compares to the information captured by the HEI.

ii. Do SenseCam images differ from responses to the HEI?

   In cases where SenseCam captures information also captured in the HEI, the extent of agreement between the two measures will be examined.

5.3 Methods

5.3.1 Ethical approval

Ethical approval for the study was granted by the UCL Ethics Committee for Research Involving Human Subjects (project approval no. 3792/001).

The letter of ethical approval is included in **Appendix 5.1**.

5.3.2 Sample and recruitment

Data collection started in July 2012 and ended in May 2013, which was the designated recruitment period. Participants were parents of young children (aged 2 to 8 years) who had taken part in previous research at University College London and agreed to be contacted about future research. A total of 94 parents were invited to take part in the study. First, a letter was sent to parents informing them about the study. Parents who had not responded to the letter were followed-up with a telephone call. Participants completed a consent form before taking part in the study. Any other adults living in the home also consented to participation. Data were collected by one researcher (SS) using two cameras, which were on loan from the SenseCam steering committee (see **Appendix 5.2** for the loan application form).

The contact letter, participant information sheets, and consent forms are included in **Appendix 5.3**.

5.3.3 Procedures

Once the consent forms were received, a suitable time was arranged for the participant to complete the HEI. Before starting the HEI, parents were asked if they had more than one child living in the home and how old each child was. If there were additional children, participants were asked to respond with regard to the child who was closest to 4 years of age (the average age of the Gemini children at the time of the HEI). Participants completed the HEI while at home, following the standard procedure (as a telephone interview). Participants were visited at home and shown how to use the SenseCam 7 to 24 days (mean = 11.87; SD = 5.82) after completing the HEI. Participants were asked to wear the camera during waking hours while at home for 4 consecutive days (including at least one weekend day, to capture a more representative picture of the home environment). A 4-day wearing period was chosen to strike a balance between capturing sufficient information about the home environment for the purposes of the study and minimising participant burden. Participants were asked to remove the camera whenever they went outside of the home. Although previous research has used SenseCam outside the home setting (e.g. (P. Kelly et al., 2011, 2012)), it was not necessary for the purposes of this study. Participants wore the SenseCam on a lanyard round their neck with adhesive fashion tape attached to the back to reduce movement. Instructions were provided on how to turn the camera on and off and how to charge it. Participants were told that they were free to turn off or remove the camera when they did not feel comfortable wearing it, such as in the bathroom or when doing online banking. A statement was provided for participants to use if they encountered other people while wearing the camera. Previous research has found that this approach is sufficient to satisfy the curiosity or allay any concerns of other members of the public ((P. Kelly et al., 2011)). After the wearing period, the camera was collected from the participant's home. A semi-structured interview was carried out to assess participants' experience of wearing the camera. Participants also had the opportunity to view and delete their images if they did not wish to have them stored for analysis. For viewing, images were downloaded to a password-protected laptop and shown using the Oxford and CLARITY-DCU SenseCam browser[5], developed specifically for the viewing of SenseCam images.

The topics covered in the semi-structured interview are included in **Appendix 5.4**.

5.3.4 Statistical analysis

5.3.4.1 Sample characteristics

To check for response bias, characteristics of participating parents were compared with those of non-responding parents. Independent t-tests were used for continuous dependent variables and chi-square tests were used for categorical variables.

5.3.4.2 Coding

The SenseCam images were manually coded using The Oxford and CLARITY-DCU SenseCam browser. Researchers have developed computer scripts that automatically segment images into particular events or groupings, also known as automatic segmentation procedures (Doherty & Smeaton, 2008). Although this approach is particularly beneficial when dealing with large amounts of data, it has not yet been used to classify images of the home environment and further work would be needed to develop such a script and confirm the reliability.

A set of home environment features that could feasibly be captured by the SenseCam was drawn up and included the following: the availability of

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[5] http://sensecambrowser.codeplex.com/

fruit/vegetables/energy-dense snacks/drinks in the home, whether fruit/vegetables/energy-dense snacks/drinks were displayed in the open (or ready-to-eat in the case of vegetables), family mealtimes, the presence of a garden and garden play equipment, the availability of TVs/VCR or DVD players/games consoles/computers in the home, the presence of a TV/games console/computer in the child's bedroom, and the caregiver's TV viewing. Home environment features that could not feasibly be captured by the SenseCam were mainly non-tangible or social aspects and included the following: whether the child was allowed to help themself to fruit/vegetables/energy-dense snacks/drinks, the frequency the child was allowed to play inside/outside the home, whether there were parks/indoor recreation centres close to the home, and whether there were any rules around media use. The presence of cable or satellite TV and child eating while watching TV were identified as features that may be difficult to capture as a cable or satellite box may be hidden, and capturing the child's behaviour depended on whether the wearer was with (or near) the child.

Each image was visually inspected and coded for the presence or absence of each environmental feature. A feature was coded as absent if it was not seen in the images. For many home environment features, it was not possible to determine their absolute absence. This was particularly the case for the availability of food and media equipment, which could be stored in places that were not accessed during the wearing period. Features could also be missed due to the poor quality of some images. Features that could be identified as absent with greater certainty (due to their salience) included the display of food/drink, a TV in the child's bedroom, and garden equipment, provided that the caregiver wore the camera in the relevant places. Bedroom media equipment was coded as missing if the child's bedroom wasn't visible. Garden equipment was coded as missing if the garden wasn't visible. Satellite TV was coded as missing if it wasn't possible to determine from the TV set.

Food variety was calculated by summing the total number of items within the particular category observed during the wearing period. Similarly, the number of TVs/computers/games consoles was the sum of the items observed during the wearing period. For the caregiver's weekday and weekend TV viewing, an average time was calculated for each period of the day (morning, afternoon, and evening), using the data available. For example, if the participant wore the camera on two weekday evenings, the average of these two times was taken to represent TV viewing duration for a typical weekday evening. If the participant only wore the camera on one weekday evening, this one time was used to indicate duration. For caregiver TV viewing (morning/afternoon/evening) and family mealtimes (breakfast/lunch/dinner), data were coded as missing if the participant did not wear the camera during the particular time. For child eating while watching TV (breakfast/lunch/dinner), data were coded as missing if the participant did not wear the camera around their child at the particular time.

Images were classified as uncodeable if features could not be determined due to low light levels, something covering the lens, or extreme blurring.

5.3.4.3 Reliability

Because the data were coded manually, and by a single coder, it was important to carry out consistency checks. The level of inconsistency in coding (which may arise from factors such as mood, fatigue, and noise) can be assessed using intra- and inter-rater reliability. Intra-rater reliability estimates the level of consistency in observations made by a single coder over time; inter-rater reliability estimates the level of consistency in observations made by two or more independent coders (all observations are guided by a pre-established scoring procedure) (Downing, 2004; Fleiss, 1986). For intra-rater reliability, one randomly selected days' worth of images was recoded by the original coder after study-completion. For inter-rater reliability, an independent coder analysed another randomly selected days' worth of images. Agreement was determined by calculating and comparing the percentage of home environment features identified across coding sessions.

5.3.4.4 Validity

SenseCam images were compared to responses provided during the HEI. Intraclass correlation coefficients (for continuous variables) and percent agreement, kappa statistics, and proportion of positive and negative agreement (for categorical variables) were used to produce validity estimates. Typically, the terms ‘sensitivity’ and ‘specificity’ are used to describe the validity of a particular measure, in place of the proportion of positive and negative agreement. In general terms, sensitivity refers to the ability of a measure to detect an existing phenomenon; specificity refers to the ability of a measure to confirm the absence of a non-existent phenomenon (Altman & Bland, 1994). Ideally, validity should be evaluated by comparison to a gold reference standard, such as direct observation by trained researchers during a home visit; error in the reference standard produces bias in sensitivity and specificity estimates (Albert & Dodd, 2004; Begg, 1987). When a measure is evaluated by comparison to a non-reference standard, as in the present study, it is recommended that researchers refer to the extent of positive and negative agreement between two measures rather than sensitivity and specificity, which directly assess the accuracy of a measure (FDA, 2007).

5.4 Results

5.4.1 Sample characteristics

Of the 94 parents contacted, 15 (16%) took part in the study. Three of the participating parents responded to the initial contact letter; the remaining participants responded to the follow-up telephone call. Thirty-four parents (36%) did not respond to the initial letter and could not be contacted by telephone or email. Among those who responded and did not wish to participate in the study (n = 45), 28 (62%) cited discomfort with wearing the camera as the reason; 17 (38%) cited other reasons such as lack of time. The sample included 13 mothers and 2 fathers. All participants were main caregivers of their children. Parent and child characteristics of the study sample are shown in **Table 5.1**. Parents had a mean age of 38 years, more than three quarters were white and had a high education level, and two thirds had more than one child living in the home. On average, parents consumed 2 ½ servings of fruit and 2 servings of vegetables per day. Children had a mean age of 4 years, two thirds were male, and almost two thirds were white.

Table 5.1. Characteristics of families who took part in the SenseCam study compared to non-responders (% (n), unless stated otherwise)

	Non-responders (N = 79)	**SenseCam sample (N = 15)**
Parent characteristics		
Age (years), mean (SD)	36.87 (7.22)[1]	38.57 (6.37)[2]
Education level		
Low	18.2 (14)[3]	6.7 (1)
Intermediate	29.9 (23)	13.3 (2)
High	51.9 (40)	80.0 (12)
Ethnicity		
White	73.8 (45)[4]	86.7 (13)
Other	26.2 (16)	13.3 (2)
Number of children in the home		
One	-[5]	33.3 (5)
More than one	-	66.6 (10)
Fruit consumption (servings per day), mean (SD)	2.26 (1.17)[6]	2.53 (0.92)
Vegetable consumption (servings per day), mean (SD)	2.27 (1.36)[6]	2.40 (1.30)
Child characteristics		
Age (years), mean (SD)	4.64 (1.16)	4.75 (1.73)
Sex		
Male	46.8 (37)	66.6 (10)
Female	51.9 (41)	33.3 (5)
Ethnicity		
White	55.7 (44)	60.0 (9)
Other	43.1 (34)	40.0 (6)

Education level categorised as: low (no qualifications or basic high-school education, intermediate (vocational or advanced high-school education), and high (university-level education).

[1]Data were missing for 8 participants on this variable (N = 71).
[2]Data were missing for 1 participant on this variable (N = 14).
[3]Data were missing for 2 participants on this variable (N = 77).
[4]Data were unavailable for 18 participants on this variable (N = 61).
[5]Data were only available for participants in the SenseCam study.
[6]Data were missing for 1 participant on this variable (N = 78).

There was no significant difference between the age of parents who took part in the SenseCam study and the age of non-responders ($t(83) = -0.819$, $p = 0.415$). More parents who completed the SenseCam study (80%) had a high education level compared to non-responders (52%); fewer parents in the SenseCam study (7%) had a low education level compared to non-responders (18%); although this difference was not statistically significant ($\chi^2(2) = 4.03$, $p = 0.133$). A greater proportion of white parents took part in the SenseCam study (87%) than non-responders (74%); fewer non-white parents took part in the SenseCam study (13%) compared to the proportion of non-white non-responders (26%); although this difference was not statistically significant ($\chi^2(1) = 1.11$, $p = 0.293$). There were no significant differences between the number of servings of fruit and vegetables eaten per day when comparing SenseCam participants and non-responders ($t(91) = -0.868$, $p = 0.388$ and $t(91) = -0.342$, $p = 0.733$, respectively).

5.4.2 Descriptive statistics

Participants wore the SenseCam for an average of 4 days (SD = 1.13; range = 1 – 5). For all but 4 participants, the wearing period included at least one weekend day; 3 participants were only able to wear the camera during the week, and one participant only wore the camera on one weekday[6]. Most participants wore the camera for at least one morning (n = 13), at least one afternoon (n = 12), and at least one evening (n = 11). The average wearing time per day was 5.93 hours (SD = 2.55; range = 1.93 – 9.67). One researcher (SS) coded a total of 60 days of data (75, 818 images). It took 100 hours to code the data.

All of the anticipated home environment features were captured to some extent. What was captured by SenseCam depended on the duration of the wearing period (11 features were captured during the shortest wearing period; 20 features were captured during the longest wearing period), and the participant's behaviour during this period. As shown in **Table 5.2**, fresh fruit and vegetables were captured in all

[6] This participant was not excluded from the analysis as the wearing period provided some, albeit limited, information about the home environment. Specifically, although it was not possible to determine maternal TV viewing or mealtimes, there was some information on physical aspects of the home environment, such as food availability and media equipment. Further, the short wearing period was apparently not due to any discomfort with the camera; the participant revealed that they simply had not had the time to wear it for the full wearing period.

cases, tinned and frozen foods were rarely captured, and energy-dense snacks were captured to a slightly less extent than reported in the HEI. In almost all cases, it was not possible to determine the sugar-content of drinks. It was possible to identify milk type using the colour of the bottle tops. The presence of cable or satellite TV was rarely captured, and child snacking while watching TV was also captured less frequently than reported in the HEI (see **Table 5.3**). In total, 4470 images were classified as uncodeable. **Figure 5.2** shows some sample images of environmental features.

Table 5.2. Descriptive statistics for HEI-reported and SenseCam-captured home food environment features (N = 15; % (n) who responded yes, unless stated otherwise)

	HEI	**SenseCam**
Availability (Yes/No)		
Fruit		
Fresh	100 (15)	100 (15)
Tinned	40 (6)	0 (0)
Dried	60 (9)	26.7 (4)
Frozen	20 (3)	0 (0)
Vegetables		
Fresh	93.3 (14)	100 (15)
Tinned	93.3 (14)	46.7 (7)
Frozen	86.7 (13)	26.7 (4)
Energy-dense snacks		
Savoury snacks	66.7 (10)	53.3 (8)
Sweet snacks	80 (12)	40 (6)
Confectionery	66.7 (10)	26.7 (4)
Non-alcoholic drinks		
Squash	33.3 (5)	26.7 (4)
Fruit juice	53.3 (8)	73.3 (11)
Fizzy drinks	13.33 (2)	26.7 (4)
Smoothies	20 (3)	6.7 (1)
Skimmed/semi-skimmed milk	66.67 (10)	86.7 (13)
Full-fat milk	33.3 (5)	40 (6)
Variety, mean (SD)		
Fruit		
Fresh	3.53 (1.36)	4.47 (2.29)
Tinned	0.60 (0.91)	0.33 (0.62)
Dried	1.93 (1.91)	0 (0)
Frozen	0.20 (0.41)	0 (0)

	HEI	SenseCam
Vegetables		
Fresh	6.33 (3.02)	6.67 (3.13)
Tinned	3.87 (1.68)	0.80 (1.01)
Frozen	1.73 (1.39)	0.27 (0.46)
Energy-dense snacks		
Savoury snacks	1.13 (1.13)	0.67 (0.72)
Sweet snacks	1.53 (1.13)	0.67 (1.05)
Confectionery	0.93 (0.80)	0.27 (0.46)
Displayed (Yes/No)		
Any fruit	100 (15)	93.3 (14)
Any ready-to-eat vegetables	13.3 (2)	0 (0)
Savoury snacks	0 (0)	0 (0)
Sweet snacks	20 (3)	13.33 (2)
Confectionery	6.7 (1)	6.7 (1)
Squash	13.3 (2)	20 (3)
Fruit juice	0 (0)	0 (0)
Fizzy drinks	6.7 (1)	0 (0)
Smoothies	0 (0)	0 (0)
Family meals (Yes/No)		
Breakfast[1]	84.6 (11)	84.6 (11)
Lunch[2]	100 (12)	83.3 (10)
Dinner[1]	84.6 (11)	92.3 (12)

[1] Data were missing in 2 cases: 1 did not wear SenseCam at breakfast/dinner time; the other said in the semi-structured interview that they had modified their mealtime routine.
[2] Data were missing in 3 cases: 2 did not wear SenseCam at lunchtime; the other said that they had modified their mealtime routine.

Table 5.3. Descriptive statistics for HEI-reported and SenseCam-captured home activity and media environment features (N = 15, unless stated otherwise; % (n) who responded yes unless stated otherwise)

	HEI	**SenseCam**
Home activity environment		
Garden/outdoor space	80 (12)	67 (10)
Garden play equipment[1]	17 (2)	8 (1)
Home media environment		
No. of TVs, mean (SD)	1.53 (1.13)	1.60 (1.12)
No. of DVD/VCR players, mean (SD)	1.47 (0.99)	1.27 (0.88)
No. of computers, mean (SD)	2.40 (0.99)	1.60 (0.94)
No. of games consoles, mean (SD)	0.73 (0.96)	0.20 (0.56)
Cable or satellite[2]	75 (3)	75 (3)
Bedroom media equipment (Yes/No)		
TV[3]	15 (2)	23 (3)
Computer[3]	8 (1)	8 (1)
Games console[3]	15 (2)	8 (1)
Child eating while watching TV		
Breakfast[4]	0 (0)	17 (2)
Lunch[5]	0 (0)	0 (0)
Dinner[4]	8 (1)	8 (1)
Snacks[6]	36 (5)	14 (2)
Main caregiver TV watching (hours), mean (SD)		
Weekday[7]	1.70 (1.31)	1.24 (0.67)
Weekend[8]	2.39 (1.67)	1.49 (0.81)

[1] Data were missing in 3 cases where the garden was only partially visible during the wearing period.
[2] Data were missing in 10 cases where the presence of satellite/cable TV could not be determined from the TV set during the wearing period.
[3] Data were missing in 2 cases where the child's bedroom was not visible during the wearing period.
[4] Data were missing in 3 cases: 1 did not wear SenseCam at breakfast/dinner time; 1 said in the semi-structured interview that they had modified their mealtime routine; the other did not have breakfast/dinner with their children during the wearing period.
[5] Data were missing in 5 cases: 2 did not wear SenseCam at lunchtime; 1 said that they had modified their mealtime routine; the other 2 did not have lunch with their children during the wearing period.
[6] Data were missing in 1 case where the caregiver did not wear SenseCam around their child.
[7] Data were missing in 6 cases where the caregiver did not wear SenseCam for all of the weekday periods (morning/afternoon/evening).
[8] Data were missing in 7 cases where the caregiver did not wear SenseCam for all of the weekend periods (morning/afternoon/evening).

______Family meal_____//______TV watching_____//_____Food storage______

Figure 5.2. Sample SenseCam images

5.4.3 Validity

Validity estimates for the home food environment variables are shown in **Table 5.4**. For food availability (Yes/No), percent agreement was generally high, with the highest scores for fresh fruit (100) and fresh vegetables (93), and lowest scores for sweet snacks (33) and frozen vegetables (40). Kappa scores were variable (0.11 – 0.73), with the lowest score for frozen vegetables and the highest score for full-fat milk. Kappa scores were not calculated for fresh fruit (which had 100% agreement), and tinned fruit, frozen fruit, and fresh vegetables (where all responses were in one direction (i.e. all 'yes' or all 'no') at the time of the HEI or as captured by SenseCam). The proportion of positive agreement ranged from 0.00 (for tinned fruit) to 1.00 (for fresh fruit). The proportion of negative agreement ranged from 0.00 (for fresh fruit and fresh vegetables) to 0.92 (for smoothies). For food variety, intraclass correlations were generally low, with the exception of fresh vegetables (0.72); the lowest value was for frozen vegetables (0.00).

For the display of food and drink, percent agreement was generally high, with 100% agreement for the display of savoury snacks, fruit juice, and smoothies. Lower percent agreement was found for the display of sweet snacks (67). Kappa scores were very low for the display of sweet snacks (-0.19) and confectionery (-0.07); kappa was higher for the display of squash (0.76). Kappa scores were not calculated for the display of savoury snacks, fruit juice, and smoothies (which had 100% agreement), and the display of fruit and fizzy drinks (where all responses were in one direction (i.e. all 'yes' or all 'no') at the time of the HEI or as captured by

SenseCam). The proportion of positive agreement ranged from 0.00 to 0.97 (for fruit); the proportion of negative agreement ranged from 0.00 to 1.00.

Percent agreement for family meals (Yes/No) was high, with 100% agreement for eating breakfast as a family. Kappa was 0.63 for eating lunch as a family; scores could not be calculated for breakfast (which had 100% agreement) and lunch (where all participants responded yes at the time of the HEI but SenseCam did not capture this). The proportion of positive agreement ranged from 0.91 to 1.00; the proportion of negative agreement ranged from 0.00 to 1.00.

Validity estimates for the home activity and media environment variables are shown in **Table 5.5**. For the presence of a garden and play equipment, percent agreement was high and kappa scores were substantial. The proportion of positive agreement was 0.91 for the presence of a garden and 0.67 for the presence of play equipment. The proportion of negative agreement was 0.75 and 0.95, respectively.

Intraclass correlation coefficients for the number of household TVs and VCR/DVD players were high. Values were lower for the number of household computers and games consoles. There was 100% agreement for the presence of satellite or cable TV (discounting cases with missing data).

For child eating while watching TV, percent agreement ranged from 64% for snacks to 92% for lunch and dinner. Kappa was 0.63 for eating dinner while watching TV; scores were low for eating breakfast and snacks while watching TV. Kappa could not be calculated for eating lunch while watching TV as one participant responded yes at the time of the HEI but there were no yes responses captured by SenseCam.

For parental TV viewing, intraclass correlation coefficients were moderate.

Table 5.4. Agreement between HEI-reported and SenseCam-captured features of the home food environment

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)	Ppos	Pneg
Availability (Yes/No)					
Fresh fruit	-	100	+	1.00	0.00
Tinned fruit	-	60	+	0.00	0.75
Dried fruit	-	67	0.39 (0.06 – 0.72)	0.62	0.71
Frozen fruit	-	80	+	0.00	0.89
Fresh vegetables	-	93	+	0.97	0.00
Tinned vegetables	-	53	0.12 (-0.11 – 0.35)	0.67	0.22
Frozen vegetables	-	40	0.11 (-0.09 – 0.30)	0.47	0.31
Savoury snacks	-	73	0.45 (0.04 – 0.87)	0.78	0.67
Sweet snacks	-	33	0.13 (-0.07 – 0.32)	0.50	0.14
Confectionery	-	60	0.31 (-0.07 – 0.69)	0.57	0.63
Fruit juice	-	80	0.59 (0.16 – 1.01)	0.84	0.73
Squash	-	80	0.51 (0.06 – 0.97)	0.67	0.84
Fizzy drinks	-	73	0.19 (-0.35 – 0.72)	0.33	0.83
Smoothies	-	87	0.44 (-0.17 – 1.06)	0.50	0.92
Skimmed/semi-skimmed milk	-	80	0.47 (0.07 – 0.88)	0.87	0.57
Full-fat milk	-	87	0.73 (0.41 – 1.04)	0.83	0.89

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)	Ppos	Pneg
Variety					
Fresh fruit	0.43 (-0.09 – 0.76)	-	-	-	-
Tinned fruit	+	-	-	-	-
Dried fruit	0.19 (-0.34 – 0.63)	-	-	-	-
Frozen fruit	+	-	-	-	-
Fresh vegetables	0.72 (0.35 – 0.90)	-	-	-	-
Tinned vegetables	0.28 (-0.25 – 0.68)	-	-	-	-
Frozen vegetables	0.00 (-0.49 – 0.50)	-	-	-	-
Total snacks	0.48 (-0.03 – 0.79)	-	-	-	-
Savoury snacks	0.37 (-0.15 – 0.73)	-	-	-	-
Sweet snacks	0.46 (-0.04 – 0.78)	-	-	-	-
Confectionery	0.38 (-0.14 – 0.74)	-	-	-	-
Displayed (Yes/No)					
Any fruit	-	93	+	0.97	0.00
Savoury snacks	-	100	+	0.00	1.00
Sweet snacks	-	67	-0.19 (-0.40 – 0.02)	0.00	0.80
Confectionery	-	87	-0.07 (-0.19 – 0.05)	0.00	0.93
Fruit juice	-	100	+	0.00	1.00

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)	Ppos	Pneg
Squash	-	93	0.76 (0.26 – 1.26)	0.80	0.96
Fizzy drinks	-	93	+	0.00	0.97
Smoothies	-	100	+	0.00	1.00
Family meals (Yes/No)					
Breakfast[1]	-	100	+	1.00	1.00
Lunch[2]	-	83	+	0.91	0.00
Dinner[1]	-	92	0.63 (-0.09 – 1.35)	0.97	0.67

Ppos = proportion of positive agreement; Pneg = proportion of negative agreement.
[1] 2 cases were coded as missing: 1 participant did not wear the SenseCam during breakfast-time; 1 participant said during the semi-structured interview that they had modified their mealtime routine.
[2] 3 cases were coded as missing: 2 participants did not wear the SenseCam during lunch-time; 1 participant had modified their mealtime routine.
- Not applicable.
+ ICC was not calculated due to zero variance items or Kappa could not be calculated due to cell counts equalling zero.

Table 5.5. Agreement between HEI-reported and SenseCam-captured features of the home activity and media environments[1]

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)	Ppos	Pneg
Activity facilities (Yes/No)					
Garden	-	87	0.67	0.91	0.75
Garden equipment[2]	-	92	0.63	0.67	0.95
Household media equipment (variety)					
Number of TVs	0.97 (0.92 – 0.99)	-	-	-	-
Number of VCR/DVD players	0.82 (0.55 – 0.94)	-	-	-	-
Number of computers	0.30 (-0.23 – 0.69)	-	-	-	-
Number of games consoles	0.55 (0.08 – 0.82)	-	-	-	-
Presence of cable or satellite[3]	-	100	+	1.00	1.00
Bedroom media equipment (Yes/No)[4]					
TV	-	93	0.76 (0.27 – 1.25)	0.80	0.96
Computer	-	100	+	1.00	1.00
Console	-	93	0.63 (-0.06 – 1.33)	0.67	0.96
Child eating while watching TV (Yes/No)	-	73	0.48 (0.10 – 0.87)	0.67	0.78
Breakfast[5]	-	77	-0.11 (-0.31 – 0.08)	0.00	0.87

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)	Ppos	Pneg
Lunch[6]	-	92	+	0.00	0.87
Dinner[5]	-	92	0.63 (-0.16 – 1.41)	0.67	0.96
Snacks[7]	-	64	0.10	0.29	0.76
Caregiver TV viewing (hours)					
Weekday[8]	0.55 (-0.13 – 0.88)	-	-	-	-
Weekend[9]	0.57 (-0.15 – 0.90)	-	-	-	-

Ppos = proportion of positive agreement; Pneg = proportion of negative agreement.
[1] Home activity and media environment variables are included in the same table due to the small number of home activity environment variables.
[2] 3 cases were coded as missing as the garden wasn't fully visible during the wearing period.
[3] It was only possible to determine the presence/absence of cable or satellite in 4 cases; the remaining cases were coded as missing.
[4] 2 cases were coded as missing as the child's bedroom was not visible during the wearing period.
[5] Data were missing in 3 cases: 1 did not wear SenseCam at breakfast/dinner time; 1 said in the semi-structured interview that they had modified their mealtime routine; the other did not have breakfast/dinner with their children during the wearing period.
[6] Data were missing in 5 cases: 2 did not wear SenseCam at lunchtime; 1 said that they had modified their mealtime routine; the other 2 did not have lunch with their children during the wearing period.
[7] Data were missing in 1 case where the caregiver did not wear SenseCam around their child.
[8] Data were missing in 6 cases where the caregiver did not wear SenseCam for all of the weekday periods (morning/afternoon/evening).
[9] Data were missing in 7 cases where the caregiver did not wear SenseCam for all of the weekend periods (morning/afternoon/evening).
- Not applicable.
+ Kappa could not be calculated due to cell counts equalling zero.

5.4.4 Reliability

There was almost 100% agreement for intra- and inter-rater reliability. For intra-rater reliability, one extra type of fresh fruit was identified in the second bout of coding. However, this fruit type had been picked up in other days of the original coding so the information was not missed from the main analysis. For inter-rater reliability, one piece of media equipment was coded as a computer by the original coder and as a TV by the second coder. When referring to the participant's data for other days, it could be clarified that the original classification (computer) was correct.

5.4.5 Acceptability

All but 1 participant completed the semi-structured interview. In terms of general usage, all completing participants said that the SenseCam was straight forward to use. One participant initially had trouble charging the camera and 2 participants initially forgot to charge it, but all soon got into the routine. One participant thought that the neck strap was slightly uncomfortable and 3 participants suggested using a clip as an alternative attachment. Two participants with younger children said that the camera sometimes got in the way when they picked up their children. Another participant suggested using a smaller-sized, more discreet camera.

Seven participants said that they forgot to wear the camera on some occasions: 6 said when they were returning from an outing, 1 said when they were rushing in the morning to get ready for work, and 1 said when their children were not around. Situations where participants said they chose not to wear the SenseCam included trips to the bathroom, getting their children ready for bed, changing their child's nappy, and when they had a visitor. While wearing the SenseCam, all participants said that they were intermittently aware of it, although the extent of awareness varied. Two participants forgot to remove the SenseCam when going outside the home.

Situations reported to heighten participants' awareness of the camera included taking it off and putting it back on after a non-wearing period, the light flashing when a picture was taken, their child reacting to the camera, while telling their child off, when in the bathroom or getting dressed, and when preparing food or eating. Participants generally reported that they were less aware of the camera during sustained wearing periods and as time went on. Almost all participants said that wearing the SenseCam made them think about certain aspects of their behaviour and household routines. One participant said that they were aware they watched too much TV and drank too much wine in the evening; another participant said that they may be too accommodating with their child's fussy eating habits; another said that they realised they didn't spend enough time with their children; and another felt that their children were not eating healthily, watched too much TV, and needed to do more constructive activities. Although many participants reported that they were aware of their behaviour, most said that wearing the camera did not modify it. Two participants said that wearing the camera did affect their behaviour; one said that they made more of an effort to eat with their child; the other said that they tried to have meals at the table instead of while watching TV and that they tried to play games with their child instead of watching TV.

Eight participants said that their children reacted in some way to the SenseCam. All reported that their children were interested in the camera, although this generally lessened with time. Almost all participants said that their children were not self-conscious around the camera; one said that their child was initially shy and one thought that their children behaved better than usual while they were wearing the camera. Eight participants reported that they had at least one visitor during the wearing period. Three participants chose to remove the SenseCam as they didn't want the visitor to feel uncomfortable. In all other cases, participants found that simply explaining the study purpose was sufficient to satisfy curiosity from others and allay any concerns. The 2 participants who wore the camera outside of the home said that no one asked them about it.

Overall, participants were generally positive about the camera. Four participants said that they felt the camera was quite intrusive and, although they were happy to wear it for the study, they were quite glad when the wearing period ended. Five participants said that they would be happy to wear the camera for a slightly longer period of 1 – 2 weeks; the remaining participants felt that 4 days was sufficient. Eight participants said that they would wear the SenseCam outside of the home, such as in a supermarket, but they would not wear it in certain situations, such as in schools. All participants felt that the SenseCam may be helpful to families who need to change aspects of their behaviour or household routine.

5.5 Discussion

This study aimed to examine whether a novel tool called ‘SenseCam’ could be used to examine the obesogenic quality of the home environment, and whether it would be useful for validation purposes. SenseCam captured almost all of the hypothesised home environment features, but to a varied extent. Features that were rarely or never captured included tinned and frozen foods, ready-to-eat vegetables, energy-dense snacks, the sugar-content of drinks, and the presence of satellite TV. It was not possible to fully capture mealtime frequency, child eating while watching TV, and parental TV viewing due to there being a single wearer and a limited wearing period. In general, there was moderate to high agreement between HEI-reported and SenseCam-captured features of the home environment. Lower agreement was reported for food variety (except for fresh vegetables), and the number of computers in the home. SenseCam was generally acceptable to participants, although there were some reservations.

While the findings indicate that SenseCam can be used to capture aspects of the obesogenic home environment, a primary issue is that what is captured depends on the actions of the wearer. Although this highlights the utility of SenseCam as a behavioural measure, it also meant that it was often not possible to determine whether SenseCam missed a particular feature or whether the feature truly was absent. For most cases of disagreement, a feature was reported at the time of the HEI but not captured by SenseCam. This was particularly the case for tinned and frozen foods, energy-dense snacks, and media equipment (excluding TVs). It is feasible that certain foods and media equipment were available in the home during the wearing period even though they weren’t captured. Some food storage places may not have been accessed during the wearing period, and extra computers or games consoles may have been stored away. It wasn’t possible to fully capture partner TV watching or child eating while watching TV as this information was only captured when the wearer was with their partner or child at the time of the behaviour. Estimates of caregiver TV watching were based on the data available during the wearing period and therefore may not be representative of typical TV viewing behaviour. Home environment features may also have been missed when there was low light, blurring, something covering the lens, or when participants forgot to put the camera back on after an outing.

Bryant and colleagues reported generally moderate to high agreement when using home visits to validate their HHS (Bryant et al., 2008). Overall agreement was high for the presence of all food types, and at least acceptable for both sensitivity and specificity, suggesting that the low agreement for some food types in the present study may indeed have been due to SenseCam missing this information. Agreement for food variety was also higher than reported in the present study. However, lower values (ICCs) were reported for sweet (0.30) and savoury (0.48) snack variety in their study, suggesting that some discrepancies in this study may be due to other reasons than SenseCam missing information, such as natural changes in food availability. As in the present study, agreement for the presence of a garden and play equipment was high. For the number of computers and games consoles, agreement was higher than in the present study (65% and 73%, respectively). Unlike the previous study, it was possible to capture eating and TV viewing behaviour, with acceptable agreement given the limited wearing period. In both studies it was not possible to validate most social aspects of the home environment, such as parental rules. Future research could use a static camera with sound recording to do so, as done previously (e.g. Wilson et al., 2011). Taken together, the findings suggest that SenseCam may be particularly useful for assessing behavioural aspects of the home environment, and understanding how the individual interacts with their home environment more generally, while home visits may be needed to more rigorously assess the availability of food and media equipment in the home.

Having participants carry out a guided tour of their home may ensure that certain features are captured by SenseCam. However, having participants simply wear the camera, as in the present study, is a more naturalistic method and may lessen the chance of bias. Having a longer wearing period, or having multiple family members wear a SenseCam, would also provide a more comprehensive picture of the home environment. Most participants in this study felt that 4 days was sufficient, suggesting that some form of incentive would be needed for a longer wearing period. Offering an incentive may also minimise data loss if participants are motivated to keep the camera on for the full wearing period. SenseCam was considered unsuitable for young children to wear, although future research could have older children and both parents wear one. Using a device that can capture higher quality images would also benefit future research. Since the start of this study, SenseCam has been superseded with a newer model, marketed as the autographer[7]. The autographer has a 5 megapixel low light sensor, meaning that it can capture indoor images to a higher standard than the original SenseCam.

There were some cases of disagreement where a feature was not reported in the HEI but was captured by SenseCam. For example, 3 participants did not report fruit juice, and 2 participants did not report fizzy drinks, but these drinks were present during the SenseCam wearing period. It is feasible that these differences were due to natural changes in food availability; however it could also reflect some bias in responding at the time of the HEI. Previous research comparing self-reports to SenseCam images have found that individuals can overestimate their activity levels (P. Kelly et al., 2011) and underestimate their dietary intake (O'Loughlin et al., 2013). To determine whether differences really were due to changes in food availability, it would have been useful to ask participants about their shopping habits during the wearing period (in addition to the time of the HEI). Follow-up interviews or a diary method could also have been used to explain discrepancies between HEI responses and SenseCam images; the former may be preferable as the latter could heighten participants' awareness of the camera and their subsequent behaviour.

Some aspects of the study protocol may have affected participants' behaviour during the wearing period. Several participants said that having to remove the camera whenever they went outside their home heightened their awareness of it. Restricting wearing to within the home was chosen to minimise the chance of certain ethical issues arising, and because it wasn't necessary for participants to wear the camera outside. For example, although photography is not prohibited in public places, there are situations where people expect privacy. Wearing a SenseCam in such situations may make the participant uncomfortable or even put them at risk if there are adverse reactions from others. During prolonged wearing, participants may also be more likely to mistakenly wear SenseCam in prohibited places or places where they do not wish to take images. Future research could have participants wear the camera outside of the home environment, as previous research has done (P. Kelly et al., 2011, 2012), provided that certain ethical issues are taken into consideration.

[7] http://www.autographer.com/#home

To be consistent with the original HEI data collection, participants completed the HEI before wearing the camera rather than vice versa. Although there was a gap between completing the HEI and wearing the SenseCam, it is possible that participants worked out the aim of the study and modified their environment or behaviour accordingly. Previous research indicates that this can happen (Terry & Beck, 1985), and 2 participants reported that they did modify aspects of their household routine. It is noteworthy that SenseCam captured fewer energy-dense snacks than was reported in the HEI, while slightly more fresh fruit and vegetables were captured. Although this could be a chance finding, participants may have modified their purchasing behaviour or their access to certain foods in the home. However, it isn't clear if any behavioural effect would result from wearing the camera, completing the interview, or both. A larger-scale validation study could use counter-balancing to control for any potential order effects. Nevertheless, most participants said that, although wearing the camera made them reflect about their home environment, they didn't think that it affected their behaviour. Research has shown that when behaviour is habitual, behavioural responses are activated automatically (Aarts & Dijksterhuis, 2000).

The large amount of data accumulated by SenseCam is an important factor to consider. Manual coding is time-consuming and coding errors can occur (although inter-rater reliability in this study was high). Automatic coding procedures for the home environment are needed, particularly if future research uses longer wearing periods and involves multiple family members. Another factor to consider is participant recruitment. Recruiting for this study was effortful as many of the families contacted were not comfortable with the idea of wearing the camera. Although there were no significant differences between the study sample and non-responders in terms of demographics, participants were motivated by some personal interest. Offering some form of incentive may encourage less motivated, harder-to-reach families to take part in future studies.

A final issue to consider is the cost of wearable cameras. SenseCam has been used by many researchers, but the £300 unit price can be limiting. For this study, it was possible to borrow some cameras from other researchers; although availability was still limited. As a response to this issue, some researchers have recently presented the SmartPhone as a platform for a wearable camera (Gurrin et al., 2013). At under £100, SmartPhones are more affordable than other camera devices; however, cameras built within mobile phones may not be ideal for image-capture in research due to their use for other functions. Other researchers have used a variation on this approach, connecting a wearable camera wirelessly to a mobile phone (de Jager et al., 2011). Such an approach may facilitate access to wearable cameras for future research.

5.5.1 Conclusion

This study found that a wearable camera can be used to examine and validate aspects of the obesogenic home environment. However, with just 15 volunteer participants, and a limited wearing period, this was a proof-of-concept study. The findings cannot be considered representative, and further research would be needed to check the validity estimates, using a more rigorous protocol. While SenseCam can capture physical aspects of the home environment, such as food and media equipment availability, its particular strength is in capturing behavioural aspects, such as mealtime routines and TV watching. An optimal validation procedure could use a combination of home visits (to assess food and media equipment availability) and wearable cameras (to assess behavioural aspects and how the individual interacts with their home environment more generally).

Chapter 6: Family characteristics associated with the obesogenic quality of the home environment in early childhood

6.1 Background

The literature reviewed in Chapter 2 indicated that the home environment plays a role in childhood weight trajectories. As overweight and obesity is notoriously difficult to treat (Yanovski & Yanovski, 2003), particularly once established in adulthood (Jeffery et al., 2000), developing a preventive approach is important. Identifying characteristics that are associated with the obesogenic quality of the home environment may help tailor obesity prevention strategies.

Parents play a key role in creating the child's home environment and are of primary importance within the context of weight management (Golan & Crow, 2004; Golan, Kaufman, & Shahar, 2006). As outlined in Chapter 2, existing research suggests that a variety of parental characteristics, including demographics, behavioural traits, and early parenting practices may be associated with the obesogenic quality of the home environment. In terms of demographic characteristics, younger, less educated parents, those with fewer financial resources, and those without the support of a partner or with multiple children, may be more likely to live in an obesogenic home environment. Parents who are at risk for overweight and obesity in terms of their behaviour and weight status, and those who used non-recommended parenting practices early on in their child's development, may also be more likely to live in an obesogenic home environment.

Few studies have explored this area and existing studies are limited in several ways. First, they have used home environment measures associated with child obesity risk but which do not capture the food, activity, and media domains (e.g. Baharudin & Luster, 1998; Dumas et al., 2005; Luster & Dubow, 1990); or they have focused on a particular aspect of the home food, activity, or media environment, rather than using more comprehensive indicators (e.g. Barr-Anderson et al., 2008; Baughcum et al., 1998; Chuang et al., 2013; Videon & Manning, 2003). Second, they have generally considered a narrow range of characteristics. Third, no studies have examined characteristics associated with the overall obesogenic quality of the home environment in early childhood even though this period may be particularly relevant for long-term overweight and obesity prevention (Dietz, 1994; Lawlor & Chaturvedi, 2006; Rolland-Cachera et al., 2006).

6.2 Aim

The aim of this study was to examine whether maternal demographics, behavioural traits, and early feeding practices are associated with the overall obesogenic quality of the home environment (hypothesised to represent the ultimate risk for weight gain) in early childhood.

6.3 Method

6.3.1 Sample

Data were from parent-child dyads (one child randomly selected from each twin pair) in the total Home Environment Interview (HEI) sample (n = 1113). Families were excluded from the analyses if they had missing data on one or more of the study variables (n = 214). Full data were available for 899 families.

6.3.2 Measures

The overall home environment composite was described in detail in Chapter 4. The choice of family characteristics to focus on was influenced by previous research (outlined in Chapter 2), and also the data available in the Gemini study. The family characteristics in this study fall into three main categories: (i) maternal demographics (namely maternal age, education level, household income, the number of other children living in the home, and the presence of a spouse or partner); (ii) maternal traits (namely BMI, eating traits, and happiness); and (iii) early parental feeding practices (namely duration of breastfeeding and timing of solid food introduction). Maternal characteristics were the main focus as almost all (99%) of the primary caregivers in the sample were mothers.

All of the maternal demographics were assessed at baseline and are described in detail in Chapter 3; information on the number of other children in the home and the presence of a spouse or partner was updated at the time of the HEI and was used in this study. Breastfeeding duration was also assessed at baseline, and timing of solid food introduction was derived from both the baseline and 15 month Gemini questionnaires (all described in Chapter 3). Maternal eating traits and happiness were assessed in the 24-month questionnaire and are also described in Chapter 3. Internal consistency (using Cronbach's alpha) for each eating trait and happiness was high in the study sample: restraint = 0.91, emotional eating = 0.93, external eating = 0.82, and happiness = 0.85. Although maternal ethnicity was among the hypothesised family characteristics, this was not included in the analyses as fewer than 5% of mothers in the sample were non-white and there was considerable ethnic diversity within the non-white group, which would make it difficult to draw meaningful conclusions from findings.

6.3.3 Statistical analyses

6.3.3.1 Sample characteristics

The total HEI sample and the study sample were compared on all of the study variables to check for response bias (t-tests for continuous variables; chi-square tests for categorical variables).

6.3.3.2 Categorisation of the study variables

For ease of interpretation, the overall home environment composite was categorised into tertiles, creating lower, medium, and higher 'risk' environment groups.

Education level was categorised as high (university-level education), intermediate (vocational or advanced high-school education), or low (no qualifications or basic high-school education). Household gross annual income was categorised as lower (≤ £30,000) or higher (> £30,000) as this categorisation was close to the UK average for 2008 (£35,532) (Office for National Statistics, 2010). Few participants in the study sample were living below the poverty line (defined as a household (disposable) income below 60% of the median[8]); therefore this was not used as a cut-off. More specifically, the UK median household gross annual income for 2009 was £29,363 (Walker, 2010), giving a poverty threshold of £17,618. Just 5% (n = 41) of the study sample had a household gross annual income of £15,000 or less, and 8% (n = 72) were on £15,000 – £22,500).

Duration of breastfeeding was categorised into two groups: i) mothers who at least partly breastfed for at least 3 months and ii) mothers who never breastfed or stopped before 3 months. This categorisation was used because research suggests that the protective effects of breastfeeding (against the development of overweight) are gained only when breastfeeding continues for at least 3 months (Gillman et al., 2001; Grummer-Strawn & Mei, 2004).

The distribution of timing of solid food introduction was skewed (see **Appendix 6.1** for graphical display); therefore, three similar-sized groups were created: earlier (1–4 months), average (5 months) and later introduction (6–12 months).

6.3.3.3 Characteristics associated with the obesogenic quality of the home environment

There was 100% correspondence between the home environment groups of within-pair twins; therefore analyses were not repeated using the unselected twin as a check.

Univariate and multivariate ordinal logistic regression analyses were used to examine characteristics associated with living in an overall higher risk home environment. For the multivariate analyses, maternal demographic characteristics were entered simultaneously into a model (also adjusting for maternal BMI) to see which were independently associated with the home environment. Research has shown that maternal age, education, income, BMI, and family structure are interrelated. In particular, younger maternal age has been associated with lower education level (Rindfuss, John, & Bumpass, 1984), single-parent status (McCarthy

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[8] http://www.poverty.org.uk/summary/income%20intro.shtml

& Menken, 1979), and having more children (Bumpass, Rindfuss, & Jamosik, 1978); and individuals seem to gain weight during young and middle adulthood (Rissanen, Heliövaara, & Aromaa, 1988; Williamson, 1993). Lower education level is associated with lower income (Blanden & Gregg, 2004), and each has been associated with higher BMI (Shrewsbury & Wardle, 2008), single-parent status (Musick & Mare, 2006; Stevenson & Wolfers, 2007), and having more children (J. E. Cohen, Kravdal, & Keilman, 2011; Heckman & Walker, 1990). It is also conceivable that maternal BMI might be associated with family structure as family routines surrounding diet and physical activity may differ in single-parent families and/or those with multiple children.

Although there was no evidence of multicollinearity (see last paragraph in this section), maternal eating traits were entered into separate multivariate models for ease of interpretation as they are conceptually interrelated. Each model adjusted for core demographic characteristics (maternal age, education, and income) plus maternal BMI. Early parental feeding practices were also entered into a model that adjusted for core demographic characteristics plus maternal BMI; these were entered in the same model as research has shown that breastfeeding duration is associated with the timing of solid food introduction (Fewtrell et al., 2003; Schrempft et al., 2013; Scott et al., 2009). As previous research has reported associations between maternal eating behaviour and child feeding practices (Birch & Fisher, 2000; Duke, Bryson, Hammer, & Agras, 2004), between maternal eating traits and happiness-related constructs (namely depression and anxiety) (Stice, 2002), between happiness-related constructs and infant feeding practices (T. Field, 2010), and between happiness and marital status (Stack & Eshleman, 1998; Stutzer & Frey, 2006), additional multivariate models were run to take into account these potentially relevant associations.

An assumption underlying ordinal logistic regression is that the slope coefficients in the model are the same across each level of the outcome variable. This is known as the parallel lines or proportional odds assumption[9]. For example, the relationship between maternal BMI and the home environment could be described as follows: for a one unit increase in maternal BMI, the odds of living in a higher risk home

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[9] http://www.ats.ucla.edu/stat/spss/dae/ologit.htm

environment versus the combined mid and lower categories are 1.85 times greater. Because of the proportional odds assumption, the same increase (1.85 times), is found when comparing the lower risk with the combined higher and mid risk categories. If the coefficients are not equal across each level of the outcome, binary or multinomial logistic regression models should be used as they have no such assumption. SPSS provides a Test of Parallel Lines. A non-significant result indicates that the slope coefficients are the same across the outcome categories.

Another assumption of ordinal logistic regression is that there is no multicollinearity. Multicollinearity is when two or more predictor variables are highly correlated, making it difficult to determine their independent contribution to variation in the outcome variable. Specifically, multicollinearity increases the error variance of the observed coefficients, such that some variables may be individually non-significant even though they explain a significant proportion of variance overall. One indicator of multicollinearity is correlations of 0.8 or above between predictor variables (A. Field, 2009).

6.4 Results

6.4.1 Sample

There were no significant differences between the total HEI sample (N = 1113) and the selected sample (n = 899) on any of the study variables: maternal age ($t(2008) = -0.758$, $p = 0.448$), BMI ($t(1993) = 0.600$, $p = 0.548$), education level ($\chi^2(2) = 3.201$, $p = 0.202$), household income ($\chi^2(1) = 1.378$, $p = 0.240$), presence of a spouse or partner ($\chi^2(1) = 1.123$, $p = 0.289$), number of other children living in the home ($t(2010) = 0.599$, $p = 0.549$), maternal restraint ($t(1867) = -0.162$, $p = 0.871$), emotional eating ($t(1867) = -0.245$, $p = 0.806$), external eating ($t(1866) = -0.004$, $p = 0.997$), happiness ($t(1866) = 0.114$, $p = 0.909$), breastfeeding duration ($\chi^2(1) = 0.161$, $p = 0.689$), and timing of solid food introduction ($\chi^2(2) = 0.546$, $p = 0.761$).

Characteristics of the study sample are shown in **Table 6.1**. Mothers had an average age of 34 years, 94% were married or cohabiting, 52% had a high education level, and three-quarters were living in homes with an average annual income of £30, 000 or more. Around half of all families (49%) had no other children; 38% had one other child; 9% had two other children; and just 4% had three or more other children. The mean BMI was 24.7 kg/m^2, and average scores for maternal restraint, emotional eating, and external eating were close to the mid-point of the scales. The average level of subjective happiness was above the mid-point of the scale. Around a third of mothers had breastfed their infant for at least 3 months. A quarter of mothers introduced solid foods between 1 and 4 months, 36% at 5 months and 39% at 6 months or later.

Table 6.1. Descriptive characteristics for the study sample (% (n), unless stated otherwise)

	N = 899
Maternal demographics	
Age (years), mean (SD)	34.02 (4.60)
Education level	
Low	13.3 (120)
Intermediate	34.8 (313)
High	51.8 (466)
Household annual income	
< £30,000	24.9 (224)
≥ £30,000	75.1 (675)
Presence of spouse or partner	
Yes	5.7 (51)
No	94.3 (848)
No. of other children living in the home, mean (SD)	0.71 (0.87)
Maternal traits, mean (SD)	
BMI	24.71 (4.48)
DEBQ restraint	2.72 (0.96)
DEBQ emotional eating	2.14 (0.96)
DEBQ external eating	3.10 (0.65)
Happiness	5.22 (1.02)
Early parental feeding practices	
Breastfeeding duration	
< 3 months	63.0 (566)
≥ 3 months	37.0 (333)
Timing of solid food introduction	
Earlier (1 – 4 months)	25.4 (228)
Average (5 months)	36.2 (325)
Later (≥ 6 months)	38.5 (346)

BMI = body mass index; DEBQ = Dutch Eating Behaviour Questionnaire.

Education level categorised as: low (no qualifications or basic high-school education, intermediate (vocational or advanced high-school education), and high (university-level education).

6.4.2 Characteristics associated with living in an overall higher risk home environment

The Parallel Lines Test showed that all of the models met the proportional odds assumption. Pearson's correlations showed that there was no multicollinearity (all associations between the predictor variables were ≤ 0.44).

Results of the ordinal logistic regression analyses are shown in **Tables 6.2** and **6.3**. At the univariate level, younger age, heavier BMI, lower education level, lower household annual income, and the absence of a spouse or partner were associated with living in a higher risk home environment. Having one or more other children living in the home was not associated with the quality of the home environment. Of the maternal traits, greater emotional and external eating, and lower levels of happiness were associated with living in a higher risk home environment. Maternal restraint was not associated with the quality of the home environment. Shorter breastfeeding duration and earlier solid food introduction were both associated with living in a higher risk home environment.

The multivariate analyses showed that all of the maternal demographic characteristics, except for the presence of a spouse or partner, were independently associated with living in a higher risk home environment (see **Table 6.2**). All of the maternal traits and early parenting practices, except for maternal restraint and emotional eating, were associated with living in a higher risk home environment when adjusting for core demographics and maternal BMI (see **Table 6.3**). These associations held when taking into account other potentially relevant factors (see **Appendix 6.2** for additional results table).

Table 6.2. Maternal demographic factors associated with living in a higher risk home environment[1] (N = 899)

	Univariate results		**Multivariate results[1]**	
	OR	**95% CI (p value)**	**OR**	**95% CI (p value)**
Maternal demographics				
Age (years)	0.94	0.92 – 0.97 (<0.001)	0.96	0.93 – 0.99 (0.003)
Education level				
High	1	–	1	–
Intermediate	2.07	1.59 – 2.71 (<0.001)	1.67	1.26 – 2.20 (<0.001)
Low	2.31	1.59 – 3.36 (<0.001)	1.70	1.15 – 2.52 (0.008)
Household annual income				
≥ £30,000	1	–	1	–
< £30,000	2.97	2.22 – 3.97 (<0.001)	2.06	1.50 – 2.83 (<0.001)
Presence of spouse or partner				
Yes	1	–	1	–
No	2.01	1.18 – 3.43 (0.010)	1.30	0.74 – 2.27 (0.358)
Number of other children	1.12	0.98 – 1.29 (0.098)	1.07	0.92 – 1.23 (0.392)

OR = odds ratio; 95% CI = 95% confidence interval; 1 denotes the reference group; BMI = body mass index.
[1] Variables entered simultaneously into the model (along with maternal BMI).

Table 6.3. Maternal traits and early parenting practices associated with living in a higher risk home environment[1] (N = 899)

	Univariate results		Multivariate results[1]	
	OR	**95% CI (p value)**	**OR**	**95% CI (p value)**
Maternal traits				
BMI (per unit increase)	1.07	1.04 – 1.10 (<0.001)	1.05	1.02 – 1.08 (0.002)
DEBQ restraint	0.97	0.86 – 1.10 (0.659)	0.90	0.79 – 1.03 (0.138)
DEBQ emotional eating	1.23	1.08 – 1.40 (0.001)	1.14	0.99 – 1.31 (0.072)
DEBQ external eating	1.34	1.11 – 1.61 (0.002)	1.34	1.10 – 1.64 (0.004)
Happiness	0.68	0.60 – 0.77 (<0.001)	0.68	0.60 – 0.78 (<0.001)
Early parental feeding practices[2]				
Breastfeeding duration				
≥ 3 months	1	–	1	–
< 3 months	2.11	1.64 – 2.72 (<0.001)	1.55	1.18 – 2.03 (0.001)
Timing of solid food introduction				
Later	1	–	1	–
Average	1.06	0.80 – 1.40 (0.702)	0.98	0.74 – 1.31 (0.895)
Earlier	2.32	1.69 – 3.17 (<0.001)	1.71	1.23 – 2.39 (0.001)

OR = odds ratio; 95% CI = 95% confidence interval; 1 denotes the reference group; DEBQ = Dutch Eating Behaviour Questionnaire.
[1] Each model adjusted for core demographics (maternal age, education level, and household income) and maternal BMI.
[2] For the multivariate analyses, breastfeeding duration and timing of solid food introduction were entered in the same model.

6.5 Discussion

6.5.1 Study findings

This study sought to identify family characteristics associated with the obesogenic quality of the overall home environment. Maternal demographics, traits, and early feeding practices were each associated with the likelihood of living in a higher risk home environment, when other key variables were controlled. Specifically, younger, less educated mothers, and those from lower income households, were more likely to live in environments that presented overall greater risk for child weight gain. Additionally, heavier mothers, those with greater responsiveness to food-related stimuli, lower levels of happiness, and those with a history of using non-recommended feeding practices, were more likely to live in higher risk home environments. The absence of a spouse or partner and other eating traits were associated with increased likelihood of living in a higher risk home environment in univariate analyses, but not after adjustment for other key variables. Overall, these findings suggest that multiple factors are relevant to the obesogenic quality of the home environment.

Previous research examining characteristics associated with individual aspects of the obesogenic home environment have consistently reported associations with indicators of socioeconomic status (SES) (e.g. Barr-Anderson et al., 2008; Bauer, Neumark-Sztainer, Fulkerson, & Story, 2011; Baughcum et al., 1998; Drewnowski & Darmon, 2005; MacFarlane et al., 2007; Videon & Manning, 2003). The findings of this study confirm that different indicators of SES, namely education level and income, are relevant to the obesogenic quality of the home environment. As discussed in Chapter 2, education and income may contribute uniquely to the home environment. For example, parents living in economically deprived areas, and with fewer financial resources may not be able to provide a wide variety of fruit and vegetables, which generally cost more than energy-dense foods (Cummins & Macintyre, 2006; Drewnowski & Darmon, 2005), and they may have limited access to activity facilities (Estabrooks et al., 2003; Macintyre, 2007). Less educated parents may not have sufficient health-related knowledge (Parmenter et al., 2000; Satia et al., 2005) or motivation (Hearty et al., 2007; Wardle & Steptoe, 2003) to put into creating an overall healthier home environment.

Although the presence of a partner was not associated with the home environment after adjustment for demographic factors and maternal BMI, this characteristic is not necessarily unimportant; rather the association with the home environment is mediated by other characteristics, such as SES. Previous studies have reported associations between the presence of a partner and the quality of the home environment, independent of SES (Baharudin & Luster, 1998; Dumas et al., 2005; Luster & Dubow, 1990). However, these studies used other indicators of the home environment, which measure the overall level of organisation within the home, and the overall extent of support for the child's cognitive and emotional development. It may be that the presence of a partner is not independently relevant within the context of the obesogenic home environment. The null finding may also be explained by limited power as just 6% of mothers in the study sample were single.

In contrast with the present study, previous studies have reported associations between the number of children in the home and the quality of the home environment, at both the univariate and multivariate level (Baharudin & Luster, 1998; Dumas et al., 2005; Luster & Dubow, 1990). However, as for the presence of a partner, previous research has used quite different measures of the home environment. In the context of obesity, other research has shown that parents with other children were more likely to introduce their younger children to non-recommended foods (Koh et al., 2010; Schrempft et al., 2013). It is possible that the number of children in a family may be specifically relevant to the home food environment; although it is not clear why this would be the case. On the other hand, most of the families in this sample had few other children, which may partly be explained by them already having twins. Associations may be apparent in samples with a greater proportion of very large families.

Apart from SES, few studies have examined other characteristics associated with the obesogenic quality of the home environment. There is some evidence that parents who are more concerned about energy-balance behaviours (EBBs) and weight are more likely to live in home environments that are supportive of a balanced diet and physical activity (Boutelle et al., 2007; Hendrie et al., 2012; Jackson et al., 2008; Pearson, Salmon, et al., 2011; Slater et al., 2011). The present study found that mothers with obesogenic eating traits, in the form of greater emotional and external eating, were more likely to live in higher risk obesogenic home environments, with external eating remaining significant after adjustment for demographic factors and maternal BMI. It may be expected that higher levels of maternal restraint would be associated with living in a lower risk home environment, in the sense that more restrained mothers may make more of a conscious effort to limit obesogenic exposures. However, restrained eating is generally not considered to be protective against weight gain (van Strien et al., 1986); and this eating pattern may be specifically relevant to aspects of the home food environment. With regard to weight status, two previous studies found few associations between maternal BMI (or skinfold thickness) and aspects of the obesogenic home environment (Sallis et al., 1995; Wardle et al., 2002). If an existing effect is small, a larger sample size and use of a composite home environment measure (as in the present study) may be required to detect it. To further test the idea that obesity-prone mothers live in overall higher risk home environments, it would be useful to use genetic markers as indicators of obesity risk.

The findings of this study also build upon previous research by demonstrating associations between maternal well-being, early feeding practices, and the quality of the home environment. The finding that higher maternal happiness was associated with reduced likelihood of living in a higher risk home environment is consistent with previous research demonstrating associations between the home environment and other well-being-related constructs, including self-esteem (Baharudin & Luster, 1998; Menaghan & Parcel, 1991), stress (Dumas et al., 2005), and depression (Martinson et al., 2011). As noted in Chapter 2, it is feasible that mothers with greater well-being have better cognitive and emotional resources to put into creating a healthier home environment (Lovejoy et al., 2000). Research reporting links between greater well-being and EBBs that protect against weight gain support this notion (Grant et al., 2009; Piqueras et al., 2011).

Mothers who breastfed for 3 months or less and introduced solid foods earlier were more likely to live in overall higher risk home environments. These findings suggest that parents with a history of non-recommended feeding practices are more likely to expose their child to other obesogenic influences later in life. In line with this, other research has shown that aspects of the home environment, such as parental feeding practices and family meals, are relatively stable (Faith, Berkowitz, et al., 2004; Gable et al., 2007); and those who introduce solid foods early in infancy are also more likely to introduce non-recommended foods in childhood (Koh et al., 2010; Schrempft et al., 2013). These associations may be explained by parental attitudes and cultural beliefs.

The findings of this study provide some insight into potential mechanisms for the development of overweight and obesity. As several of the characteristics in this study have been identified as risk factors for child overweight and obesity, it is feasible that reported associations are at least partly explained by the obesogenic quality of the home environment. For example, the consistent association between maternal and child weight status (Agras, Hammer, McNicholas, & Kraemer, 2004; Danielzik, Czerwinski-Mast, Langnäse, Dilba, & Müller, 2004; Locard et al., 1992; Reilly, 2005) may be explained by genetic inheritance and that heavier mothers are more likely to expose their child to an obesogenic home environment. Research suggests that the association between SES and weight is complex, with gender, ethnicity, and SES indicator playing a role (Shrewsbury & Wardle, 2008; Y. Wang & Zhang, 2006; Y. Wang, 2001); however, the home environment may be a mediating factor. Other potential risk factors for weight gain are breastfeeding duration (Armstrong & Reilly, 2002; Harder, Bergmann, Kallischnigg, & Plagemann, 2005; Weng, Redsell, Swift, Yang, & Glazebrook, 2012) and the timing of solid food introduction (Baker, Michaelsen, Rasmussen, & Sørensen, 2004; Huh, Rifas-Shiman, Taveras, Oken, & Gillman, 2011; Schack-Nielsen, Sørensen, Mortensen, & Michaelsen, 2010), although the findings have been mixed, especially for solid food introduction (Farrow, Haycraft, & Mitchell, 2013; Lefebvre & John, 2013; Pearce, Taylor, & Langley-Evans, 2013). It is possible that genetic and environmental factors confound reported associations. For example, hungrier infants may elicit feeding (A. S. Anderson et al., 2001; Wasser et al., 2011), and parents who introduce solid foods early may also expose their child to other risk factors within the home environment (due to their attitudes or cultural beliefs), which further increases the risk for overweight and obesity.

6.5.2 Limitations

Although most of the characteristics were assessed before the home environment measurement, it is not possible to make causal inferences. For example, in the case of maternal BMI, it is feasible that heavier mothers create or seek out home environments that are in line with their obesogenic tendencies, also known as active gene-environment correlation (r_{GE}) (Rutter, 2007). A number of studies have found that measures of the family environment are heritable (Plomin, Reiss, Mavis, & Howe, 1994), supporting this notion. On the other hand, it is also feasible that the home environment influences maternal weight, which is in line with evidence for weight loss following home environment interventions (Gorin et al., 2008, 2013).

Although the findings of this study are interesting, it would have been useful to examine other potentially relevant characteristics, which were not available in the data set. For example, previous research has indicated that maternal ethnicity is associated with various aspects of the home environment (Chuang et al., 2013; Skala et al., 2012), but this could not be examined due to the limited ethnic diversity of the sample. It would also be useful to directly assess the relevance of parental health-consciousness and self-efficacy in creating a healthier home environment.

This study focused on maternal characteristics associated with the obesogenic quality of the home environment; an important research endeavour given that mothers are generally main caregivers within the home environment. However, it is acknowledged that aspects of the home environment may be influenced by other family members, including partners and the children. Research indicates that parenting practices are responsive to child characteristics including temperament (Kiff, Lengua, & Zalewski, 2011; Wasser et al., 2011), behaviour (A. S. Anderson et al., 2001; Pearson, Salmon, et al., 2011; Webber, Cooke, Hill, & Wardle, 2010a), and weight status (Webber, Hill, et al., 2010). Future research should further test the child-responsive model within the context of the overall obesogenic home environment. To assess the role of child characteristics, it would be important to have the same kind of information for all children living in the home (which was not available in this study).

As in previous studies in this area, all characteristics were assessed using parent report (and retrospectively for early feeding practices), which may be prone to bias. However, the reliability and validity of the DEBQ (van Strien et al., 1986; van Strien, Peter Herman, & Anschutz, 2012; Wardle, 1987), happiness scale (Lyubomirsky & Lepper, 1999), and retrospective infant feeding data (Launer et al., 1992; R. Li, Scanlon, & Serdula, 2005) has been demonstrated previously.

Another limitation is that the findings may not generalise to families without twins. There is some evidence that families with twins differ from non-twin families. For example, mothers with twins are more likely to experience depression than those without (Choi, Bishai, & Minkovitz, 2009; Glazebrook, Sheard, Cox, Oates, & Ndukwe, 2004; Thorpe, Golding, MacGillivray, & Greenwood, 1991), possibly due to the additional stresses (financial and otherwise) that having twins presents. It is also possible that the home environments of twins differ in some ways to those of non-twin children. For example, research has shown that mothers of twins interact differently with their children than mothers of singletons do (Rutter & Redshaw, 1991). Although these differences could affect the nature of associations, the findings of this study are generally in line with those from non-twin samples, suggesting that any differences are not sufficient to modify the overall pattern of results.

6.5.3 Conclusion

This study found that maternal demographic characteristics, traits, and early feeding practices were associated with the overall obesogenic quality of the home environment in early childhood. Although further research is needed to fully understand the nature of associations, the present findings offer some insight into the development of child overweight and obesity and its prevention.

Chapter 7. Associations between the obesogenic quality of the home environment and energy-balance behaviours in early childhood

7.1 Background

Despite some mixed findings, a number of energy-balance behaviours (EBBs) have been associated with weight status in childhood (Reilly, 2008; te Velde et al., 2012; van Stralen et al., 2012); and it is widely acknowledged that reducing positive energy-balance is essential for overweight and obesity prevention. With high rates of positive EBBs even among young children (M. K. Fox, Condon, Briefel, Reidy, & Deming, 2010; Ng et al., 2012; Reilly, 2008), it is important to identify potential influences.

As outlined in Chapter 2, research has shown that multiple aspects of the home environment are associated with EBBs including food consumption, physical activity, and TV viewing. However, much of this research has focused on school-aged children and adolescents, with less focus on the preschool years; even though the home environment is thought to play a key role in early weight trajectories. Furthermore, existing studies have typically focused on how specific aspects of the home environment relate to behaviour. Although this is an important research endeavour, it is also important to understand how composite measures of the obesogenic home environment relate to EBBs, and subsequently weight. No studies have examined how composite indicators of the home environment relate to EBBs in preschool-aged children.

7.2 Aim

This study aimed to examine associations between composite indicators of the home environment (reflecting the home food, activity, and media domains) and EBBs in early childhood.

7.3 Methods

7.3.1 Sample

Data were from parent-child dyads (one child randomly selected from each twin pair) in the HEI sample (N = 1113), which is described in Chapter 4. Full data were available for 1096 parent-child dyads.

7.3.2 Measures

7.3.2.1 Home environment

The home environment composites are described in detail in Chapter 4.

7.3.2.2 Energy-balance behaviours

Child EBBs were assessed at the time of the HEI and included the child's fruit, vegetable, energy-dense snack, fast food, convenience food, sugar-sweetened drink, sugar-free drink, fruit juice, and milk consumption, their physical activity level, and weekly TV viewing.

7.3.2.2.1 Food and drink consumption

Parents rated, on average, how often their twins consumed food and drink from each availability category assessed in the HEI (i.e. fruit, vegetables, savoury snacks, sweet snacks, confectionery, sugar-sweetened drinks, sugar-free drinks, fruit juice, and milk) on an 8-point scale (1 = never or less than once a month; 8 = four or more times a day). The questions were based on those used in brief dietary assessment methods, such as the Dietary Instrument for Nutrition (DINE), which has been validated against 4-day diet diaries (Roe, Strong, Whiteside, Neil, & Mant, 1994). As for food availability, fruit consumption did not include fruit juice, vegetable consumption included salad items but not potatoes, savoury snack consumption included snacks such as peanuts, crisps, and cheesy biscuits (but not rice cakes, oatcakes, and crackers), sweet snack consumption included snacks such as biscuits, cakes, and ice-cream, and confectionery consumption included chocolate and sweets. For all food categories, consumption included food consumed between meals and as part of a meal.

7.3.2.2.2 Fast and convenience food consumption

Fast food consumption was measured using the question 'How often do your twins eat fast food from places such as McDonald's, Burger King, and Subway?' Other convenience food consumption was measured using the question 'How often do your twins eat other convenience foods for their main meal? This includes food that requires no preparation such as ready-made pizza, microwaveable meals, and takeaway food such as fish and chips, Chinese, and Indian.' As for the other consumption questions, participants responded using an 8-point scale (1 = never or less than once a month; 8 = four or more times a day). As there are no known validated measures of child fast and convenience food consumption, the questions were based on those used in previous research, which have been associated with child BMI (Taveras et al., 2006; Taveras, Berkey, et al., 2005).

7.3.2.2.3 Activity level

Due to funding constraints, it was not possible to objectively measure physical activity in Gemini. Activity level was therefore assessed using the item: 'Compared to other children of the same age and sex, how physically active are your twins?' Responses were measured on a 5-point scale (1 = much less active; 5 = much more active). The question has been used in the Twins Early Development Study (TEDS) and correlated with objectively measured activity in 11-year-old children (Purslow, van Jaarsveld, Semmler, & Wardle, 2009).

7.3.2.2.4 Sedentary behaviour

Child TV watching was assessed using questions adapted from those used by Anderson and colleagues (Anderson, Field, Collins, Lorch, & Nathan, 1985), described in Chapter 4 for maternal and paternal TV viewing. Responses were recorded in hours and minutes, and weekly TV viewing was calculated.

7.3.3 Statistical analysis

7.3.3.1 Sample characteristics

As in the previous study, the selected sample was compared to the total HEI sample on all study variables, to check for response bias. T-tests were used for continuous variables; chi-square tests were used for categorical and ordinal variables.

7.3.3.2 Reliability

As for the home environment variables, test re-test reliability of the EBBs was assessed using single measure intraclass correlation coefficients (ICCs) for continuous variables, and percent agreement and weighted Kappa for ordered categorical variables. Kappa coefficients were defined as: 0.00 – 0.20 = slight, 0.21 – 0.40 = fair, 0.41 – 0.60 = moderate, 0.61 – 0.80 = substantial and 0.81 – 1.00 = almost perfect (Landis & Koch, 1977); ICC values were categorised as: < 0.40 = poor, 0.40 – 0.75 = fair to good agreement and > 0.75 = excellent (Fleiss, 1986). Items with Kappa > 0.6 and/or percent agreement ≥ 60% were considered to have acceptable reliability.

7.3.3.3 Categorisation of the study variables

Home environment tertiles were used for ease of interpretation; reflecting lower, medium, and higher ‘risk’ environment groups.

To quantify the child’s overall energy-dense snack consumption, a variable was created using the mean of responses to the child’s savoury snack, sweet snack, and confectionery consumption. Before calculating the mean, responses on each consumption variable (sweet snack, savoury snack, and confectionery) were recoded to reflect the extent of daily intake i.e. never or less than once a month = 0 times per day; 1 – 3 times a month = 0.07 times per day; once a week = 0.14 times per day; 2 – 4 times per week = 0.43 times per day; 5 – 6 times per week = 0.79 times per day; once a day = once a day; 2 – 3 times a day = 2.5 times a day; and 4 or more times a day = 4 times a day. It would be incorrect to add the original scale scores together as the intervals between each response category were not the same. As the EBBs were skewed, these outcome variables were dichotomised, using existing guidelines for preschool children, where available. In line with the 5-a-day recommendation (World Health Organisation, 2003), fruit and vegetable consumption were each categorised so that the higher consumption group represented twice or more a day. As child nutrition guidelines recommend that energy-dense snacks, specifically those high in fat, salt, or sugar, be consumed only very occasionally (National Institute for Health and Care Excellence, 2008), the higher consumption group represented the inverse of this recommendation, namely frequent consumption of at least once a day. Similarly, as it is recommended that sugar- or artificially-sweetened drinks should rarely, if ever, be given to young children (Children's Food Trust, 2012), the higher consumption group represented frequent consumption of at least once a day. Guidelines for fruit juice and milk consumption are generally framed in terms of the amount or quality to be given. For example, it is recommended that fruit juice should be diluted for preschoolers and that full-fat milk is not necessary at this age (Children's Food Trust, 2012). As this information was not available, these variables were categorised in the same way as the other drinks variables, so that the higher consumption group represented frequent consumption: at least once a day for fruit juice; at least twice a day for milk. In accordance with guidelines provided by the American Academy of Pediatrics (2001), the higher TV viewing group represented 2 or more hours per day. Physical activity level was categorised so that the active group included those who were more active than other children of the same age and sex.

7.3.3.4 Associations between the home environment and energy-balance behaviours

Logistic regression was used to examine hypothesised associations between the home environment composites and EBBs. Specifically, associations were examined between the home food environment composite and each consumption variable, between the home activity environment composite and the child's physical activity level, and between the home media environment and the child's TV viewing.

The child's sex, age at the time of the HEI, and maternal BMI and education level were identified as covariates as it was hypothesised that they may relate to the outcome variables. Previous research has reported associations between these factors and child EBBs (Cooke et al., 2004; Fisher & Birch, 1995; Hoyos Cillero & Jago, 2010; Sallis et al., 2000). Research has also reported associations between ethnicity and EBBs in children (e.g. Cooke et al., 2004; Hoyos Cillero & Jago, 2010). However, ethnicity wasn't included as a covariate in the present study as almost all children (90%) were white, and in 57 other cases (5% of the study sample), it was not possible to determine the child's ethnicity as information on the natural father's ethnicity was missing. Analyses were performed using SPSS version 18.0.

Although the home environment groups within twin pairs were the same, there were some within-pair differences in EBBs, therefore all analyses were repeated using the other twin as a check. Differences in consumption (after dichotomisation) were reported in 73 cases for fruit, 42 cases for vegetables, 6 cases for energy-dense snacks, 1 case for convenience food, 9 cases for sugar-sweetened drinks, 43 cases for artificially-sweetened drinks, 40 cases for fruit juice, and 109 cases for milk. Differences in physical activity level and TV viewing (after dichotomisation) were reported in 124 and 6 cases, respectively.

7.4 Results

Test-retest results for the child's food consumption, physical activity level, and TV viewing are shown in **Table 7.1**. Percent agreement and Kappa scores for the consumption variables were moderate to high (56.8 – 86.4%; 0.53 – 0.84), with lowest scores for sweet snack consumption and highest scores for milk consumption. Reliability for the child's overall snack consumption, activity level, and TV viewing was good (ICC = 0.70; percent agreement = 72.7% and Kappa = 0.68; ICC = 0.87).

Table 7.1. Single measure Intraclass correlation coefficients (and 95% confidence intervals), percent agreement, Kappa values (and 95% confidence intervals) for the energy-balance behaviours (N = 44)

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)
Food			
Fruit consumption (1 = never or less than once a month; 8 = 4 or more times a day)	-	77.3	0.63 (0.37 – 0.88)[w]
Vegetable consumption	-	77.3	0.79 (0.63 – 0.95)[w]
Savoury snack consumption	-	63.6	0.54 (0.33 – 0.75)[w]
Sweet snack consumption	-	56.8	0.53 (0.37 – 0.70)[w]
Confectionery consumption	-	81.8	0.84 (0.73 – 0.95)[w]
Snacks consumption (mean intake)	0.70 (0.51 – 0.83)	-	-
Fast food consumption	-	84.1	0.69 (0.46 – 0.91)[w]
Convenience food consumption	-	70.5	0.74 (0.60 – 0.87)[w]
Sugar sweetened drinks consumption	-	61.4	0.53 (0.30 – 0.75)[w]
Sugar free drinks consumption	-	75.0	0.75 (0.58 – 0.91)[w]
Milk consumption	-	86.4	0.84 (0.68 – 1.00)[w]
Fruit juice consumption	-	70.5	0.73 (0.58 – 0.88)[w]
Physical activity			
Activity level (1 = much less active; 5 = much more active)	-	72.7	0.68 (0.52 – 0.83)[w]

	Intraclass correlations (95% CI)	% agreement	Kappa (95% CI)
Media			
TV viewing (hours per week)	0.87 (0.78 – 0.93)	-	-

[w] Weighted Kappa for items with 3 or more ordered response options.

7.4.1 Sample characteristics

The total HEI sample comprised 1113 families; 17 families were excluded due to missing data for maternal BMI. There were no significant differences between the total HEI sample (N = 1113) and the selected sample (n = 1096) on any of the other study variables: home food environment composite ($t(2207) = 0.028$, $p = 0.978$), home activity environment composite ($t(2207) = -0.047$, $p = 0.963$), home media environment composite ($t(2207) = 0.066$, $p = 0.947$), overall home environment composite ($t(2207) = 0.021$, $p = 0.983$), child's age at the time of the home environment interview ($t(2207) = -0.061$, $p = 0.951$), child's sex ($\chi^2(1) = 0.00$, $p = 0.983$), maternal education level ($\chi^2(2) = 0.007$, $p = 0.996$), child's consumption of fruit ($\chi^2(1) = 0.01$, $p = 0.928$), vegetables ($\chi^2(1) = 0.00$, $p = 0.976$), energy-dense snacks ($\chi^2(1) = 0.01$, $p = 0.937$), fast food ($\chi^2(1) = 0.00$, $p = 0.983$), convenience food ($\chi^2(1) = 0.02$, $p = 0.904$), sugar-sweetened drinks ($\chi^2(1) = 0.02$, $p = 0.882$), artificially-sweetened drinks ($\chi^2(1) = 0.03$, $p = 0.863$), fruit juice ($\chi^2(1) = 0.00$, $p = 0.958$), and milk ($\chi^2(1) = 0.00$, $p = 0.999$), and child's physical activity ($\chi^2(1) = 0.00$, $p = 0.978$) and TV viewing level ($\chi^2(1) = 0.00$, $p = 0.988$).

Table 7.2 shows the characteristics of the study sample and the proportions of children within each of the EBB categories. Descriptive statistics for the raw EBB variables are included in **Appendix 7.1**. Approximately three-quarters of children in the sample consumed fruit at least twice a day, while approximately half consumed vegetables at least twice a day. More than 10% of children consumed energy-dense snacks at least once a day, just 7% consumed fast food at least once a week, and around a quarter of children consumed convenience food at least twice a week. Approximately 10% of children consumed sugar-sweetened drinks at least once a day, and more than half consumed artificially-sweetened drinks this frequently. Almost half of children consumed fruit juice at least once a day, and nearly two thirds consumed milk this frequently. Almost two thirds of children were reported to be more physically active than other children of the same age and sex. More than a third of children watched 2 or more hours of TV a day.

Table 7.2. Descriptive characteristics for the study sample (% (n), unless stated otherwise)

	N = 1096
Maternal education level	
Low	15.4 (169)
Intermediate	36.3 (398)
High	48.3 (529)
Maternal BMI, mean (SD)	24.84 (4.58)
Child's sex	
Male	50.1 (549)
Female	49.9 (547)
Child's age (years), mean (SD)	4.17 (0.40)
Child's energy-balance behaviours	
Fruit consumption	
≥ twice a day	77.7 (852)
< twice a day	22.3 (244)
Vegetable consumption	
≥ twice a day	51.2 (561)
< twice a day	48.8 (535)
Energy-dense snack consumption	
≥ once a day	13.4 (147)
< once a day	86.6 (949)
Fast food consumption	
≥ once a week	7.4 (81)
< once a week	92.6 (1015)
Convenience food consumption	
≥ twice a week	26.6 (292)
< twice a week	73.4 (804)
Sugar-sweetened drink consumption	
≥ once a day	10.7 (117)
< once a day	89.3 (979)
Artificially-sweetened drink consumption	
≥ once a day	52.5 (575)
< once a day	47.5 (521)
Fruit juice consumption	
≥ once a day	48.4 (531)
< once a day	51.6 (565)
Milk consumption	
≥ twice a day	64.1 (702)
< twice a day	35.9 (394)
Physical activity level[1]	
Somewhat or much more active	61.0 (669)
About average or less active	39.0 (427)
TV viewing	
≥ 2 hours per day	39.1 (428)
< 2 hours per day	60.9 (668)

BMI = body mass index.
Education level categorised as: low (no qualifications or basic high-school education, intermediate (vocational or advanced high-school education), and high (university-level education).
[1]Compared to other children of the same age and sex.

7.4.2 Associations between the home environment composites and energy-balance behaviours

As the univariate and multivariate results were the same, only the multivariate results are presented here. The univariate results are included in **Appendix 7.1**.

The associations were replicated when using data for the other twin as a check.

7.4.2.1 Home environment composites and energy-balance behaviours

As shown in **Table 7.3**, children living in higher risk home food environments were less likely to consume fruit and vegetables, more likely to consume energy-dense snacks, convenience food, fast food, and sugar-sweetened drinks than children living in lower risk home food environments (p values < 0.001 and 0.001 for fast-food consumption). There were no significant differences in child consumption when comparing the mid and lower risk home environments, except for a trend for less vegetable (p = 0.046) and more energy-dense snack (p = 0.055) consumption in the mid risk group. There were no significant associations between the home food environment and artificially-sweetened drink, fruit juice, or milk consumption. There was a dose-response relationship between the home activity environment and physical activity level, and between the home media environment and TV viewing. Children living in higher and mid risk home activity environments were less active than children living in lower risk home activity environments (p values < 0.001 and 0.004, respectively). Children living in higher and mid risk home media environments were more likely to watch TV for at least 2 hours a day than children living in lower risk home media environments (p values < 0.001).

Table 7.3. Multivariable[1] associations between the home environment tertiles and corresponding energy-balance behaviours (N = 1096)

	OR (95% CI), P value % (n)[2]		
	Lower risk food environment	**Mid risk food environment**	**Higher risk food environment**
Outcome variables			
Fruit (≥ twice a day)	1.00 85.5 (312)	0.73 (0.49 – 1.08), 0.113 80.6 (295)	0.37 (0.25 – 0.53), <0.001 67.1 (245)
Vegetables (≥ twice a day)	1.00 60.5 (221)	0.73 (0.54 – 0.99), 0.046 52.2 (191)	0.48 (0.36 – 0.66), <0.001 40.8 (149)
Energy-dense snacks (≥ once a day)	1.00 7.7 (28)	1.63 (0.99 – 2.70), 0.055 12.0 (44)	2.96 (1.85 – 4.73), <0.001 20.5 (75)
Convenience food (≥ twice a week)	1.00 19.7 (72)	1.29 (0.91 – 1.84), 0.159 24.0 (88)	2.25 (1.60 – 3.15), <0.001 36.2 (132)
Fast food (≥ once a week)	1.00 5.2 (19)	0.57 (0.27 – 1.20), 0.135 3.3 (12)	2.69 (1.53 – 4.72), 0.001 13.7 (50)
Sugar-sweetened drinks (≥ once a day)	1.00 6.6 (24)	1.23 (0.70 – 2.17), 0.466 7.9 (29)	3.19 (1.94 – 5.27), <0.001 17.5 (64)
Artificially-sweetened drinks (≥ once a day)	1.00 52.9 (193)	0.86 (0.64 – 1.17), 0.344 50.5 (185)	0.89 (0.65 – 1.21), 0.440 54.0 (197)

	OR (95% CI), P value % (n)[2]		
	Lower risk food environment	**Mid risk food environment**	**Higher risk food environment**
Fruit juice (≥ once a day)	1.00 49.0 (179)	1.02 (0.76 – 1.36), 0.910 49.2 (180)	0.97 (0.72 – 1.29), 0.812 47.1 (172)
Milk (≥ twice a day)	1.00 93.7 (342)	1.51 (0.78 – 2.92), 0.222 95.6 (350)	0.90 (0.50 – 1.63), 0.726 93.2 (340)
	Lower risk activity environment	**Mid risk activity environment**	**Higher risk activity environment**
Physical activity (more active)	1.00 70.7 (258)	0.64 (0.47 – 0.87), 0.004 61.0 (224)	0.43 (0.32 – 0.59), <0.001 51.4 (187)
	Lower risk media environment	**Mid risk media environment**	**Higher risk media environment**
TV viewing (≥ 2 hours per day)	1.00 15.4 (56)	2.98 (2.07 – 4.30), <0.001 38.1 (139)	6.59 (4.52 – 9.60), <0.001 63.5 (233)

95% CI = 95% confidence interval; 1.00 denotes the reference group.
[1]Adjusting for maternal education level, maternal BMI, the child's age at the time of the HEI, and the child's sex.
[2] Values are raw values i.e. not derived from the multivariate models.

7.5 Discussion

7.5.1 Study findings

This is the first study to examine associations between composite indicators of the home environment and EBBs in a large sample of preschool children. Consistent with previous research focusing on particular aspects of the home environment (e.g. Campbell et al., 2007; Crawford et al., 2010; De Craemer et al., 2012; Neumark-Sztainer, Hannan, et al., 2003; Van Der Horst, Oenema, et al., 2007), there were significant associations between the home environment composites and EBBs.

For the total sample, rates of EBBs were generally more favourable than those reported in previous research. National surveys have reported that most young children in the UK do not consume the recommended five portions of fruit and vegetables per day (Health Survey for England, 2011; Low Income Diet and Nutrition Survey, 2007), most do not meet recommended guidelines for physical activity (Health Survey for England, 2008b), and many watch more than 2 hours of TV per day (Ofcom, 2011). Despite some dietary improvements among younger children, many still derive much of their daily energy from energy-dense snacks and sugar-sweetened beverages (Whitton et al., 2011). In this sample, a majority of children ate fruit (78%) and vegetables (51%) regularly, fewer consumed fast food (7%), convenience food (27%), energy-dense snacks (13%), and sugar-sweetened drinks (11%) on a regular basis, and parents tended to report that their child was somewhat more active than other children of the same age and sex. Although direct comparisons cannot be made due to differences in measurement, the trend for more favourable rates of EBBs in this sample may be explained by the demographic nature of the Gemini sample. Research has shown that rates of positive EBBs are higher in lower-SES and non-white samples (e.g. Brug, van Stralen, Chinapaw, et al., 2012; Cooke et al., 2004; Sallis et al., 2000; Van Der Horst, Paw, et al., 2007). It is also possible that families in the Gemini sample are generally more health-oriented than other samples due to their ongoing participation in a health-related study. Consistent with previous research, and contrary to guidelines, many children (39%) watched 2 or more hours of TV per day (Reilly, 2008).

As food preference is a predictor of intake (e.g. Bere & Klepp, 2005; Cullen et al., 2003; Gibson, Wardle, & Watts, 1998), the finding that more children ate fruit regularly than they did vegetables is consistent with the general preference for sweet tastes among young children, thought to reflect an innate neophobic disposition (Birch, 1999; Cowart, 1981).

Associations between the home environment composites and EBBs were in the expected directions. Specifically, children living in higher risk home food environments consumed ‘healthier’ foods (fruit and vegetables) less frequently and ‘unhealthier’ foods (energy-dense snacks, fast food, convenience food, and sugar-sweetened drinks) more frequently than children living in lower risk home food environments; children living in higher risk home activity environments were less physically active than children living in lower risk home activity environments; and children living in higher risk home media environments watched more TV than children living in lower risk home media environments. A dose-response pattern was observed when examining associations between the home activity and media environments and corresponding EBBs. However, the consumption patterns of children living in mid and lower risk home food environments did not significantly differ; although there was a trend for fruit and vegetable consumption in the expected direction. This may be attributable to the range of scores in the current data set. Significant differences between mid and lower risk home environments may emerge if a wider range of environments are included in analyses. Another possible reason is that there may have been more measurement error in the home food environment composite. Although the test-retest reliability was acceptable (see Chapter 4), it was lower than the other home environment composites.

Effect sizes were generally moderate when comparing higher and lower risk home environments. The largest association was between the home media composite and the child’s TV viewing level, suggesting that the home context is particularly relevant to this behaviour. The home food and activity environments are not necessarily less relevant to EBBs; associations could be more complex or it is possible that the media composite measured the relevant domain more reliably than the food and activity composites.

The strong association between the home media composite and child TV viewing is particularly relevant given that this EBB has been identified as a risk factor for child obesity (Hawkins & Law, 2006; Reilly, 2008; te Velde et al., 2012). Reduced energy expenditure and increased energy intake are both thought to explain the association as TV viewing is a sedentary behaviour and may promote energy-dense food consumption. The associations with child food and beverage consumption and physical activity level are also relevant as, despite some mixed findings (Newby, 2007; te Velde et al., 2012), most of these EBBs are relevant to weight trajectories and management. Addressing EBBs early is important as they tend to persist over time (Biddle et al., 2010; Mikkilä et al., 2005; Y. Wang et al., 2002), potentially increasing the chance of weight gain.

There were no significant associations between the home food composite and the child's consumption of artificially-sweetened drinks, fruit juice, or milk. Previous research has reported associations between specific aspects of the home environment, including home availability and accessibility (Cullen et al., 2003; Hanson et al., 2005; Nicklas et al., 2001), and child or adolescent fruit juice/milk consumption. Nevertheless, composite measures of the home environment may not be related to fruit juice and milk consumption. Indeed, the relevance of artificially-sweetened drinks, fruit juice and milk consumption to weight status is unclear (Barba et al., 2005; Berkey et al., 2005; Dennison et al., 1997; Newby et al., 2004; O'Connor et al., 2006). On the other hand, it is possible that associations may have been detected if a more detailed consumption measure had been used. For example, children may consume fruit juice or milk equally frequently but some may drink undiluted fruit juice or full-fat milk, which provide more energy than diluted or skimmed alternatives.

7.5.2 Limitations

A limitation of the present study is the use of parent-report via telephone interview and concurrent assessment of the home environment and EBBs, which may have introduced some bias in the reported associations. Test-retest reliability for the home environment composites and EBBs was moderate to high, and the associations reported in Chapter 6 (where maternal characteristics were assessed prior to the HEI) provide some evidence for construct validity. Nevertheless, using objective measures, or assessing the home environment and EBBs at separate time points, would capture associations more reliably.

As the findings of the present study are cross-sectional, causal processes cannot be inferred. The assumed mechanism is that various aspects of the home environment cumulatively influence behaviour, with positive EBBs promoting weight gain, if sustained over time. Although it is feasible that child behaviours influence certain aspects of the home environment, previous research has reported longitudinal associations between aspects of the home environment and EBBs (e.g. Cleland et al., 2010; Larson et al., 2007; Pearson, Ball, et al., 2011), while interventions (e.g. French et al., 2011; Gorin et al., 2008, 2013; T. N. Robinson & Borzekowski, 2006) and experimental studies (Addessi et al., 2005; Bellisle et al., 2004; Fisher & Birch, 1999b; Wansink et al., 2006) provide further evidence for a causal role of the home environment. Future research should examine longitudinal associations between composite indicators of the home environment and EBBs, with multiple assessments of each.

The present study did not focus on how the home environment influences EBBs, which is another important research endeavour. With multiple aspects of the home environment and a number of EBBs, various mechanisms have been proposed. Collectively, the proposed mechanisms fit with a dual-process view, according to which the home environment influences behaviour both directly and indirectly (Kremers et al., 2006). Direct influences reflect automatic, unconscious processes, such as behavioural mimicry and emotion. Indirect influences reflect the mediating role of behaviour-specific cognitions, such as attitudes and self-efficacy. Although identifying associations between the home environment and EBBs is in itself informative for weight-management interventions, identifying factors that mediate and moderate these associations would provide further information. Much of this research would have to be carried out in older samples, however, as it is more difficult to measure cognitive constructs in young children.

7.5.3 Conclusion

This study found associations between composite measures of the obesogenic home environment and a number of EBBs in early childhood. The findings are in line with the notion that the home environment is an avenue for longer-term obesity prevention.

Chapter 8. Associations between the obesogenic quality of the home environment and BMI in early childhood

8.1 Background

The home environment is hypothesised to influence weight via its influence on energy-balance behaviours (EBBs). As outlined in Chapter 2, numerous studies have reported associations between aspects of the home environment and EBBs, such as food consumption, activity level, and TV viewing; and the findings presented in the preceding chapter built upon this by showing associations between composite indicators of the home environment and EBBs. However, substantially fewer studies have examined associations between the home environment and weight, particularly in early childhood. As for the energy-balance literature, existing research has tended to focus on particular aspects of the home environment, rather than considering it as a whole. As discussed in Chapter 2, it is important to measure the overall obesogenic quality of the home environment because homes may present risk for weight gain in some ways but not others. Currently no studies have examined associations between composite measures of the home environment and weight in early childhood.

8.2 Aim

The aim of this study was to examine associations between composite indicators of the home environment and BMI at 4 years (child's age at the time of the HEI) and BMI change from 4 to 5 years.

8.3 Methods

8.3.1 Sample

Data were parent-child dyads (one child randomly selected from each twin pair) from the total HEI sample (n = 1113). Families were included in the analysis if they had data on all of the study variables. Full data were available for 915 families for the four-year BMI analyses and for 503 families for the four to five-year BMI change analyses.

8.3.2 Measures

The home environment composites are described in Chapter 4. Child body mass index (BMI) was calculated (weight (kg) / height $(m)^2$) using parent-reported height and weight measurements, which are provided at regular intervals using standard growth charts and electronic weighing scales, as described in Chapter 3. BMI standard deviation scores (SDS) were calculated adjusting for age and sex using British 1990 growth reference data and the LMS growth macro for excel. The child's sex, birth weight, and maternal education level, included as covariates in the study, were assessed in the baseline Gemini questionnaire, which is described in Chapter 3.

8.3.3 Statistical analysis

8.3.3.1 Associations between the home environment composites and child BMI

Analysis of covariance (ANCOVA) was used to examine associations between each home environment composite (food, activity, media, overall) and child BMI. This statistical approach is appropriate when there is a categorical or ordinal grouping variable, a continuous outcome variable, and the need to adjust for variables that may also influence the outcome (covariates) (A. Field, 2009). In the present study, each model included the home environment tertile assignment (lower, medium, or higher risk) as the grouping variable and child BMI as the outcome variable. A child's BMI standard deviation score (SDS), or Z-score, is optimal for assessing adiposity on a single occasion as it provides information on how the child compares to a reference population of the same age and sex (National Obesity Observatory, 2011). However, research indicates that change in BMI is better measured using raw BMI as BMI SDS shows greater within-child variability over time (Cole, Faith, Pietrobelli, & Heo, 2005). BMI SDS was therefore used for the four-year BMI analyses; raw BMI was used for the four to five-year BMI change analyses. BMI SDS at 4 years was calculated using the closest available data to 48 months; BMI at 5 years was calculated using the closest available data to 60 months.

The child's sex, age at the time of the HEI, age at BMI measurement, and birth weight, and maternal education level were identified as covariates as it was hypothesised that they may relate to the outcome. Growth charts using measurements from a large number of children, show that BMI varies by sex and age (Royal College of Paediatrics and Child Health, 2013), and research has shown that birth weight is strongly related to subsequent growth parameters (Binkin, Yip, Fleshood, & Trowbridge, 1988; Illingworth, 1950; Weng et al., 2012). Socioeconomic status (SES) has also been associated with BMI; education level has been identified as a more consistent predictor than other SES indicators (Shrewsbury & Wardle, 2008). Partially and fully adjusted models were used to examine associations between the home environment composites and child BMI. Partially adjusted models included the child's sex, age at the time of the HEI, and age at BMI measurement as covariates. The fully adjusted models additionally included the child's birth weight and maternal education level as covariates. For the four to five-year BMI change analyses (partially and fully adjusted models), the child's raw BMI at 4 years was also included as a covariate.

For a sensitivity check, the ANCOVA models were re-run using the home environment composite variations 1 and 2 (described in Chapter 4), and the composite variations where child eating while watching TV was included as part of the food composite instead of the media composite. As all but 4 twins within a pair had different BMIs at 4 years, analyses were also repeated using the other twin. Additional analyses were carried out to examine associations between the individual home environment variables included in the composites and child BMI. Due to the large number of tests ($n = 30$), Bonferroni's correction ($\alpha/n = 0.05/30$) was applied (Bland & Altman, 1995), giving a significance level of 0.002. ANCOVAs were used for categorical predictor variables and linear regressions were used for continuous predictor variables, adjusting for the covariates outlined in the preceding paragraph.

ANCOVA has the same assumptions as any general linear model: (i) each of the groups should be normally distributed on the outcome variable (normality), and (ii) each group should have equal variances on the outcome variable (homogeneity of variance). Additional assumptions of ANCOVA are: (iii) the covariates should not be related to the grouping variable (independence of the covariate and treatment effect), and (iv) relationships between the outcome and covariates should be the same across each level of the grouping variable (homogeneity of regression slopes)[21]. The third assumption is important when conducting experiments (Keppel, 1991) and therefore was not tested in the present study.

One way to test the first assumption is to check the extent of skewness (how symmetrical the distribution is) and kurtosis (how peaked the distribution is) in the data. Values greater than 1.0 (or less than -1.0) are usually taken to indicate that the data is not normally distributed (Bowen & Guo, 2011). Levene's test, provided in SPSS, is typically used to indicate whether or not group variances are equal; a significant result suggests unequal variances. A significant result is much more likely with large sample sizes; therefore the variance ratio (largest group variance divided by the smallest group variance) can be used as a double check. Values greater than 2 suggest that the variances are likely heterogeneous (A. Field, 2009). The homogeneity of regression slopes assumption can be checked by specifying a model that includes the interaction between the grouping variable and the covariate. A significant interaction effect indicates that the relationship between the grouping variable and the outcome vary with different scores on the covariate (A. Field, 2009).

8.3.3.2 Associations between energy-balance behaviours and child BMI

As the home environment is hypothesised to influence child BMI via its influence on EBBs, associations between each EBB (food and drink consumption, physical activity, and TV viewing) and child BMI were examined using a series of linear regressions. As for the home environment analyses, partially adjusted models included the child's sex, age at the time of the HEI, and age at BMI measurement.

Fully adjusted models additionally included the child's birth weight and maternal education level. Applying Bonferroni's correction ($\alpha/n = 0.05/11$) gave a significance level of 0.006.

If the home environment composites and EBBs were associated with child BMI, it would be possible to carry out mediation analysis (Baron & Kenny, 1986), specifically testing the model (outlined in Chapter 1) that EBBs mediate (or explain) the associations between the home environment and child BMI.

8.4 Results

8.4.1 Sample characteristics

For the four-year BMI analyses, there were 198 families with missing data on one or more of the study variables; these cases were excluded, giving a total sample of 915 families. There were no significant differences between this sample and the total sample on any of the study variables: food composite tertiles ($\chi^2(2) = 0.01$, $p = 0.995$), activity composite tertiles ($\chi^2(2) = 0.67$, $p = 0.716$), media composite tertiles ($\chi^2(2) = 1.45$, $p = 0.484$), overall composite tertiles ($\chi^2(2) = 0.24$, $p = 0.887$), child's age at the time of HEI completion ($t(2026) = 1.45$, $p = 0.147$), age at four-year BMI measurement ($t(1850) = 0.06$, $p = 0.951$), birth weight ($t(1998) = 0.21$, $p = 0.833$), BMI SDS at 4 years ($t(1847) = 0.24$, $p = 0.814$), and sex ($\chi^2(1) = 0.00$, $p = 0.964$), and maternal education level ($\chi^2(2) = 0.95$, $p = 0.623$).

For the four to five-year BMI change analyses, there were 610 families with missing data on one or more of the study variables; these cases were excluded, giving a total sample of 503 families. There were no significant differences between this sample and the total sample on almost all of the study variables: food composite tertiles ($\chi^2(2) = 1.20$, $p = 0.549$), activity composite tertiles ($\chi^2(2) = 0.53$, $p = 0.766$), overall composite tertiles ($\chi^2(2) = 3.51$, $p = 0.173$), child's age at the time of HEI completion ($t(1614) = 1.19$, $p = 0.233$), birth weight ($t(1591) = -0.12$, $p = 0.908$), BMI at 4 years ($t(1343) = 0.665$, 0.506), BMI at 5 years ($t(1072) = -0.33$, $p = 0.743$), and sex ($\chi^2(1) = 0.70$, $p = 0.404$), and maternal education level ($\chi^2(2) = 3.72$, $p = 0.156$). There were fewer families living in higher risk media environments among those who were included in the four to five-year BMI analyses (26%) than those who were not included (33%) ($\chi^2(2) = 8.28$, $p = 0.016$).

The average BMI SDS at 4 years was -0.06 (SD = 0.97; range = -3.91 – 3.18). The average BMI at 5 years was 15.40 (SD = 1.24; range = 12.25 – 20.25). For the four-year BMI SDS variable, 71% of the measurements were taken when the child was 48 months or within 3 months of this age; 18% were taken within 6 months, 7% within 9 months, and 4% within 12 months. For the five-year BMI variable, 91% of the measurements were taken when the child was 60 months or within 3 months of this age; 9% were taken within 6 months. For the four-year BMI variable used in the five-year BMI analyses, 74% of the measurements were taken when the child was 48 months or within 3 months of this age; 26% were taken within 6 months. There was no overlap in age between the four and five-year BMI variables used in the BMI change analysis. On average, there was a 14-month gap between the two measurements (SD = 3.88; range = 4 – 23 months).

8.4.2 Statistical assumptions

The assumptions of normality and homogeneity of variance were met for all models. For the ANCOVA models, there were no significant interaction effects between any of the covariates and the grouping variable.

8.4.3 Associations between the home environment composites and child BMI

Results of the partially adjusted ANCOVA models (F_{df}, p value) showed that there were no significant associations between the home food ($2.60_{2, 909}$, 0.075), activity ($0.09_{2, 909}$, 0.916), media ($1.05_{2, 909}$, 0.352), or overall ($0.90_{2, 909}$, 0.405) environment tertiles and child BMI SDS at 4 years. There were also no associations with BMI change from 4 to 5 years: food ($0.44_{2, 496}$, 0.643), activity ($1.61_{2, 496}$, 0.201), media ($1.28_{2, 496}$, 0.279), and overall ($0.60_{2, 496}$, 0.552). As shown in **Table 8.1**, these findings were replicated in the fully adjusted ANCOVA models. The pattern of findings was the same when using the composite variations as the outcome variables, and when repeating analyses with the other twin.

Table 8.1. Multivariable associations between the home environment tertiles and BMI at 4 years[1] and BMI change from 4 to 5 years[2]

	BMI SDS at 4 years (N = 915)	BMI change, 4 – 5 years (N = 503)
	Adjusted mean (SD); F_{df}, (p value)	
Overall environment		
Lower risk	-0.00 (0.96)	15.44 (1.19)
Mid risk	-0.09 (0.89)	15.34 (1.19)
Higher risk	-0.10 (1.07)	15.43 (1.35)
	$0.35_{2, 906}$ (0.703)	$0.47_{2,493}$ (0.627)
Food environment		
Lower risk	0.01 (1.01)	15.54 (1.30)
Mid risk	-0.16 (0.89)	15.21 (1.01)
Higher risk	-0.04 (1.02)	15.47 (1.37)
	$2.64_{2, 906}$ (0.072)	$0.51_{2,493}$ (0.603)
Activity environment		
Lower risk	-0.08 (1.02)	15.39 (1.20)
Mid risk	-0.07 (0.93)	15.51 (1.23)
Higher risk	-0.04 (0.98)	15.30 (1.28)
	$0.48_{2, 906}$ (0.619)	$1.55_{2,493}$ (0.212)
Media environment		
Lower risk	-0.00 (0.90)	15.35 (1.14)
Mid risk	-0.07 (0.93)	15.41 (1.20)
Higher risk	-0.12 (1.09)	15.47 (1.42)
	$0.53_{2, 906}$ (0.588)	$0.78_{2,493}$ (0.457)

[1] Adjusting for the child's age at the time of the BMI measurement, age at the home environment measurement, birth weight, and sex, and maternal education level.
[2] BMI at 4 years was included as a covariate.

8.4.4 Associations between individual home environment variables and child BMI

Associations were not examined for whether the child was allowed to help themself to sugar-sweetened drinks as fewer than 5% of each sample responded yes on this variable (2% in the four-year BMI analysis sample; 1% in the four to five-year BMI change analysis sample). Similarly, associations were not examined for whether there was a garden/outdoor space as fewer than 5% of each sample responded no on this variable (1% in the four-year BMI analysis sample; 1% in the four to five-year BMI change analysis sample). The results of the partially adjusted models were very similar to those of the fully adjusted models, therefore only the latter are presented here (**Appendix 8.1** includes the partially adjusted results). As shown in **Table 8.2**, just three of the home environment variables were (positively) associated with BMI SDS at 4 years: maternal restriction, covert restriction, and monitoring. However, the effect sizes were small and the significance values were just above the 0.002 threshold. There were no associations between any of the individual home environment variables and BMI change from 4 to 5 years. The pattern of findings was the same when repeating the analyses with the other twin.

Table 8.2. Multivariable associations between individual home environment variables and BMI SDS at 4 years[1] and BMI change from 4 to 5 years[2]

	BMI SDS at 4 years (N = 915)	BMI change, 4 – 5 years (N = 503)
	F_{df}, p value or B (95% CI), p value[3]	
Food environment variables		
More types of fruit in the home	0.01 (-0.01 – 0.03), 0.586	-0.01 (-0.05 – 0.02), 0.461
More types of vegetable in the home	0.00 (-0.02 – 0.02), 0.891	-0.02 (-0.05 – 0.01), 0.217
More types of energy-dense snack in the home	0.02 (-0.01 – 0.05), 0.143	-0.02 (-0.08 – 0.04), 0.505
Sugar-sweetened drinks in the home	$2.73_{1,907}$, 0.099	$0.50_{1, 495}$, 0.482
Fruit on display (visible)	$4.85_{1, 907}$, 0.021	$0.75_{1, 495}$, 0.387
Child is allowed to help themself to fruit	$0.93_{1, 907}$, 0.335	$0.11_{1, 495}$, 0.740
Ready-to-eat vegetables in the fridge or on the kitchen counter	$0.36_{1, 907}$, 0.547	$1.32_{1, 495}$, 0.251
Child is allowed to help themself to vegetables	$0.08_{1, 907}$, 0.778	$0.02_{1, 495}$, 0.888
Energy-dense snacks on display (visible)	$0.56_{1, 907}$, 0.456	$0.03_{1, 495}$, 0.870
Child is allowed to help themselves to energy-dense snacks	$0.08_{1, 907}$, 0.785	$0.06_{1, 495}$, 0.815
Sugar-sweetened drinks on display (visible)	$0.03_{1, 907}$, 0.873	$0.23_{1, 495}$, 0.634
Family meals at the table	0.01 (-0.03 – 0.05), 0.551	-0.02 (-0.09 – 0.04), 0.492
Maternal modelling of healthy eating	0.02 (-0.07 – 0.10), 0.733	0.06 (-0.10 – 0.22), 0.471
Parental encouragement for the child to eat	0.06 (-0.06 – 0.17), 0.325	-0.01 (-0.23 – 0.21), 0.924
Parental use of food as a reward	0.03 (-0.07 – 0.12), 0.594	0.01 (-0.16 – 0.18), 0.903
Parental use of food to make the child feel better	0.12 (0.01 – 0.22), 0.029	0.09 (-0.10 – 0.28), 0.366

	BMI SDS at 4 years (N = 915)	BMI change, 4 – 5 years (N = 503)
	F_{df}, p value or B (95% CI), p value[3]	
Parental covert restriction of the child's unhealthy food intake	0.11 (0.03 – 0.19), 0.005	0.03 (-0.11 – 0.17), 0.668
Parental monitoring of the child's unhealthy food intake	0.09 (0.02 – 0.16), 0.009	0.04 (-0.08 – 0.16), 0.523
Parental restriction of unhealthy foods	0.08 (0.03 – 0.14), 0.004	0.11 (0.00 – 0.21), 0.045
Home activity environment variables		
Play equipment in the garden	$1.00_{1, 898}$, 0.318	$0.01_{1, 491}$, 0.929
Greater frequency that the child is allowed to play actively in the garden	-0.05 (-0.13 – 0.03), 0.250	0.02 (-0.12 – 0.16), 0.779
Greater frequency that the child is allowed to play actively inside the home	-0.07 (-0.17 – 0.03), 0.810	-0.06 (-0.24 – 0.12), 0.535
Parental support of physical activity	0.02 (-0.09 – 0.13), 0.754	0.06 (-0.12 – 0.25), 0.508
Parental modelling of physical activity	0.02 (-0.06 – 0.11), 0.578	0.09 (-0.05 – 0.24), 0.215
Home media environment variables		
Greater amount of media equipment in the home	-0.01 (-0.03 – 0.01), 0.381	0.01 (-0.03 – 0.05), 0.652
TV in the child's bedroom	$0.06_{1, 907}$, 0.810	$1.08_{1, 495}$, 0.299
Greater maternal TV watching	-0.00 (-0.01 – 0.00), 0.403	-0.00 (-0.02 – 0.01), 0.716
Greater paternal TV watching	-0.01 (-0.02 – 0.00), 0.076	0.00 (-0.01 – 0.01), 0.974
Rules around media use	$0.02_{1, 907}$, 0.893	$0.50_{1, 495}$, 0.481
Child eats while watching TV	0.03 (-0.01 – 0.07), 0.127	0.02 (-0.06 – 0.09), 0.611

[1] Adjusting for the child's age at the time of the BMI measurement, home environment measurement, birth weight, and sex, and maternal education level.
[2] BMI at baseline (4 years) was an additional covariate.
[3] ANCOVAs were used for categorical individual home environment variables (F_{df}, p value); linear regressions were used for the continuous home environment variables (B (95% CI), p value).

8.4.5 Associations between energy-balance behaviours and child BMI

The results of the partially-adjusted models were the same as the fully-adjusted models therefore just the latter are presented here (see **Appendix 8.2** for the partially-adjusted results). As shown in **Table 8.3**, none of the EBBs were associated with child BMI at 4 years, and just two (frequency of fruit and milk consumption) were inversely associated with BMI change from 4 to 5 years; although the p value for fruit consumption (0.007) was just above the significance threshold when applying Bonferroni's correction (0.006). The results were replicated when using data from the other twin.

Table 8.3. Multivariable associations between energy-balance behaviours and BMI SDS at 4 years[1] and BMI change from 4 to 5 years[2]

	BMI SDS at 4 years (N = 915)	**BMI change, 4 – 5 years (N = 503)**
	B (95% CI), p value	
Fruit consumption	0.04 (-0.03 – 0.11), 0.250	-0.13 (-0.22 – -0.04), 0.007
Vegetable consumption	-0.00 (-0.06 – 0.06), 0.984	-0.07 (-0.15 – 0.01), 0.073
Energy-dense snack consumption	-0.02 (-0.21 – 0.18), 0.876	-0.06 (-0.30 – 0.19), 0.649
Fast food consumption	0.08 (-0.02 – 0.18), 0.097	0.03 (-0.09 – 0.14), 0.618
Convenience food consumption	0.02 (-0.03 – 0.08), 0.427	0.08 (0.01 – 0.14), 0.030
Sugar-sweetened drink consumption	0.03 (-0.00 – 0.07), 0.061	-0.00 (-0.05 – 0.04), 0.881
Artificially-sweetened drink consumption	-0.03 (-0.05 - -0.00), 0.031	0.00 (-0.03 – 0.03), 0.849
Fruit juice consumption	-0.01 (-0.04 – 0.03), 0.729	0.01 (-0.03 – 0.05), 0.524
Milk consumption	0.04 (-0.02 – 0.11), 0.210	-0.11 (-0.19 – -0.04), 0.002
Physical activity	0.04 (-0.04 – 0.12), 0.299	0.04 (-0.06 – 0.14), 0.450
TV viewing	0.00 (-0.01 – 0.01), 0.911	0.01 (-0.00 – 0.02), 0.193

[1] Adjusting for the child's age at the time of the BMI measurement, home environment measurement, birth weight, and sex, and maternal education level.
[2] BMI at baseline (4 years) was an additional covariate.

8.5 Discussion

Currently no published studies have examined associations between composite indicators of the home environment and BMI in early childhood. The present study found no associations between composite measures of the home environment and BMI in a large sample of young children. There were still no associations when adding or removing variables from the original composites, providing some support for the robustness of the findings. None of the EBBs were associated with BMI SDS at 4 years.

Just three American studies have examined associations between composite measures of the home environment and child or adolescent BMI. However, the first incorporated EBBs into the composite measure, meaning it was not possible to determine the specific effects of the home environment (Ihmels, Welk, Eisenmann, Nusser, et al., 2009); the second used a cluster analytic technique, being concerned with identifying specific family 'types', and included a limited number of variables (Martinson et al., 2011); and the third, although it used a comprehensive, purely home environment measure, only presented the simple pearson's correlation ($r = 0.24$, $p < 0.05$) (Pinard et al., 2013).

Previous studies examining associations with BMI have generally focused on particular aspects of the home environment (e.g. Arcan et al., 2012; Crawford et al., 2010; Dennison et al., 2002; Gable et al., 2007; MacFarlane et al., 2009). Of the home environment aspects examined in the present study, frequency of family meals (S. E. Anderson & Whitaker, 2010; Fulkerson, Neumark-Sztainer, et al., 2008; Gable et al., 2007; Sen, 2006; Taveras, Rifas-Shiman, et al., 2005), parental feeding practices (Faith, Scanlon, et al., 2004; Hurley et al., 2011; Wardle & Carnell, 2007), parental support of activity (Klesges et al., 1986; Zabinski et al., 2003), parental activity level (Davison & Birch, 2002; Trost et al., 2001), parental TV viewing (Davison et al., 2005), media equipment availability (Bauer, Neumark-Sztainer, Fulkerson, Hannan, & Story, 2011; Crawford et al., 2010; M. Li et al., 2008; Timperio et al., 2008), presence of a TV in the child's bedroom (Adachi-Mejia et al., 2006; Cameron et al., 2013; Delmas et al., 2007; Dennison et al., 2002; Van Zutphen et al., 2007), eating while watching TV (Dubois et al., 2008; Liang et al., 2009; Matheson et al., 2004), and parental rules around media use (Crawford et al., 2010) have previously been associated with child or adolescent BMI; although findings have not always been consistent, and there is little evidence of causality. There has been more (and stronger) evidence for parental feeding practices, family meals, and the presence of a TV in the child's bedroom; although the precise nature of the associations is also not yet clear.

The present study did find associations between three of the parental feeding practices (restriction, covert restriction, and monitoring), and BMI SDS at 4 years. However, these associations were small, borderline significant when applying Bonferroni's correction, and were not associated with BMI change from 4 to 5 years. Nevertheless, the findings are broadly consistent with previous research finding cross-sectional associations between controlling feeding practices and child BMI, while longitudinal associations and evidence for associations with other parental feeding practices are limited (Faith, Scanlon, et al., 2004; Hurley et al., 2011; Wardle & Carnell, 2007). Some theorists hypothesise that controlling feeding practices, particularly restriction, promote overeating as the child relies on external rather than internal cues for consumption (Faith, Scanlon, et al., 2004). Given the positive associations between restriction, covert restriction, and monitoring, it may seem counterintuitive that these feeding practices were identified by the expert panel as protective against weight gain. However, research suggests that controlling feeding practices are responsive to child characteristics, such that parents with heavier children are more likely to use restrictive measures to control food intake (Rhee et al., 2009; Rifas-Shiman et al., 2011; Webber, Cooke, et al., 2010b). In the long-term, restrictive feeding practices may protect against further weight gain (Campbell et al., 2010).

Most of the studies reporting an association between the home environment and BMI have been conducted in adolescents, some in school-aged children, and fewer in preschool-aged children. It is therefore possible that, although the home environment is relevant to EBBs in early childhood, influences on weight may not emerge until later in development. Home environmental influences on EBBs may need to be sustained beyond early childhood, or may become more influential over time. In line with this, research has shown that young children are better able to regulate their energy intakes than older children and adults, reducing their intakes of a particular food in accordance with the caloric content of a preload meal (Birch & Deysher, 1986; Cecil et al., 2005). One explanation is that older children and adults have had more food-related experiences than younger children, therefore their expectations regarding the caloric content and satiety value of food may have a greater influence on their intake following a preload meal than their internal, physiological cues (Birch & Deysher, 1986).

Some researchers have identified the period of adiposity rebound (AR), which typically occurs between 5 and 7 years, reflecting an upward trend in BMI following its nadir, as a particularly sensitive period for weight trajectories (Dietz, 1994; Rolland-Cachera et al., 2006). The home environment may be particularly influential during this time, which could explain the null associations in the present study, as most children had probably not yet reached adiposity rebound. On the other hand, some research suggests that adiposity rebound may just identify children with a high BMI centile and/or crossing upwards; and because centile crossing is associated with later obesity at all ages, adiposity rebound per se may not be critical (Cole, 2004). Early childhood in general may be important because food and activity habits are formed during this time (Barnett et al., 2009; Birch & Fisher, 1998; Savage et al., 2007). Adolescence has also been identified as a critical period for weight trajectories, from a physiological and behavioural perspective (Alberga, Sigal, Goldfield, Prud'homme, & Kenny, 2012). Certain psychosocial aspects of the home environment, such as mealtime interactions (Berge, Wall, Larson, Loth, & Neumark-Sztainer, 2013), may have greater relevance for weight in adolescence when there are important emotional transitions (Patton & Viner, 2007). Older children and adolescents are also exposed to a wider range of obesogenic influences, including the school environment and new peer groups (Dietz & Gortmaker, 2001), which may have a cumulative effect on weight.

Although limited, some studies have found associations between aspects of the home environment and BMI in children as young as 4 years of age. For example, having a TV in the bedroom was associated with increased risk for overweight in a sample of 2761 American children (Dennison et al., 2002); not eating dinner at least 6 days per week was associated with increased risk for obesity in a sample of 8550 American children (S. E. Anderson & Whitaker, 2010); and daily snacking while watching TV was associated with higher BMI in a sample of 1549 Canadian children (Dubois et al., 2008). All of these studies used more diverse samples (in terms of ethnic background and/or SES) than the present study and may have been better powered to detect an association with weight. Previous research indicates that lower SES and some ethnic minority groups may live in more obesogenic home environments (e.g. Barr-Anderson et al., 2008; Chuang et al., 2013; Skala et al., 2012; Vereecken et al., 2004) and may be heavier than other demographic groups

(Shrewsbury & Wardle, 2008; Y. Wang & Beydoun, 2007; Y. Wang & Zhang, 2006; R. C. Whitaker & Orzol, 2006). In the study by Dennison and colleagues, almost half of the sample had a TV in their bedroom (n = 1380), compared to 93 in the present study. In the study by Anderson and Whitaker, 1573 children were obese, while just 80 were classified as being overweight or obese at 4 years in the present study sample (using the International Obesity Task Force (IOTF) cut-offs; National Obesity Observatory, 2011). Although the present study also examined associations with composite home environment measures, which may be better powered to detect an effect than when focusing on individual aspects, the range of scores may still have been somewhat narrow. It is also noteworthy that the outlined studies were carried out in American/Canadian samples, where some environmental factors may be more obesogenic than in the UK. For example, although the proportion of adverts promoting non-core foods is high in many countries, it is particularly high in the US and Canada (B. Kelly et al., 2010).

The null associations between EBBs and weight in the present study are not completely surprising, as previous research findings in preschool-aged samples have been inconsistent, especially with regard to dietary intake (Newby, 2007; te Velde et al., 2012; van Stralen et al., 2012). A primary issue seems to be the assessment of multiple diet-related variables, and the use of various assessment procedures, which may have limited reliability and validity. In this study, food and beverage consumption was assessed using a brief parent-report measure, which may miss important information and be prone to bias. An optimal way to assess dietary intake is the use of diet diaries, which can be used to calculate actual energy and nutrient intakes in addition to specific food and beverage consumption. Diet diaries were used in Gemini when the twins were 2 years old. However, it was not considered appropriate to use the data in this study given the long time-gap between the diet diary and home environment assessments.

That fruit and milk consumption were inversely associated with BMI change from 4 to 5 years is somewhat surprising given the absence of other significant associations, and that previous research findings on the role of these EBBs in child and adolescent weight have been inconsistent (Barba et al., 2005; Berkey et al., 2005; Ledoux, Hingle, & Baranowski, 2011; Newby et al., 2004; O'Connor et al., 2006). There is evidence that dietary calcium and other bioactive compounds in dairy products (such as vitamin D) moderate fat accumulation (Shah, 2000; Zemel, 2002). However, extra calories from milk may promote weight gain. Consumption of fruit (along with vegetables) may protect against weight gain due to their generally low energy-density and satiating properties, having a high water- and/or fibre-content (Rolls, Bell, & Thorwart, 1999; Slavin & Green, 2007). There is, however, some evidence that dietary fructose may be detrimental to body weight regulation via its effects on the metabolic and endocrine system (Elliott, Keim, Stern, Teff, & Havel, 2002; Stanhope, 2012). And as with milk consumption, extra calories from fruit may promote weight gain.

Review studies have identified physical activity and TV viewing as more consistent predictors of weight status in preschool children (Hawkins & Law, 2006; Reilly, 2008; te Velde et al., 2012). Many of the identified studies reporting an association between physical activity and weight used accelerometers or similar devices, which directly monitor human movement, and are likely more precise than the simple parent-report measure used in this study (even though it has been correlated with objectively-measured physical activity (Purslow et al., 2009)). On the contrary, most of the identified studies reporting an association between child TV viewing and weight used parent-report measures of viewing behaviour. One possible reason for the null association in this study is the use of a continuous measure of body size, as most of the studies reporting an association used overweight or obesity status as the outcome. This may additionally explain the null association for physical activity, as studies using a continuous measure of weight have reported mixed findings. This study did not use overweight or obesity status as the outcome as there were very few overweight or obese children, and may therefore have been underpowered to detect an effect. The possibility that EBBs may have developmental effects on weight is supported by a longitudinal study, which found no association between TV viewing and BMI at 4 or 5 years, but there was a significant association at 6 years (Jago, Baranowski, Baranowski, Thompson, & Greaves, 2005). The association may be particularly strong in older children, for whom average daily TV viewing time is greater (Hoyos Cillero & Jago, 2010; Ofcom, 2011).

Although there were no associations between the home environment and weight in this study, the associations between the home environment and EBBs (presented in Chapter 7) support the notion that the home is an important setting for long-term obesity prevention (Davison & Birch, 2001; Ebbeling et al., 2002; Golan & Crow, 2004; Tabacchi et al., 2007). To determine whether there are indeed developmental effects of the home environment and EBBs on weight, future research should incorporate composite indicators of the home environment into a longitudinal design, with multiple assessments of the home environment, EBBs, and weight. Moreover, these associations should be examined in more diverse samples to capture a greater range of obesogenic home environments.

It is possible that associations between the home environment and weight may have been detected if more complex analyses were used to estimate particular growth parameters, such as size (mean weight throughout early childhood), tempo (the age at which there is an upward trend in BMI (adiposity rebound)), and velocity (the size or steepness of the growth curve). Previous research found that, while size and velocity were highly heritable aspects of infant growth, tempo was predominantly environmentally determined (L. Johnson, Llewellyn, van Jaarsveld, Cole, & Wardle, 2011). Other research has shown that early infant feeding is related to the timing of adiposity rebound (an indicator of tempo) (Chivers et al., 2010). Other aspects of the home environment may also be related to tempo.

It is also feasible that associations between the home environment and weight may be evident among those who are genetically susceptible to weight gain. Research has consistently shown that weight has a strong genetic basis (Wardle, Carnell, Haworth, & Plomin, 2008), and there is evidence that individuals respond differently to aspects of the home environment (Andreyeva et al., 2011; Birch et al., 2003; Jansen et al., 2003; Keller et al., 2012). In the study by Ihmels and colleagues, the FNPA score had the strongest association with BMI change in those with high initial BMI values, suggesting that the home environment may be particularly influential among overweight (or genetically susceptible) youth (Ihmels, Welk, Eisenmann, Nusser, et al., 2009). However, although it is generally acknowledged that genetic and environmental influences interact to influence weight, no studies have directly tested this using a composite measure of the obesogenic home environment in early childhood. The study in the following chapter attempts to test the gene-environment interaction hypothesis in the context of the obesogenic home environment.

The composites used in the present study were derived by summing a number of variables hypothesised to be relevant to weight gain. Although it seems reasonable to expect that associations with weight would be better detected when taking into account a number of home environment variables, some aspects of the home environment may relate more strongly to weight than others. Currently, there is insufficient evidence to determine how home environment variables might be weighted when creating composite scores. In order to create stronger composite measures, it is important for research to continue examining associations between aspects of the home environment and weight, with meta-analyses to outline effect sizes.

As with many other studies in this area, this study used parent-report measures, which may be subject to bias. Although BMI measurements are preferably taken by health professionals, the evidence indicates that parents can provide accurate measurements if they measure the child themselves at home (Himes, 2009; Huybrechts et al., 2011), as done so in the present study. Although BMI is an important indicator of weight status (and the most feasible given the sample size), other measures of body fat such as skinfold thickness and waist circumference can provide further information on body composition (Okorodudu et al., 2010).

8.5.1 Conclusion

Although an avenue for long-term obesity prevention, home environmental influences on weight may only emerge as children age or among those genetically susceptible to weight gain.

Chapter 9: Does the heritability of BMI in early childhood vary according to the obesogenic quality of the home environment?

9.1 Background

With dramatic increases in overweight and obesity highlighting the influence of the environment (Finucane et al., 2011; Onis et al., 2010), and evidence for a strong genetic influence on BMI (Wardle, Carnell, Haworth, & Plomin, 2008), there is general consensus that genes and environments work together to influence weight. Several theorists have identified the home environment as a key influence in the development of childhood overweight and obesity (e.g. Davison & Birch, 2001; Golan, 2006; Tabacchi et al., 2007). However, as outlined in Chapter 2, few studies have found associations between aspects of the home environment and child BMI. One possible explanation is that the home environment moderates the influence of genetic effects on adiposity. According to diathesis-stress accounts of pathology, exposure to high risk environments triggers the expression of a genetic predisposition for a condition (Rende & Plomin, 1992; Shanahan & Hofer, 2005). In the context of obesity, the behavioural susceptibility model specifically proposes that individuals with a genetic predisposition to weight gain engage in obesity-promoting behaviours (and therefore gain weight) when exposed to an obesogenic environment (Carnell & Wardle, 2008a).

However, evidence for gene-environment interaction (G x E) is sparse, particularly in the context of childhood overweight and obesity. Many studies indicate that children are differentially susceptible to various aspects of the home environment (e.g. Andreyeva et al., 2011; Birch et al., 2003; Jansen et al., 2003; Keller et al., 2012). However, none of these studies used a genetically informed design, which can further test the possibility of G x E. One method is to use twin modelling to see whether the heritability of a particular phenotype is moderated by an environmental exposure (Rutter, 2007). Existing research has used this approach in the context of psychological or cognitive outcomes (Rutter & Silberg, 2002), with somewhat less research in the context of obesity. Some researchers have examined whether specific behaviours, such as diet and exercise (Mustelin et al., 2009), or broader environmental exposures, such as education and income level (e.g. Johnson et al., 2011), moderate the heritability of BMI. However, no studies have examined the effects of the obesogenic home environment on the heritability of weight in early childhood. Understanding the role of proximal environmental influences (which are amenable to change) is important to inform childhood obesity prevention efforts.

9.2 Aim

The aim of this study was therefore to examine whether the heritability of BMI in early childhood varies according to the level of obesogenic risk within the home environment. In line with the behavioural susceptibility model, it was hypothesised that the heritability of BMI would be higher among children living in more obesogenic home environments.

9.3 Methods

9.3.1 Sample

The sample comprised 925 twin pairs (1850 twins) in the Gemini study with data on all of the study variables.

9.3.2 Measures

Twin zygosity was determined using a validated zygosity questionnaire and DNA samples, as described in Chapter 3. The Home Environment Interview (HEI) is described in Chapter 4. BMI at 4 years was calculated using height and weight measurements provided by the twins' parents; BMI standard deviation scores (SDS) were calculated (adjusting for age and sex) using British 1990 growth reference data and the LMS growth macro for excel, as described in Chapter 8.

9.4 Statistical analyses

9.4.1 Sample characteristics

As for all previous studies, response bias was checked by comparing the study sample with the total HEI sample on all variables included in the analysis (t-tests for continuous variables; chi-square tests for categorical variables).

9.4.2 Heritability analyses

Estimates of genetic and environmental effects on a particular trait can be derived by comparing monozygotic (MZ) twins (who share 100% of their genes) and dizygotic (DZ) twins (who share approximately 50% of their genetic material). Greater resemblance between MZ than DZ twins indicates genetic influence on the particular trait. Heritability is a statistic that indexes the size of genetic influence. Specifically, it refers to the proportion of observed variance on a particular trait that can be attributed to genetic effects. The remaining observed variance can be attributed to shared environmental influences, which are shared experiences that make twins within a pair similar, and non-shared environmental influences, which are experiences unique to an individual and make twins within a pair different (Plomin, 2008).

Two methods were used to estimate heritability of four-year BMI: twin correlations and covariance modelling (described in detail below). Twin correlations provide initial indications of genetic and environmental influences on a trait; covariance modelling is a more rigorous method, which produces 95% confidence intervals for the parameter estimates (Rijsdijk & Sham, 2002).

For each method, BMI SDS at 4 years was residualised for age at BMI measurement and sex effects using linear regression. This is a standard practice in heritability analyses because age and sex are correlated within twin pairs, meaning that any effect of these variables on BMI SDS could inflate the shared environmental effect (McGue & Bouchard, 1984). As a further check, the analyses were repeated using BMI SDS scores additionally residualised for gestational age, which could also inflate the shared environmental effect, being exactly correlated within twin pairs.

Heritability estimates for BMI SDS at 4 years were calculated for the total sample and for home environment groups dichotomised on the mean (0): lower (≤ 0) and higher (> 0) risk overall, food, activity, and media home environments. A mean split was used to create the home environment groups to ensure that there were sufficient MZ and DZ twins within each group.

9.4.3 Twin correlations

Intraclass correlations were calculated for each zygosity group (MZs and DZs) and for each zygosity group by each home environment group (e.g. MZs living in an overall higher risk home environment) using SPSS version 18.0. Doubling the difference between MZ correlations and DZ correlations provides a rough estimate of heritability (h^2) as MZ twins are genetically twice as similar as DZ twins ($h^2 = 2*(r_{MZ} – r_{DZ})$). Within-pair similarity is assumed to be attributable to both genetic and shared environmental factors. Estimates for shared environmental effects (c^2) can therefore be calculated by subtracting the heritability estimate from the MZ correlation ($c^2 = r_{MZ} – h^2$). The remaining variance provides an estimate of non-shared environmental influence plus measurement error ($e^2 = 1 – r_{MZ}$) (Falconer & Mackay, 1996). Parameter estimates were calculated in Microsoft Excel 2010.

9.4.4 Model-fitting

Univariate twin models, with Mx Maximum Likelihood Structural Equation Modeling Software (version 32; Virginia Commonwealth University, Richmond, VA), were used to produce parameter estimates for the total sample and to test for quantitative differences in parameter estimates between the lower and higher risk home environment groups. Additive[10] genetic effects (A), shared environmental effects (C), and non-shared environmental effects (E) were estimated in each model by using the covariance between twins. Because MZ twins share 100% of their genetic material and DZ twins share approximately 50%, the genetic correlations within MZ and DZ pairs were fixed at 1.0 and 0.5, respectively. As it is assumed that shared

[10] Additive refers to the combined effects of alleles at different loci being equal to the sum of their individual effects.

environmental influences are equal for MZ and DZ twins, the shared environmental correlation was fixed at 1.0 for both zygosities.

To compare parameter estimates in lower and higher risk home environment groups, a common effects model was fitted to the data. In this type of model, the magnitude of variance explained by the parameter estimates is allowed to differ between groups. The fit of different nested models are then compared to the original model (in this case the common effects model) using likelihood ratio tests. A significant difference between the negative log-likelihood (-2LL) of the nested model and that of the original model indicates a deterioration in model fit (Davis, Arden, & Plomin, 2008; Neale & Maes, 2001). The goodness-of-fit of a nested model can also be judged by referring to Akaike's Information Criteria (AIC = chi-square – 2 df), with lower values indicating better fit (Burnham & Anderson, 2002). The two nested models in this study were the scalar model, which allows variance differences but not quantitative differences between groups, and the null model, which constrains all parameters to be the same across groups. If the scalar or null model show a better fit than the common effects model, there are no quantitative differences in parameter estimates between groups (Davis et al., 2008; Neale & Maes, 2001).

9.5 Results

9.5.1 Sample characteristics

Of the total HEI sample (N = 1113 families; 2226 twins), 12 twin pairs had unknown zygosity, and data were missing for BMI SDS at 4 years (174 cases for the first-born twin; 177 cases for the second-born twin). This left the total study sample at 925 twin pairs (1850 twins). There were no significant differences between the study sample (n = 925) and the total HEI sample (n = 1113) on any of the study variables: home food ($\chi^2(1) = 0.01$, p = 0.915), activity ($\chi^2(1) = 0.00$, p = 0.984), media ($\chi^2(1) = 0.63$, p = 0.426), and overall ($\chi^2(1) = 0.11$, p = 0.738) environment groups, zygosity ($\chi^2(1) = 0.00$, p = 0.957), sex ($\chi^2(1) = 0.04$, p = 0.849), gestational age (t(2029) = -0.79, p = 0.432), age at BMI measurement (t(1859) = 0.04, p = 0.967; t(1862) = 0.28, p = 0.782), and BMI SDS at 4 years (t(1859) = -0.00, p = 0.999; t(1862) = -0.02, p = 0.988).

The characteristics of the study sample are shown in **Table 9.1**. Approximately one third of twin pairs were MZ and two thirds were DZ. The average age at the time of the HEI was 4 years; half of the sample was male. The proportion of twin pairs living in higher and lower risk home environments was roughly equal, with slightly more twin pairs living in lower risk home environments. Average BMI SDS at 4 years was below that of the reference population (-0.01 and -0.10 for first and second born twins, respectively).

Table 9.1. Characteristics of the study sample (% (n), unless stated otherwise)

	N = 925 families; 1850 twins
Twin pairs	
Monozygotic	33.9 (314)
Dizygotic	66.1 (611)
Sex	
Male	49.5 (915)
Female	50.5 (935)
Twins' age at HEI (years), mean (SD)	4.14 (0.40)
BMI SDS at 4 years, mean (SD)	
First born	-0.01 (1.03)
Second born	-0.10 (1.03)
Overall home environment	
Lower risk families	54.9 (508)
Higher risk families	45.1 (417)
Home food environment	
Lower risk families	51.8 (479)
Higher risk families	48.2 (446)
Home activity environment	
Lower risk families	57.2 (529)
Higher risk families	42.8 (396)
Home media environment	
Lower risk families	57.7 (534)
Higher risk families	42.3 (391)

HEI = Home Environment Interview; BMI = body mass index; SD = standard deviation; SDS = standard deviation score.

Table 9.2 presents the mean BMI SDS of twins (at 4 years) within each of the home environment groups. For the home food, media, and overall home environment, the mean BMI SDS was slightly lower in the higher risk groups. There were no significant differences between groups: home food environment (t(1848) = 0.86, p = 0.392); home activity environment (t(1848) = -0.28, p = 0.778); home media environment (t(1848) = 1.25, p = 0.211); overall home environment (t(1848) = 1.00, p = 0.317).

Table 9.2. BMI SDS at 4 years by home environment risk

	BMI SDS at 4 years, mean (SD)
Overall home environment	
Lower risk families (n = 1015)	-0.03 (1.01)
Higher risk families (n = 835)	-0.08 (1.06)
Home food environment	
Lower risk twins (n = 959)	-0.04 (1.02)
Higher risk families (n = 891)	-0.08 (1.04)
Home activity environment	
Lower risk families (n = 1059)	-0.06 (1.04)
Higher risk families (n = 791)	-0.05 (1.03)
Home media environment	
Lower risk families (n = 1065)	-0.03 (0.96)
Higher risk families (n = 785)	-0.09 (1.12)

9.5.2 Heritability estimated from twin correlations

The ICCs for BMI SDS at 4 years (adjusted for age and sex) by zygosity and home environment groups are shown in **Figures 9.1** and **9.2**. Correlations were always higher between MZ than DZ twins, indicating a genetic contribution to BMI. The size of the difference between MZ and DZ twins varied according to the level of home environment risk, with greater differences in higher than lower risk home environments; although the difference was smaller between higher and lower risk media environments. Heritability estimates calculated from the ICCs are presented in **Table 9.3**. For the total sample, heritability of BMI was high (70%). Heritability was particularly high in the higher risk overall (92%), food (86%), and activity (92%) home environments; estimates were lower but substantial in the lower risk overall (54%), food (56%), and activity (54%) home environments. Heritability estimates for higher and lower risk home media environments were more similar (78% and 64%, respectively). The pattern of results was the same when using BMI SDS (at 4 years) additionally adjusted for gestational age.

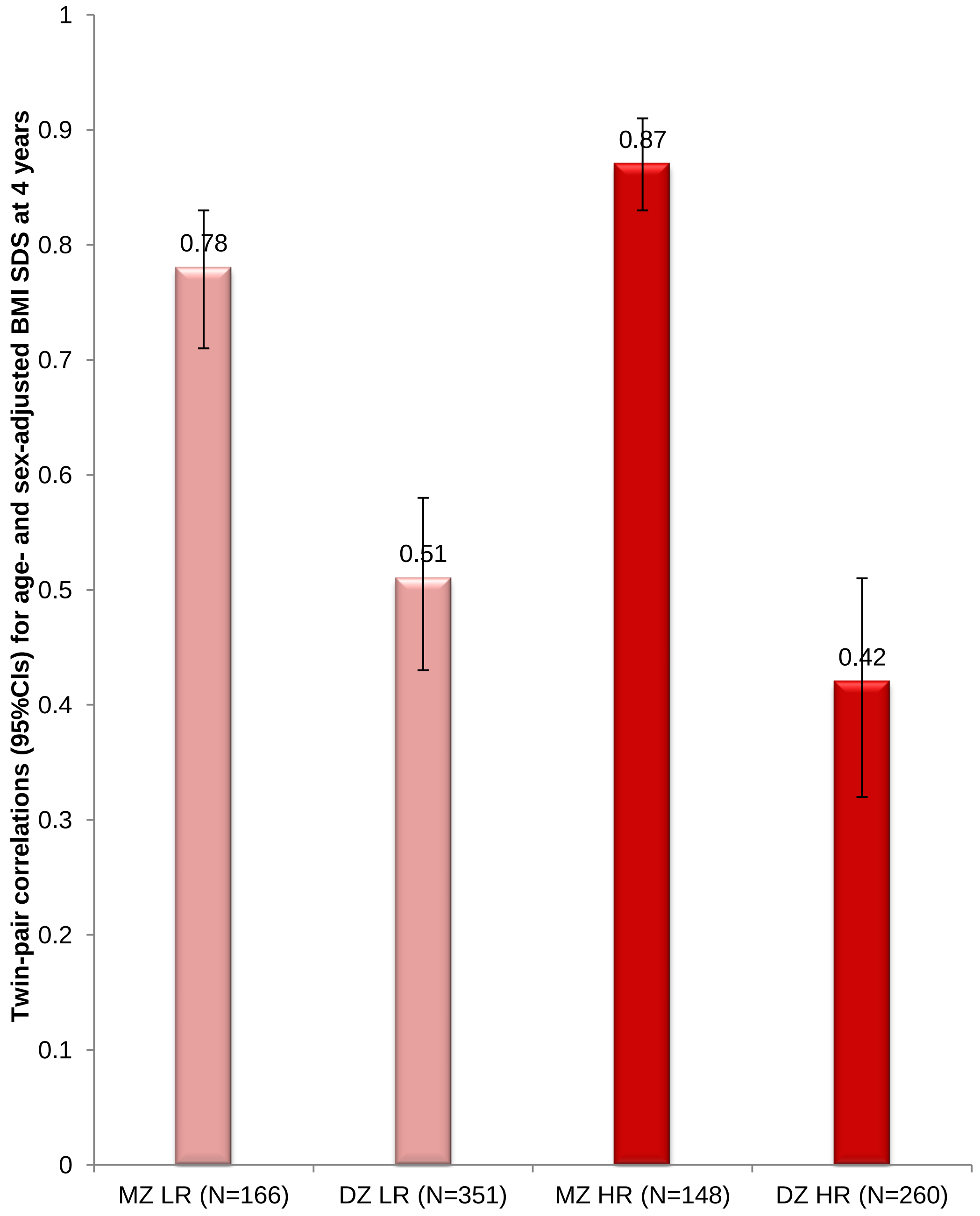

Figure 9.1. intraclass correlations of BMI SDS at 4 years by zygosity and overall home environment risk
MZ LR = monozygotic twins living in a lower risk home environment; DZ LR = dizygotic twins living in a lower risk home environment; MZ HR = monozygotic twins living in a higher risk home environment; DZ HR = dizygotic twins living in a higher risk home environment.

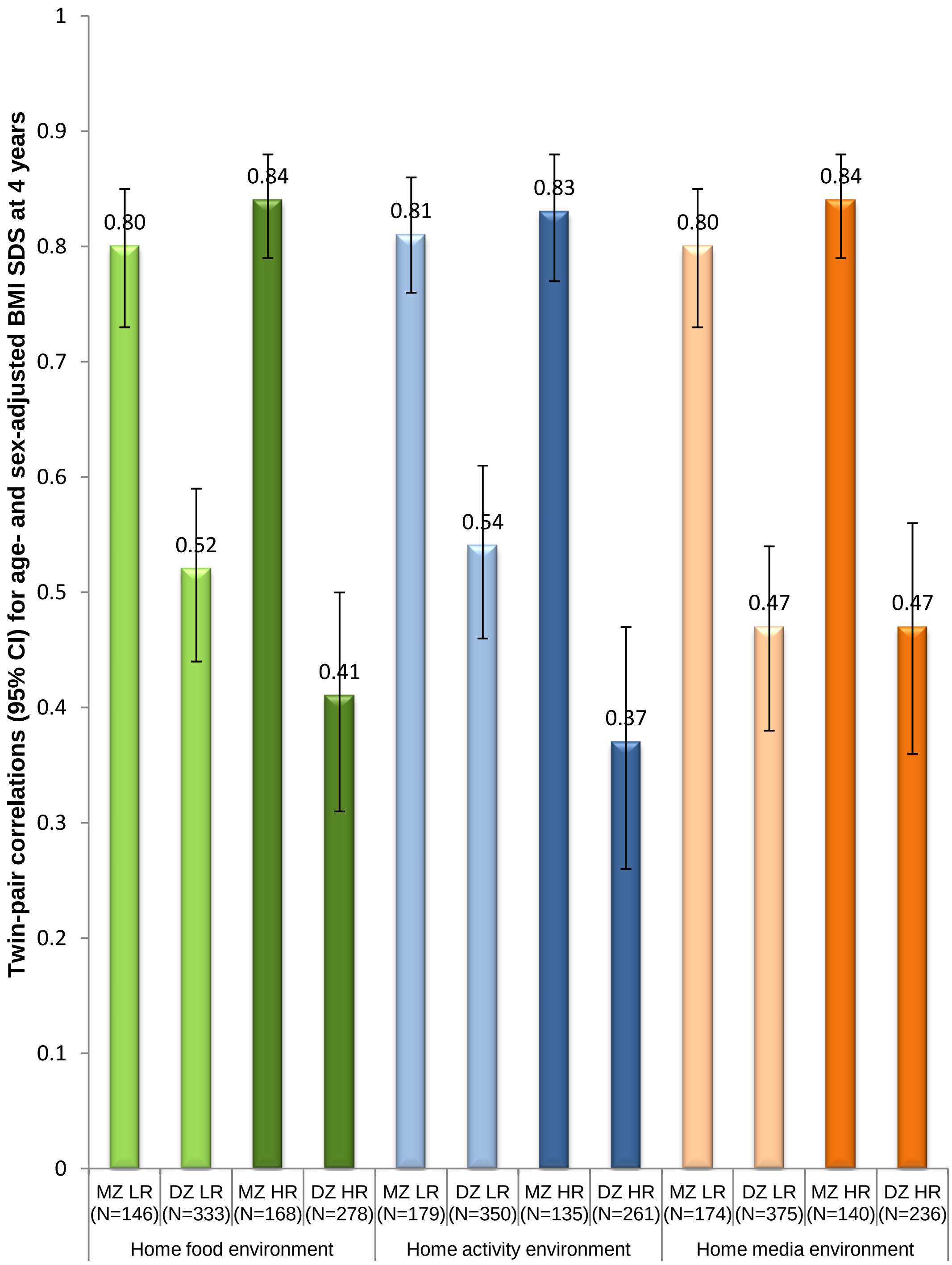

Figure 9.2. intraclass correlations of BMI SDS at 4 years by zygosity and home food, activity, and media environment risk

MZ LR = monozygotic twins living in a lower risk home environment; DZ LR = dizygotic twins living in a lower risk home environment; MZ HR = monozygotic twins living in a higher risk home environment; DZ HR = dizygotic twins living in a higher risk home environment.

Table 9.3. Parameter estimates (A, C, and E) calculated from twin intraclass correlation coefficients for the total study sample and by home environment risk

	N MZ pairs	N DZ pairs	A	C	E
Total sample	314	611	0.70	0.12	0.18
Overall home environment					
Lower risk	166	351	0.54	0.24	0.22
Higher risk	148	260	0.92	-0.05	0.13
Home food environment					
Lower risk	146	333	0.56	0.24	0.20
Higher risk	168	278	0.86	-0.02	0.16
Home activity environment					
Lower risk	179	350	0.54	0.27	0.19
Higher risk	135	261	0.92	-0.09	0.17
Home media environment					
Lower risk	174	375	0.64	0.16	0.20
Higher risk	140	236	0.78	0.06	0.16

MZ = monozygotic; DZ = dizygotic; A = variance explained by additive genetic influence; C = variance explained by shared environmental influence; E = variance explained by non-shared environmental influence plus error.

9.5.3 Heritability estimated from model fitting

For the total sample, additive genetic factors explained 62% of the variance in BMI SDS at 4 years (95% CI = 49 – 75%), shared environmental factors explained 18% (5 – 29%), and non-shared environmental factors explained 20% (17 – 24%). Parameter estimates for higher and lower risk home environments are summarised in **Table 9.4**. For the overall home environment, the common effects model gave the best fit to the data, as both the scalar and null models resulted in a significant worsening of fit (p value's < 0.001). In line with the hypothesis, the common effects model showed that the heritability of BMI SDS was higher in overall higher risk home environments. This pattern of results was replicated when fitting the models to the home food and physical activity environment data (p value's ≤ 0.01), indicating that parameter estimates differed according to home environment risk. For the home media environment, the scalar model fitted the data better than the common effects model (∆ AIC = -4.265), indicating variance differences between higher and lower risk groups. Additive genetic factors explained at least 80% of the variance in BMI SDS for twin pairs living in higher risk home environments (overall, food, and activity), and no more than 49% of the variance for those living in lower risk home environments (overall, food, and activity). Heritability estimates did not differ when comparing twin pairs living in lower and higher risk home media environments. These results were replicated when using BMI SDS (at 4 years) additionally adjusted for gestational age.

Table 9.4. Goodness of fit statistics and parameter estimates (95% confidence intervals) for home environment interaction models, which examined the heritability of BMI SDS at 4 years[1] (N = 1857)[2]

	Model[3]	Additive Genetic Effect (a^2)	Shared Environment Effect (c^2)	Non-shared Environment Effect[4] (e^2)	-2LL	Df	Δ AIC	χ^2 (df)	*P*
Overall	**1. Common effects**				4738.484	1847	-	-	-
	Lower risk	0.39 (0.21 – 0.57)	0.34 (0.18 – 0.49)	0.27 (0.21 – 0.33)					
	Higher risk	0.86 (0.68 – 0.89)	0.00 (0.00 – 0.00)	0.14 (0.11 – 0.18)					
	2. Scalar	0.80 (0.40 – 0.83)	0.00 (0.00 – 0.00)	0.20 (0.16 – 0.27)	4766.663	1850	22.180	28.180(3)	<0.001
	3. Null	0.80 (0.41 – 0.83)	0.00 (0.00 – 0.00)	0.20 (0.16 – 0.23)	4766.735	1851	20.251	28.251(4)	<0.001
Food	**1. Common effects**				4746.976	1847	-	-	-
	Lower risk	0.40 (0.23 – 0.59)	0.35 (0.18 – 0.49)	0.25 (0.20 – 0.31)					
	Higher risk	0.83 (0.65 – 0.87)	0.00 (0.00 – 0.00)	0.17 (0.13 – 0.21)					
	2. Scalar	0.80 (0.41 – 0.83)	0.00 (0.00 – 0.00)	0.20 (0.16 – 0.27)	4766.458	1850	13.481	19.481(3)	<0.001
	3. Null	0.80 (0.41 – 0.83)	0.00 (0.00 – 0.00)	0.20 (0.16 – 0.27)	4766.596	1851	11.620	19.620(4)	0.001
Activity	**1. Common effects**				4753.873	1847	-	-	-
	Lower risk	0.49 (0.33 – 0.65)	0.31 (0.15 – 0.44)	0.21 (0.17 – 0.26)					
	Higher risk	0.80 (0.60 – 0.84)	0.00 (0.00 – 0.00)	0.20 (0.16 – 0.26)					
	2. Scalar	0.80 (0.40 – 0.83)	0.00 (0.00 – 0.37)	0.20 (0.16 – 0.27)	4767.237	1850	7.364	13.364(3)	0.004
	3. Null	0.80 (0.41 – 0.83)	0.00 (0.00 – 0.37)	0.20 (0.16 – 0.27)	4767.267	1851	5.394	13.394(4)	0.010
Media	**1. Common effects**				4744.116	1847	-	-	-
	Lower risk	0.60 (0.42 – 0.78)	0.18 (0.01 – 0.33)	0.23 (0.18 – 0.29)					
	Higher risk	0.65 (0.46 – 0.84)	0.17 (0.00 – 0.34)	0.19 (0.14 – 0.23)					

2. Scalar	0.63 (0.50 – 0.76)	0.17 (0.04 – 0.29)	0.21 (0.17 – 0.24)	4745.851	1850	-4.265	1.735(3)	0.629
3. Null	0.62 (0.49 – 0.76)	0.17 (0.05 – 0.29)	0.20 (0.17 – 0.24)	4759.223	1851	7.107	15.107(4)	0.004

[1] The BMI SDS scores modelled were residuals adjusted for age at BMI measurement and sex.
[2] Presented models include all children with valid data for age, sex, HEI score, and BMI SDS at 4 years. An extra 7 cases, where just one twin within the pair had available BMI data, were included in the MX modelling.
[3] Statistical analyses: Standard ACE model-fitting analyses for continuous data were used to model BMI SDS at 4 years.
[4] Includes measurement error.
Abbreviations: -2LL, -2 log likelihood; df, degrees of freedom; AIC, Akaike's Information Criterion.

9.6 Discussion

This is the first study to examine whether the heritability of BMI varies according to the obesogenic quality of the home environment in early childhood. As hypothesised, heritability of BMI was significantly higher among children living in overall higher risk home environments than those living in overall lower risk home environments. There was no evidence of a shared environmental effect in the overall higher risk group, while there was a moderate effect in the overall lower risk group. The findings were similar when modelling BMI in home food and activity environments presenting differential risk, but not when comparing lower and higher risk home media environments. Overall, the findings are suggestive of G x E.

For the total sample, the proportion of variance in BMI was largely explained by additive genetic factors (62%), moderately explained by shared environmental factors (18%), and moderately explained by the unique environment plus measurement error (20%). These estimates largely concur with those reported in previous studies focusing on four-year-old children, which have generally reported substantial genetic influence (50 – 70%), moderate shared environmental influence (11 – 39%), and less unique environmental influence (7 – 20%) on variation in BMI (Silventoinen, Rokholm, Kaprio, & Sørensen, 2010). Research suggests that the heritability of BMI increases throughout childhood (Haworth et al., 2008; Silventoinen et al., 2010), perhaps as individuals seek out environments that are in line with their genotype (active r_{GE}) (Dick, 2005), or because gene expression changes developmentally (Bergen, Gardner, & Kendler, 2007). For adolescents and adults, a greater proportion of variance in BMI is explained by unique than shared environmental influences (Nan et al., 2012), perhaps reflecting the increasing independence of individuals from their parents.

The findings of the present study build upon previous research showing that individuals respond differently to various aspects of the obesogenic home environment (e.g. Andreyeva et al., 2011; Birch et al., 2003; Jansen et al., 2003; Keller et al., 2012); a precondition for further exploring the possibility of G x E (Moffitt et al., 2006). While other research has used twin modelling to provide evidence for G x E in the context of obesity, none of these studies used proximal environmental measures, focusing instead on the moderating effects of specific behaviours, such as physical activity (Mustelin et al., 2009), or distal environmental measures, such as socioeconomic status (SES) (W. Johnson et al., 2011). Considering proximal environmental exposures in the context of G x E is an important research endeavour as these are more amenable to change than distal environmental exposures. Proximal environmental exposures are also more likely to meet G x E criteria for an environmental risk factor and it is easier to hypothesise about their potential impact on neurobiological pathways that mediate the development of overweight and obesity (Moffitt et al., 2006).

The findings of the present study are in line with a diathesis-stress model of G x E, according to which individuals who are genetically predisposed to a disorder are more sensitive to environmental risk factors than those who are not predisposed (Rende & Plomin, 1992; Shanahan & Hofer, 2005). In particular, the findings support the behavioural susceptibility model, which proposes that exposure to an obeosgenic environment triggers the expression of obesity-related genes (Carnell & Wardle, 2008a). The findings also contrast with the view that only extreme environments can modify the expression of genetic influences (Scarr, 1992; Turkheimer & Gottesman, 1991), as differences in heritability emerged in groups split on the mean, in a generally higher SES sample. It is possible that differences in heritability would be even more pronounced when using more extreme home environment cut-offs; this was not feasible to examine in the present study due to the limited sample size.

It is not clear why there was no difference in heritability when comparing lower and higher risk home media environments. It is possible that G x E occurs only in extreme home media environments as there was a skew towards lower risk in the present sample; although there seemed to be sufficient variation. It may also be that only certain aspects of the home media environment are relevant to G x E. Existing research suggests that individuals respond differently to food commercials (Andreyeva et al., 2011; Falciglia & Gussow, 1980) and branding (Keller et al., 2012), with susceptible individuals consuming more in the presence of food cues. Each of these factors is food-related and might trigger appetitive responses in susceptible individuals. On the other hand, purely media aspects of the home environment, such as the number of media equipment and the presence of a TV in the bedroom, may influence weight but not necessarily via G x E. Another possibility is that G x E does arise when susceptible individuals are exposed to an obesogenic media environment; however the effects are not evident until later in development when media influences are generally more prominent (Ofcom, 2011). Future research should further examine the possibility of G x E using the home media environment as the exposure, perhaps in more diverse and older samples.

It was intriguing to observe that although there were differences in the heritability of BMI by home environment, there was not a mean difference in BMI between groups. A previous study (examining the heritability of disordered eating in divorced versus intact families) also found group differences in heritability in the absence of a significant phenotypic association; although they did report a trend in the expected direction (Suisman, Burt, McGue, Iacono, & Klump, 2011). The authors noted that the absence of a significant phenotypic association does not negate group differences in heritability as G x E may attenuate the association, in the sense that it is less likely to be present in individuals without genetic predispositions. In the present study, another plausible explanation is that the home environment immediately affects the genetic influence on BMI, but it takes some time for the genetic influence on BMI to be expressed as a discordant phenotype (i.e. the children in the higher risk group have a higher BMI than the children in the lower risk group).

Candidate gene and genome-wide association studies have provided insight into the genetic architecture of overweight and obesity (Barsh et al., 2000; Choquet & Meyre, 2011; Clement, Boutin, & Froguel, 2002), and suggest pathways for G x E to occur. Many of the genes identified as being relevant to overweight and obesity are specific to the hypothalamus (Hofker & Wijmenga, 2009), which plays a central role in regulating appetite and food intake (Kalra et al., 1999; Suzuki, Simpson, Minnion, Shillito, & Bloom, 2010). There is also emerging evidence that food intake is influenced by cortical and subcortical brain regions related to reward sensitivity and incentive motivation (Volkow et al., 2008; Volkow & Wise, 2005). Although the precise neurobiological mechanisms underlying G x E in obesity are yet to be understood, it is feasible that exposure to a home environment with multiple food cues triggers genes that signal appetitive and reward-related pathways, which prompt increased food intake, and subsequently weight. Using the candidate gene approach, recent research has shown that physical activity suppresses the effect of obesity-related genes on BMI, perhaps also via appetitive and reward-related pathways (S. Li et al., 2010; Rampersaud, Mitchell, Pollin, & et al, 2008). Future research should directly examine whether the home environment moderates genetic expression. Taking into account multiple obesity-related genes, perhaps using a genetic risk score, may be a more informative approach than considering single genetic markers as BMI is a highly polygenic trait (Llewellyn, Trzaskowski, Plomin, & Wardle, 2013; Yang et al., 2011).

Although the findings of this study add to the existing literature exploring G x E, there are several limitations to note. While the findings are suggestive of G x E, it was not possible to determine the precise form of gene-environment interplay. For example, obesity-related genes and pathways may be activated by living in a higher risk home environment, but it is also feasible that living in a protective home environment suppresses the expression of obesity genes (Shanahan & Hofer, 2005). Comparing the heritability of weight across the continuum of home environment risk would provide some insight into the nature of gene-environment interplay. Heritability might be similarly high in mid and higher risk home environments, and lower only in environments that exert controls; or it may increase in a linear fashion as home environment risk increases. It is also feasible that the present findings are to some extent explained by gene-environment correlation (r_{GE}) (Dick, 2005, 2011). Several types of r_{GE} may operate. For example, a child may be born into a home environment that is correlated with their genotype (passive r_{GE}); and some aspects of the home environment, such as parental feeding practices, may be responsive to the child's genotype (reactive r_{GE}). MX scripts have been developed to directly examine the influence of an environmental moderator on the heritability of a phenotype while taking into account possible r_{GE} effects (Purcell, 2002). However, larger sample sizes are needed.

There are also some general limitations of the twin method, including its reliance on critical assumptions, which may lead to overestimation of heritability estimates. The most commonly cited assumption is that of equal shared environments in DZ and MZ twins, with several researchers arguing that MZ twins actually experience more similar environments than DZ twins do (Guo, 2001; Hettema, Neale, & Kendler, 1995). There is also some evidence that certain factors, such as the prenatal environment, may make MZ twins less similar than the twin method assumes (Evans & Martin, 2000). However, the extent of these issues may be insufficient to alter overall conclusions from twin studies. For example, studying twins reared apart overcomes the equal environments assumption, and principal findings are in line with those reported in twin modelling studies (Stunkard et al., 1990). More generally, findings from twin studies may not apply to other members of the population. Twins are less representative of the general population than singletons in several ways, including their growth (Estourgie-van Burk et al., 2006); although there is no evidence that growth patterns differ between MZ and DZ twins, which would compromise findings from studies using the twin method.

Another limitation is that the findings may not generalise to other ethnic groups, as the sample comprised predominantly white children. Although it is not clear whether or how G x E would vary by ethnicity, some research suggests that heritability of BMI is higher in Caucasian than East Asian adolescents (Hur et al., 2008). It would therefore be informative to replicate the present findings in a more ethnically diverse sample. Finally, as in other cohort studies, heritability estimates were derived from parent reports of BMI. However, research has shown that parent-reported and measured BMI correlate highly, supporting the validity of parent reports (Haworth et al., 2008; Reed & Price, 1998).

9.6.1 Conclusion

The present study built upon existing research by examining the heritability of BMI in home environments presenting differential risk for weight gain. That heritability of BMI was higher in more obesogenic home environments is consistent with a diathesis-stress model of G x E, providing further insight into the mechanisms underlying overweight and obesity and how they may be prevented early in development.

Chapter 10: General discussion

10.1 Prelude

High rates of overweight and obesity, among young children as well as adults, highlight the need for preventive efforts. Understanding the role of modifiable risk factors for overweight and obesity is central to developing effective prevention and intervention strategies. The home environment is thought to be a key influence on early weight trajectories. However, research in this area is limited in a number of ways. Few studies have used composite measures of the home environment, and few have reported the psychometric properties of their measures. There is little research examining associations between the home environment and weight in early childhood, and no studies have tested the gene-environment interaction (G x E) hypothesis in the context of the obesogenic home environment.

This thesis aimed to provide further insight into the role of the home environment. The first study developed a comprehensive measure of the home environment, including quantification of the extent to which the home environment presents risk for childhood weight gain. The next study used a wearable camera called 'SenseCam' to capture and validate aspects of the home environment measure. Study 3 explored maternal characteristics associated with the obesogenic quality of the home environment. Studies 4 and 5 examined whether the obesogenic quality of the home environment was associated with energy-balance behaviours (EBBs) and weight in early childhood. The final study tested the G x E hypothesis, by examining whether the observed heritability of weight was higher in an obesogenic home environment. This chapter provides an overview of the study findings and their contribution to the literature. Limitations and directions for future research are also discussed.

10.2 Summary of findings and contribution to the literature

10.2.1 Quantifying the obesogenic quality of the home environment

While focusing on individual aspects of the home environment is an important research endeavour, composite measures may be better powered to detect an association with weight, if they are appropriately aggregated. Study 1 (Chapter 4) developed a comprehensive measure, along with a composite scoring procedure, to capture the overall obesogenic quality of the home environment, incorporating the core domains of food, activity, and media. There are just three other home environment measures that comprehensively assess both physical and social aspects of each core domain (Bryant et al., 2008; Pinard et al., 2013; Spurrier et al., 2008); and just one of these presented a total scoring procedure (Pinard et al., 2013). The latter was published towards the end of this thesis.

That there were fewer activity and media-related variables than food-related variables in the home environment measure highlights the current state of the literature, as there has been more research attention in the food domain. Although some might argue that the food domain is the most relevant to risk for weight gain, via its influence on energy intake (Cutler et al., 2003; Luke & Cooper, 2013; Swinburn et al., 2009), physical activity and sedentary behaviour do play a role in weight management (J. O. Hill & Peters, 2013; J. O. Hill, 2006; Hu, 2008), and it is important to further understanding of the activity and media domains for a comprehensive picture.

Test-retest reliability for the individual items in the measure was generally moderate to high, with lower scores observed for savoury and sweet snack variety. Other research also indicates that home food availability is a somewhat unstable aspect of the home environment (Bryant & Stevens, 2006; Bryant et al., 2008; Sisk et al., 2010), varying at least in part due to actual consumption and/or purchase patterns. Associations between home food availability and how usual the reported amount of food was indicated that lower reliability could partly be explained by natural changes in household food availability; this was taken into account when creating the composite scores.

An expert panel was consulted to ensure that the home environment composites included variables relevant to risk for child weight gain. This technique has been used in the development of previous home environment measures (Boles et al., 2013; Bryant et al., 2008; Golan & Weizman, 1998; Ihmels, Welk, Eisenmann, & Nusser, 2009; Pinard et al., 2013), although the number of experts consulted in this thesis was larger than previously reported, increasing confidence in the reliability of the outcome. Most of the expert panel (≥ 60%) identified 20 out of 32 home food environment variables, 6 out of 9 home activity environment variables, and 6 out of 8 home media environment variables as being relevant to risk for weight gain in childhood. These variables were included in the composites.

Each composite had adequate (food) to high (overall, activity, and media) test-retest reliability, and the separate composites (food, activity, and media) correlated highly with the overall one. The home food and activity composites, and the home food and media composites were moderately correlated, indicating that homes presenting higher risk in one domain were also likely to present higher risk in another domain. These findings are consistent with previous research showing that risk factors for obesity can cluster together (Davison & Birch, 2002; Epstein, Roemmich, et al., 2005; Taveras et al., 2006). However, the home activity and media composites were only slightly correlated, supporting the notion that these should be considered as separate constructs in the obesity literature. This finding also highlights the importance of taking into account multiple aspects of the home environment when assessing risk for weight gain. As demonstrated in previous research, seemingly contrary EBBs (Ford et al., 2005; Nelson et al., 2005) and features of the home environment (Martinson et al., 2011) can co-occur.

Composite variations were created using the expert feedback (first aggregating variables where there was consensus among 50% or more of the experts, and then where there was consensus among 85% or more of the experts) and correlated highly with the original versions, providing some support for robustness.

10.2.2 Using a novel tool called ‘SenseCam’ to examine and validate aspects of the home environment

Although it is important to demonstrate the validity of home environment measures, few researchers have done so (Pinard et al., 2012). Validating home environment measures using standard home visits is costly, labour-intensive, and limited to assessing physical aspects of the environment, generally on a single occasion. Study 2 (Chapter 5) demonstrated that researchers can use wearable cameras to assess both physical and behavioural aspects of home environment measures over time; although there are practical and ethical issues to consider.

SenseCam captured various aspects of the home environment including the availability of food/beverages, activity equipment/facilities, and media equipment, the display of food/beverages, family meals, and parental TV viewing. Features that were rarely captured included the availability of frozen and tinned foods, the sugar-content of drinks, the presence of satellite TV, and child eating while watching TV. Information was missed due to the poor quality of some images, because feature-capture was dependent on the wearer’s behaviour, and due to the limited wearing period. It was not possible to capture certain social aspects of the home environment, namely parental feeding practices, support of physical activity, and rules around media use.

Agreement between the HEI and SenseCam was moderate to high for most home environment features; lower agreement was reported for food variety (except fresh vegetables) and the number of computers in the home. A main issue was that, for many variables, the observed level of agreement was based on what could be seen in the images and may not have been a reflection of reality. Participants were generally positive about the utility of SenseCam, although there were situations where they didn’t feel comfortable wearing the camera and many felt that a four-day wearing period was sufficient.

10.2.3 Characteristics associated with the overall obesogenic quality of the home environment

The development of overweight and obesity is the result of complex interactions between multiple factors (Vandenbroeck, Goossens, & Clemens, 2007). In order to fully understand the role of the home environment in weight trajectories, it is important to consider how it relates to other factors that are relevant to risk for weight gain. Study 3 (Chapter 6) was the first study to examine multiple characteristics associated with the overall obesogenic quality of the home environment in early childhood. Several maternal characteristics, also relevant to risk for weight gain, were associated with the overall obesogenic quality of the home environment, providing further support for the notion that parents play a key role in the development and management of child overweight and obesity (Golan & Crow, 2004; Hendrie et al., 2012; Savage et al., 2007).

Specifically, younger, less educated mothers, and those living in lower income households were more likely to live in home environments that presented overall greater risk for child weight gain, after adjusting for other relevant variables. Heavier mothers, those with higher levels of external eating behaviour, lower levels of happiness, and those who introduced solid foods earlier, and breastfed for a shorter period, were also more likely to live in overall higher risk home environments. The absence of a partner or spouse, and maternal emotional eating were associated with the quality of the home environment in univariate models, but not after adjustment for other variables. The number of other children living in the home was not associated with the home environment.

10.2.4 Associations between the obesogenic quality of the home environment and energy-balance behaviours in early childhood

Findings from Study 4 (Chapter 7) provided further support for the importance of preventive efforts in the context of obesity. Although rates of EBBs were lower than those reported in samples of lower socioeconomic status (SES) and greater ethnic diversity, they nevertheless indicated that a considerable proportion of young children engaged in behaviours that promote positive energy imbalance. That more than a third of children exceeded existing guidelines for TV viewing is particularly relevant as high levels of TV viewing has been more consistently associated with increased risk for overweight in this age group than other EBBs (Hawkins & Law, 2006; Reilly, 2008; te Velde et al., 2012; van Stralen et al., 2012). Although evidence for associations between dietary variables and weight in young children is weaker, research has shown that EBBs can persist over time (Biddle et al., 2010; Mikkilä et al., 2005; Y. Wang et al., 2002), potentially becoming increasingly relevant to risk for weight gain.

Rates of positive EBBs were particularly high among children living in more obesogenic home environments, supporting the notion that the home context is an important avenue for preventing overweight and obesity (Davison & Birch, 2001; Ebbeling et al., 2002; Golan, 2006; Tabacchi et al., 2007). The home food, activity, and media environment composites, which formed the overall home environment composite, were each associated with corresponding EBBs at 4 years. In particular, children living in higher risk home food environments were less likely to consume fruit and vegetables frequently, and more likely to consume energy-dense snacks, fast food, convenience food, and sugar-sweetened drinks than children living in lower risk home food environments. There were no associations with child fruit juice, milk, or artificially-sweetened drink consumption. Children living in higher risk activity environments were less physically active than those living in lower risk activity environments, and children living in higher risk media environment were more likely to watch TV for at least 2 hours each day than those living in lower risk media environments. Taken together, these findings indicate that the home environment may influence weight via several behavioural pathways.

10.2.5 Associations between the obesogenic quality of the home environment and BMI in early childhood

Contrary to expectations, Study 5 (Chapter 8) found no associations between the overall obesogenic quality of the home environment, or the food, activity, and media domains, and child BMI at 4 years or BMI change from 4 to 5 years. The findings were replicated when using the composite variations, providing some support for robustness. When examining associations between the individual home environment variables and BMI at 4 years, there were positive associations with three of the parental feeding practices: restriction, covert restriction, and monitoring; although the effects were small and just above the significance threshold when applying bonferroni's correction. None of the other home environment variables were associated with BMI at 4 years and none were associated with BMI change from 4 to 5 years. None of the EBBs were associated with BMI at 4 years, and just two of the EBBs (frequency of fruit and milk consumption) were associated (negatively) with BMI change from 4 to 5 years.

These findings are in line with previous studies reporting few significant associations between multiple aspects of the home environment and weight (Bauer, Neumark-Sztainer, Fulkerson, Hannan, & Story, 2011; MacFarlane et al., 2009; Sallis et al., 1995); and build upon existing research by additionally using composite measures of the home environment in a large sample, which may be better powered to detect associations with weight. The null associations between EBBs and weight are not completely surprising in that previous research findings in preschool-aged samples have been mixed, especially with regard to food and beverage consumption (te Velde et al., 2012; van Stralen et al., 2012). The findings do not discount the relevance of the home environment to weight trajectories as it is feasible that associations with weight may emerge later in development, when EBBs have been sustained over time.

10.2.6 Variation in the heritability of BMI according to the obesogenic quality of the home environment in early childhood

The relevance of the home environment to weight trajectories was highlighted in Study 6 (Chapter 9), which found that the heritability of BMI at 4 years was higher among children living in overall higher risk home environments than those living in overall lower risk home environments. There was no shared environmental effect in overall higher risk home environments, while there was a moderate effect in overall lower risk home environments. This pattern of findings emerged when examining heritability in higher and lower risk home food and activity environments, but not in home media environments. Taken together, these findings are in line with the behavioural susceptibility hypothesis, which proposes that the environment influences weight by triggering the expression of genetic predispositions in the form of obesogenic behaviours (Carnell & Wardle, 2008a, 2008b). If G x E underlies any association between the home environment and weight, this may explain some of the null findings reported in previous research; associations may only appear among those genetically predisposed to weight gain, and the strength of associations may increase with greater genetic risk.

Consistent with previous behavioural genetic studies in this age group (Silventoinen et al., 2010), variance in BMI for the total sample was largely explained by genetic factors, moderately explained by shared environmental factors, and moderately explained by non-shared environmental factors (plus measurement error).

10.2.7 Implications for interventions attempting to modify the home environment

It is generally acknowledged that the family and home environment plays a key role in child weight-management programs. Systematic reviews have reported favourable (albeit small to moderate) effects of family-based interventions on weight-related outcomes (Gerards, Sleddens, Dagnelie, de Vries, & Kremers, 2011; Knowlden & Sharma, 2012; Skouteris et al., 2011). However, strategies have varied considerably in their approach, with little process evaluation, and there is limited evidence for the effectiveness of purely home-based interventions; potentially because no studies have intervened on multiple levels of the home environment (Showell et al., 2013). In adults, there is some recent evidence that weight-loss programs incorporating modifications to multiple aspects of the home environment produce better weight loss outcomes than standard behavioural programs, especially in women. However, these weight-loss outcomes were not maintained (Gorin et al., 2013). It seems important to further clarify the role of the home environment in weight trajectories so that home-based interventions can be appropriately delivered.

In the light of findings from this thesis, interventions attempting to change the obesogenic quality of the home environment might be successful if they take into account other factors that are relevant to the weight-gain trajectory. Although speculative, interventions may be beneficial if they aim to enhance the health-related knowledge of less educated mothers, inform low-income families how they can create healthier home environments in a cost-effective way, and promote maternal psychological well-being. Individuals who are susceptible to weight gain may particularly benefit from interventions targeting the home environment, and early interventions may reduce the chance that the child experiences other obesogenic exposures later in life.

Novel technologies may also have a role to play in intervention studies. While potential behavioural effects of wearing SenseCam are a limitation from a validation point of view, they do highlight its potential as an intervention tool. All participants said that wearing SenseCam made them think about their home environment, which is a starting point for behaviour change (Prochaska & Velicer, 1997). Recent research has also shown that viewing SenseCam images is highly stimulating (Silva, Pinho, Macedo, & Moulin, 2013) and prompts reflection (Lindley et al., 2011), which could motivate behaviour change. Viewing would need to be selective, however, due to the large number of images collected during even relatively short wearing periods.

10.3 Limitations and directions for future research

10.3.1 Identifying the relevant home environment variables

Although there was a majority expert-view for most of the home environment variables, opinion was divided in many cases, highlighting a need for further investigation into the role of specific variables, especially if robust composites are to be created. A general issue in determining the relevance of home environment variables is whether the associated behaviours (namely food and beverage consumption, physical activity, and TV viewing) relate to weight. While it is generally accepted that high energy intake combined with low energy expenditure promotes weight gain, the role of specific EBBs (especially dietary variables) is less clear. As noted previously, research findings have been particularly inconsistent regarding the role of fruit juice, milk, and artificially-sweetened drinks (Barba et al., 2005; Berkey et al., 2005; de Ruyter et al., 2012; Dennison et al., 1997; Giammattei et al., 2003; Newby et al., 2004; O'Connor et al., 2006); and evidence supporting the notion that fruit and vegetable consumption protects against weight gain (due to their generally low energy-density and high water-content) is also limited (Ledoux et al., 2011). Clarifying the role of specific EBBs in weight trajectories would further clarify the relevance of specific home environment variables.

Examining associations between individual aspects of the home environment and EBBs, using standard, validated measures, would permit direct comparisons between studies and systematic assessment of specific contributions to weight trajectories.

10.3.2 Aggregating the home environment variables

In addition to clarifying whether specific home environment variables present increased or decreased risk for weight gain, clarifying their relative contribution may help to create more sophisticated composite measures than those used in this thesis. The food, activity, and media domains were each divided by the number of comprising variables to ensure they contributed equally to the overall one. However, some researchers might argue that the food domain should carry the most weight, if energy intake is most relevant to risk for weight gain (Cutler et al., 2003; Swinburn et al., 2009).

It is also possible that the patterning of risk factors within the home environment is relevant. In particular, the combined effect of certain variables may have a greater influence on behaviour than the combined effect of other variables, even if the total numbers of risk factors (or overall scores) are similar. For example, children who live in homes with a garden, are allowed to play regularly in the garden, but there is no outdoor play equipment, may be more physically active than those who live in homes with a garden that has outdoor play equipment, but they are rarely allowed to play outside. Similarly, children who live in homes with few snacks, but the snacks are physically accessible, and the children are allowed to help themselves, may eat snacks more frequently than those who live in homes with many snacks, the snacks are physically accessible, but the children are not allowed to help themselves. Examining how specific patterns of home environment variables relate to EBBs and weight may therefore provide further insight. Indeed, two recent studies have used this approach (Grunseit et al., 2011; Martinson et al., 2011). However, ideally analyses should be hypothesis- rather than data-driven, and it will be important to replicate preliminary findings before these can be taken into account when creating composite scores.

Nevertheless, it is important to note that other research has shown that composites created using unit weighting (as in this thesis) perform as well as those created using differential weighting, especially when the number of variables to be aggregated is large (Ree et al., 1998; Wainer, 1976; Wilks, 1938).

10.3.3 Measuring the home environment, energy-balance behaviours, and weight

Although there was insufficient information from the existing literature to perform power calculations for Study 5, a sample size of almost 1000 participants should be sufficient to detect even small effects, provided that measurement error is not large. Although there may be developmental effects of the home environment and EBBs on weight, the null associations reported in this thesis could be attributable to measurement error.

Although a practical necessity given the age of the Gemini children and the large sample size, using parent report to measure the home environment is a limitation. As primary caregivers and providers, parents are in a good position to answer questions about the home environment. However, parents may be more likely to respond in a socially desirable way when asked sensitive health-related questions and when talking to an interviewer over the telephone, which creates more social 'pressure' than self-completed questionnaires (Aquilino & Sciuto, 1990; Bowling, 2005; Fowler, 2009; Hochstim, 1967; Wiseman, 1972). The findings from this thesis and other research indicate that parent-report measures of the home environment are generally reliable, with some (albeit limited) support for validity (Pinard et al., 2012). It would be useful to see how home environment composites based on direct observation compare with those based on parent report.

With new mobile-phone technologies and automatic coding software (Doherty et al., 2013), wearable cameras represent important tools for objectively assessing the obesogenic quality of the home environment from a more naturalistic perspective. At present, however, wearable cameras are expensive, and manual coding of data is time-using and prone to human error, raising doubts over any reductions in cost relative to standard home visits. It will be important to carry out direct comparisons on cost-effectiveness. There are also technical and ethical issues to consider when using wearable cameras, which do not arise when using home visits. As with other monitoring devices (and home visits), potential behavioural effects of wearing a camera represent a disadvantage from a validation perspective. These issues are not insurmountable, however. Future research should focus on developing protocols to minimise behavioural effects of wearable cameras in validation studies.

Associations between the EBBs and weight may have been detected had more detailed and/or objective methods been used, such as diet diaries to assess energy intake, and accelerometers to assess physical activity, over multiple days. This might particularly be the case for physical activity as many studies reporting an association with adiposity in preschool-aged samples used accelerometers or other objective methods (Hawkins & Law, 2006; Reilly, 2008; te Velde et al., 2012). However, it is noteworthy that null associations between dietary intake and adiposity in preschool-aged samples have been reported even when using more detailed dietary measures (Newby, 2007; te Velde et al., 2012). Having both parents contribute to reports on child dietary intake, and taking into account outside influences on dietary intake (such as childcare), is one way to further improve the accuracy of reports (Livingstone & Robson, 2000). Some recent research indicates that wearable cameras may capture dietary intake more accurately than report methods (O'Loughlin et al., 2013); although the feasibility of their use with young children would need to be evaluated. Using wearable cameras in conjunction with accelerometers would also be useful as it would reveal the context of activity/sedentary behaviour. It would be particularly useful to see how the home environment is associated with composite measures of EBBs as these may be better indicators of risk for weight gain than individual behaviours (Kant, 1996).

As the EBBs were not associated with BMI, it also raises the possibility that the associations between the home environment and the EBBs were biased by the use of parent-report combined with their concurrent assessment. However, the associations do concur with those reported in other studies where aspects of the home environment and EBBs were assessed on separate occasions (e.g. Craggs et al., 2011; Crawford et al., 2010; Ezendam et al., 2010; Larson et al., 2007; Pearson, Ball, et al., 2011).

Research has shown that parents can accurately measure and weigh their child at home (Himes, 2009; Huybrechts et al., 2011), especially when provided with standard equipment and detailed instructions, as done so in Gemini. However, it is possible that associations between the home environment/EBBs and weight would have been detected had more detailed anthropometric measures been used. Methods that distinguish between fat-free and fat mass, such as dual-energy X-ray absorptiometry (DXA), are particularly useful measures of body composition; although they are less feasible in longitudinal studies with large samples (Wells & Fewtrell, 2006). In adults, BMI has correlated highly with these other measures of adiposity, but the association has been more variable in children and adolescents due to developmental changes in fat-free mass as well as fat mass (Freedman et al., 2004). Nevertheless, it is noteworthy that null effects of the home environment have also been reported in studies measuring body fat by skinfold thickness and dual-energy X-ray absorptiometry (DXA) (Bauer, Neumark-Sztainer, Fulkerson, Hannan, & Story, 2011; Sallis et al., 1995).

10.3.4 Developmental effects on weight

The null associations between the home environment and weight, and between the EBBs and weight (reported in Study 5), meant it was not possible to directly test the model proposed in Chapter 1. Clarifying whether there are developmental effects of the home environment on weight is therefore an important future research endeavour. It will be important to examine longitudinal associations between composite home environment measures, EBBs, and weight; and to directly test the hypothesis that EBBs mediate any associations with weight. Ideally, the home environment (and all other variables of interest) should be assessed at each time point so that reverse and reciprocal causation can be considered; and there should be sufficient time between each assessment point for small effects on the outcome variable to emerge (Zapf, Dormann, & Frese, 1996). Modelling specific features of weight trajectories, such as rate of change, would provide further insight. Collection of height and weight data in Gemini is ongoing; therefore it will be possible to further examine associations with weight.

10.3.5 Role of maternal characteristics

The findings from Study 3 raised several questions regarding pathways for the development of overweight and obesity, all of which were speculative and could be addressed in future research, with implications for intervention strategies. In particular, does the home environment mediate associations between SES and weight? Is the association between maternal eating traits and the obesogenic quality of the home environment bidirectional? Are previously reported associations between early feeding practices (breastfeeding and solid food introduction) and weight later in life partly explained by ongoing exposure to an obesogenic home environment? If so, what factors explain the association?

10.3.6 Factors affecting heritability estimates and the role of individual susceptibility

The findings from Study 6 do not definitively reflect G x E. Other forms of gene-environment interplay, namely gene-environment correlations ($_{rGE}$), may at least partly explain the differences in heritability (Dick, 2005, 2011). For example, it is possible that mothers with a genetic propensity for weight gain seek out or create home environments that are in line with this propensity (active $_{rGE}$); the environment may be correlated with the child's genotype (passive $_{rGE}$); and parents may modify aspects of the environment in response to their child's genotype (reactive $_{rGE}$). Although it is not feasible to experimentally manipulate the overall home environment and then observe weight-change differences within MZ and DZ twin-pairs (which would discount the possibility of $_{rGE}$), there are now Mx scripts that statistically adjust for $_{rGE}$, although large sample sizes are needed (Purcell, 2002).

In addition to $_{rGE}$, there are other factors that may have affected heritability estimates. A key assumption of twin models is that MZ and DZ twins share equally similar environments. As discussed previously, there is evidence that MZ twins share more similar environments than DZ twins do (Guo, 2001; Hettema et al., 1995), which would overestimate heritability estimates. However, research indicates that the more similar treatment of MZ twins is more so a consequence of their genetic identity than the cause of their greater phenotypic similarity (Kendler, Neale, Kessler, Heath, & Eaves, 1993). Moreover, family studies and those of twins reared apart corroborate findings from twin models (Maes, Neale, & Eaves, 1997; Stunkard et al., 1990).

Another potential influence on heritability estimates is assortative mating, whereby couples mate according to trait-similarity (Vandenberg, 1972). For example, research has reported small but significant associations between the BMIs of individuals and their partners (Allison et al., 1996). Assortative mating would underestimate heritability because, in this situation, DZ twins are genetically more similar than twin models assume, while genetic similarity remains at 100% for MZ twins. Although it is possible that zygosity-differences in the similarity of shared environments and assortative mating may have affected heritability estimates, it is unclear why these would systematically differ between higher and lower risk home environments.

Additional research is therefore needed to directly test the G x E hypothesis. One method would be to use a candidate-gene approach or genetic-risk scores, which take into account multiple obesity-related genes (e.g. Elks et al., 2010). Stronger associations between the genetic-risk scores and weight in those living in higher vs. lower risk home environments would provide further support for the behavioural susceptibility hypothesis, especially if incorporated into a twin model that statistically controlled for $_{rGE}$. DNA samples have been collected in the Gemini study so it will be possible to explore this in the near future. Knowledge on the genetic architecture of obesity is still developing, however, and there may be limited power.

It will also be important to examine the mechanisms for genetic expression in higher risk home environments. A major premise of the behavioural susceptibility hypothesis is that genes operate partly through appetitive traits to influence weight, and genetically determined differences in appetitive traits confer differential susceptibility to obesogenic environments (Carnell & Wardle, 2008a, 2008b). In line with this, research has shown that appetitive traits are highly heritable (Llewellyn, Jaarsveld, Johnson, Carnell, & Wardle, 2010), have been prospectively associated with variation in weight (van Jaarsveld, Llewellyn, Johnson, & Wardle, 2011), and share a genetic pathway with weight (Llewellyn, van Jaarsveld, Plomin, Fisher, & Wardle, 2012). To further test this pathway, future research in Gemini could examine whether the heritability of appetite also varies according to the obesogenic quality of the home environment, and whether the home environment moderates associations between appetite and weight.

10.3.7 Generalisability of findings

Although there were no significant differences between the individual study samples and the total Gemini sample, the Gemini families are predominantly White-British and of higher SES in comparison to families in the UK general population. It will therefore be important to investigate the effects reported in this thesis in more diverse samples, where there may be more variety in the obesogenic quality of home environments. Replicating effects from cohort samples in non-cohort samples would be important even in the absence of significant sociodemographic differences as families participating in an ongoing health-related study may be more invested in health-related issues than non-participating families.

Another issue is that findings from twin samples may not apply to singletons. There is some evidence that the home environments of twins and singletons do differ. For example, mothers may interact differently with twins than singletons (Rutter & Redshaw, 1991); although it is unclear how physical aspects of the home environment would differ (the availability of food, activity, and media equipment may vary according to the number of children in the home, but this would be the same in families with singleton children). Nevertheless, the associations reported in Studies 3 and 4 are generally in line with previous research using singleton samples. Twins are born earlier and smaller than singletons (Alexander, Kogan, Martin, & Papiernik, 1998; Glinianaia, Skjaerven, & Magnus, 2000; Kiely, 1990; Min et al., 2000), and the mean BMI for the sample in Study 5 was below that of the reference population. Although there seemed to be sufficient variation in BMI, it is possible that the null association between the home environment and weight was partly explained by a limited upper-BMI range; although this could also arise in singleton samples.

10.4 Conclusion

The findings of this thesis provide some support for the notion that the home environment is an important setting for overweight and obesity prevention; although further research is warranted. In particular, this thesis highlights the importance of adopting a comprehensive view of the obesogenic home environment, assessing the validity of home environment measures, and taking into account individual susceptibility for weight gain.

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Appendices

Appendix 3.1: Gemini baseline questionnaires

Family ID Number

WELCOME TO

gemini

health and development in twins

Booklet 1 - You and Your Family

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HOW TO FILL IN THIS BOOKLET

Thank you for agreeing to fill out this booklet. Before you start, here is a bit of guidance:

- We realise that parents of twins are very busy! We are especially grateful.
- We know the questionnaire is quite long, but please try to answer *all* the questions you are asked. This will help us to get a full picture of you and your twins' circumstances.
- Please be as honest as you can when answering our questions. We want to know what you really think. Everything you tell us will be kept strictly confidential.
- This may sound obvious, but please write as clearly as possible. This will help us use all the valuable information you have provided.

Here is an example of how a question *could* be answered.

Most of the questions in this booklet will ask you to tick a box next to the answer that is most suitable. Some will also ask you to describe this answer in more detail, for example:

A1. Do you think your twins are identical or non-identical? Identical ☑ Non-identical ☐

Why do you think this? ...The twins shared the same sac and placenta...

A2. As your twins grow older, do you have more time for yourself? Yes ☑ No ☐

THIS QUESTIONNAIRE IS TO BE COMPLETED BY THE MOTHER OF THE TWINS.
IF YOU ARE NOT THE MOTHER, PLEASE CONTACT US AND WE WILL SEND YOU THE APPROPRIATE QUESTIONNAIRE

THANK YOU FOR YOUR TIME AND ASSISTANCE IN FILLING OUT THIS BOOKLET

YOUR TWINS

A1. **Are you the primary caregiver of the twins?** Yes ☐ No ☐

A2. **What is your first born twin's name?** ____________________

Is your first born twin a boy or a girl? Boy ☐ Girl ☐

What is his/her date of birth? _____ / _____ / _______
DD MM YYYY

A3. **What is your second born twin's name?** ____________________

Is your second born twin a boy or a girl? Boy ☐ Girl ☐

The next few questions are all about whether your twins are identical or non-identical. This section needs to be completed only if you have same sex twins (please note: non-identical twins are often called fraternal twins)

If your twins are opposite sex, please go straight to B1 on page 6

A4. **Have you ever been told by a health professional (e.g. doctor, nurse, consultant) that your twins are identical or non-identical?**

Yes, identical ☐ Yes, non-identical ☐ No ☐

If YES, why did they think this?____________________

____

A5. **Do you think your twins are identical or non- identical?**

Identical ☐ Non-identical ☐

Why do you think this is? ____________________

____

A6. As your twins have grown older, has the likeness between them:

Become less ☐ Remained the same ☐ Become more ☐

A7. When looking at the twins:

	None	Only slight difference	Clear difference
Are there differences in the shade of your twins' hair?	☐	☐	☐
Are there differences in the texture of your twins' hair (fine or coarse, straight or curly etc)?	☐	☐	☐
Are there differences in the colour of your twins' eyes?	☐	☐	☐
Are there differences in the shape of your twins' ear lobes?	☐	☐	☐

A8. Have either of your twins' teeth begun to come through? Yes ☐ No ☐

If yes, was it at about the same time?

Yes, the twins had matching teeth on the same side come through within a few days of each other ☐

Yes, the twins had matching teeth on opposite sides come through within a few days of each other ☐

Yes, the twins had different teeth come through within a few days of each other ☐

No, the twins' first teeth did not come through within a few days of each other ☐

A9. Do you know your twins' ABO blood group and Rhesus (Rh) factors?

Yes ☐ No ☐

If YES, what are they? (please tick a blood group and rhesus factor for each twin)

	Blood group: A	B	AB	O	Rhesus factor: Rh+	Rh-
1st born	☐	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐	☐

A10. When looking at a new photograph of your twins, can you tell them apart (without looking at their clothes or using any other clues)?

Yes, easily	Yes, but it is hard sometimes	No, I often confuse them in photographs
☐	☐	☐

A11. Do any of the following people ever mistake your twins for each other?

	Yes, often	Yes, sometimes	Rarely or never	Not applicable
Your partner / husband	☐	☐	☐	☐
Older brothers or sisters	☐	☐	☐	☐
Other relatives	☐	☐	☐	☐
Babysitter or day carer	☐	☐	☐	☐
Close friends	☐	☐	☐	☐
Casual friends	☐	☐	☐	☐
People meeting the twins for the first time	☐	☐	☐	☐

A12. If the twins are ever mistaken for one another, does this ever happen when they are together?

Yes, often	Yes, sometimes	No, almost never	They are not mistaken for one another
☐	☐	☐	☐

A13. Would you say that your twins:

Are as physically alike as "two peas in a pod" (virtually the same)	☐
Are as physically alike as brothers and sisters are	☐
Do not look very much alike at all	☐

ABOUT YOU

B1. What is your date of birth? _____ / _____ / _______ (DD / MM / YYYY)

B2. In general, would you say your own health is:

Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor ☐

B3. About how tall are you?

______ centimetres (cms) OR ______ feet (ft) and ______ inches

B4. About how much do you weigh? If possible, use weighing scales for current weights, otherwise please give estimates

______ kilograms (kgs) OR ______ stones (st) and ______ pounds (lbs)

B5. Given your age and height, would you say that you are:

Very underweight ☐ Slightly underweight ☐ About the right weight ☐ Slightly overweight ☐ Very overweight ☐

B6. Do you have any educational qualifications? (please tick all that apply or equivalents)

No qualifications ☐ CSE, GCSE or 'O' Level ☐ Vocational qualification (GNVQ, BTEC) ☐ 'A' or 'AS' level ☐ Higher National Certificate (HNC) or Diploma (HND) ☐ Undergraduate degree ☐ Postgraduate qualification (Masters, PhD) ☐

Other, please describe: ______________________________

B7. Do you currently have a job?

On maternity leave ☐ Yes, full-time ☐ Yes, part-time ☐ No ☐ Stay at home to look after the children ☐

If NO, or stay at home to look after children please go straight to B9 on page 7

B8. What is your FULL job title? (please describe) ______________________________

Do you need any special qualifications for your job?

Yes ☐ No ☐ Unsure ☐

If YES, please describe: ______________________________

____

B9. What is your ethnic group? Tick the appropriate box to indicate your cultural background

White	Black	Asian	Mixed	Chinese or any other
White British ☐	Caribbean ☐	Indian ☐	White and Black Caribbean ☐	Chinese ☐
		Pakistani ☐	White and Black African ☐	
White Irish ☐	African ☐			
		Bangladeshi ☐	White and Asian ☐	
Other White background ☐ (please specify) ____	Other Black background ☐ (please specify) ____	Other Asian background ☐ (please specify) ____	Other Mixed background ☐ (please specify) ____	Any other ☐ (please specify) ____

B10. Do you smoke cigarettes at all nowadays? Yes ☐ No ☐

If Yes, how many cigarettes a day do you usually smoke? ____ cigarettes per day

B11. Do you usually participate in the following activities? If so, how many times per week and for how long? (Write 0 if you do not participate in any activity)

Strenuous exercise (heart beats rapidly)
i.e. running, jogging, hockey, football, squash, vigorous swimming, vigorous cycling — ____ times per week ____ minutes per session

Moderate exercise (not exhausting)
i.e. fast walking, tennis, easy cycling, badminton, easy swimming, dancing — ____ times per week ____ minutes per session

Mild exercise (minimal effort)
i.e. yoga, fishing from river bank, bowling, golf, easy walking — ____ times per week ____ minutes per session

B12. In the last week about how many servings of .... did you eat?

	Less than 1 per week	1 per week	2-4 per week	5-6 per week	1 per day	2 per day	3 per day	4 or more per day
VEGETABLES (excluding potatoes)	☐	☐	☐	☐	☐	☐	☐	☐
FRUIT (fresh, frozen or canned)	☐	☐	☐	☐	☐	☐	☐	☐

B13. What is your marital status?

Married or cohabiting	Divorced	Widowed	Separated	Single
☐	☐	☐	☐	☐

If you are not married or cohabiting, please go to straight to D1 on page 10

ABOUT THE PERSON YOU LIVE WITH
(i.e. your husband or partner)

C1. What is your partner's relationship to the twins?

Natural father of the twins ☐ Legal guardian of the twins ☐ Other ☐

If other, please describe: ______

C2. What is your partner's date of birth? ____ / ____ / ____
DD MM YYYY

C3. About how tall is your partner?

____ centimetres (cms) OR ____ feet (ft) and ____ inches

C4. About how much does your partner weigh? If possible, use weighing scales for current weights, otherwise please give estimates

____ kilograms (kgs) OR ____ stones (st) and ____ pounds (lbs)

C5. Does your partner have any educational qualifications? (please tick all that apply or equivalents)

No qualifications	CSE, GCSE or 'O' Level	Vocational qualification (GNVQ, BTEC)	'A' or 'AS' level	Higher National Certificate (HNC) or Diploma (HND)	Undergraduate degree	Postgraduate qualification (Masters, PhD)
☐	☐	☐	☐	☐	☐	☐

Other, please describe: ______

C6. Does your partner currently have a job?

Yes, full-time ☐ Yes, part-time ☐ No ☐ Stay at home to look after the children ☐

If NO, or stay at home to look after children, please go straight to C8 on page 9

C7. What is your partner's FULL job title? (please describe) ______

Are there any special qualifications needed for their job?

Yes ☐ No ☐ Unsure ☐

If YES, please describe: ______

C8. What is your partner's ethnic group? Tick the appropriate box to indicate your partner's cultural background

White	**Black**	**Asian**	**Mixed**	**Chinese or any other**
White British ☐	Caribbean ☐	Indian ☐	White and Black Caribbean ☐	Chinese ☐
		Pakistani ☐	White and Black African ☐	
White Irish ☐	African ☐			
		Bangladeshi ☐	White and Asian ☐	
Other White background ☐ (please specify) ______	Other Black background ☐ (please specify) ______	Other Asian background ☐ (please specify) ______	Other Mixed background ☐ (please specify) ______	Any other ☐ (please specify) ______

C9. Does your partner smoke cigarettes at all nowadays? Yes ☐ No ☐

If Yes, how many cigarettes a day does your partner usually smoke? ____ cigarettes per day

C10. Does your partner usually participate in the following activities? If so, how many times per week and for how long? (Write 0 if your partner does not participate in any activity)

Strenuous exercise (heart beats rapidly)
i.e. running, jogging, hockey, football, squash, vigorous swimming, vigorous cycling — ____ times per week ____ minutes per session

Moderate exercise (not exhausting)
i.e. fast walking, tennis, easy cycling, badminton, easy swimming, dancing — ____ times per week ____ minutes per session

Mild exercise (minimal effort)
i.e. yoga, fishing from river band, bowling, golf, easy walking — ____ times per week ____ minutes per session

C11. In the last week about how many servings of .... did your partner eat?

	Less than 1 per week	1 per week	2-4 per week	5-6 per week	1 per day	2 per day	3 per day	4 or more per day
VEGETABLES (excluding potatoes)	☐	☐	☐	☐	☐	☐	☐	☐
FRUIT (fresh, frozen or canned)	☐	☐	☐	☐	☐	☐	☐	☐

ABOUT OTHER CHILDREN IN THE HOME

D1. **How many other children live in the home with your twins?** (please write number)

__________ children

If there are no other children living in the home, please go straight to E1 on page 11

D2. **Please tell us about all the children who live in the home with the twins:**

Child's name	Date of birth	Sex		Does the child have the same mother as the twins?		Does the child have the same natural father as the twins?	
		Boy	Girl	Yes	No	Yes	No
____________	___/___/____ DD MM YYYY	☐	☐	☐	☐	☐	☐
____________	___/___/____ DD MM YYYY	☐	☐	☐	☐	☐	☐
____________	___/___/____ DD MM YYYY	☐	☐	☐	☐	☐	☐
____________	___/___/____ DD MM YYYY	☐	☐	☐	☐	☐	☐
____________	___/___/____ DD MM YYYY	☐	☐	☐	☐	☐	☐
____________	___/___/____ DD MM YYYY	☐	☐	☐	☐	☐	☐

If there are more than six other children or if there is anything else you would like to tell us about your family, please tell us in the open space below

YOUR PREGNANCY WITH THE TWINS

E1. About how much weight did you gain during your pregnancy with the twins?

______ kilograms (kgs) OR ____ stones (st) and ____ pounds (lbs)

E2. When you became pregnant with the twins, were you having any fertility treatment? Yes ☐ No ☐

If YES, please describe: ________________________________

E3. Were you regularly taking any medicine whilst pregnant? Yes ☐ No ☐

If YES, was this: (please tick all that apply) For first 3 months ☐ For middle 3 months ☐ For last 3 months ☐

Please describe the type of medication: ________________________________

E4. Did you smoke any cigarettes whilst pregnant? Yes ☐ No ☐

If YES, was this: (please tick all that apply) For first 3 months ☐ For middle 3 months ☐ For last 3 months ☐

How many cigarettes a day did you smoke, on average? (write 0 if you smoked no cigarettes whilst pregnant) _______ cigarettes per day

E5. Did you drink any alcohol whilst pregnant? Yes ☐ No ☐

If YES, was this: (please tick all that apply) For first 3 months ☐ For middle 3 months ☐ For last 3 months ☐

How many units of alcohol did you drink per week, on average?
(1 unit = 1 glass of wine, or 1 measure of spirits, or ½ a pint of beer)
(write 0 if you drank no alcohol whilst pregnant) _______ units per week

E6. Did you experience any severe stress during your pregnancy (e.g. bereavement, serious illness in the family or major money problems)? Yes ☐ No ☐

If YES, please describe: ________________________________

____

E7. During your pregnancy did you experience any of the following:

	Yes	No	Unsure
Morning sickness	☐	☐	☐
High blood pressure (pregnancy induced / gestational)	☐	☐	☐
Diabetes (pregnancy induced / gestational)	☐	☐	☐
Toxaemia / pre-eclampsia	☐	☐	☐
Vaginal bleeding	☐	☐	☐
Anaemia / iron deficiency	☐	☐	☐
Rubella / German Measles	☐	☐	☐
Slow growth of baby / babies	☐	☐	☐
Other serious pregnancy related problem (please describe)	☐	☐	☐

____

____

E8. Did you experience any physical or mental health problem in the first 6 months after birth; and were any of those problems diagnosed by a doctor?

Yes, diagnosed by a doctor ☐ Yes, but not diagnosed by a doctor ☐ No ☐

If YES, please describe: ____

____

E9. Have you ever been diagnosed with heart disease or diabetes, before or after your pregnancy?

	Yes	No	Unsure
Heart disease	☐	☐	☐
Diabetes (unrelated to pregnancy)	☐	☐	☐

E10. In their lives, have any family members ever been diagnosed with heart disease or diabetes?

	Father of twins	Brother or sister of twins	Your mother	Your father	Mother of the twins' father	Father of the twins' father	None
Heart disease	☐	☐	☐	☐	☐	☐	☐
Diabetes	☐	☐	☐	☐	☐	☐	☐

E11. In general, how would you describe the weights of your family members throughout their lives?

	Very underweight	Slightly underweight	About the right weight	Slightly overweight	Very overweight	Unsure
Father of the twins	☐	☐	☐	☐	☐	☐
Your mother	☐	☐	☐	☐	☐	☐
Your father	☐	☐	☐	☐	☐	☐
Mother of the twins' father	☐	☐	☐	☐	☐	☐
Father of the twins' father	☐	☐	☐	☐	☐	☐

THE TWINS' BIRTH

F1. **How many weeks pregnant were you at the time of delivery?** __________ weeks

F2. **Was the birth by Caesarean section?**

Yes	No	Unsure
☐	☐	☐

If YES, why? ____

____

F3. **Approximately how long was the gap between the births?**

_______ hours OR ________ minutes

F4. **Did transfusion between twins occur (twin to twin transfusion syndrome)?**

Yes	No	Unsure
☐	☐	☐

F5. **Did your babies get a blood transfusion soon after birth?**

Yes	No	Unsure
☐	☐	☐

F6. **Were there any other complications or concerns about either twin <u>at birth</u>?**

	Yes	No	Unsure
1st born	☐	☐	☐
2nd born	☐	☐	☐

If Yes in 1st born, please describe: ____

____

____

____

If Yes in 2nd born, please describe: ____

____

____

____

F7. Did either of the twins have any special care after birth (e.g. incubators)?

	Yes	No
1st born	☐	☐
2nd born	☐	☐

If Yes in 1st born, please describe: ______________________

____

If Yes in 2nd born, please describe: ______________________

____

F8. If yes, how long did they stay in special care?

1st born _____ days or _____ weeks

2nd born _____ days or _____ weeks

F9. How long did the twins stay in hospital after birth?

1st born _____ days or _____ weeks

2nd born _____ days or _____ weeks

F10. Do either of your twins have:

	Yes, 1st born	Yes, 2nd born	Neither
Physical problems (e.g. cleft lip, hole in the heart)	☐	☐	☐

If Yes in 1st born, please describe: ______________________

If Yes in 2nd born, please describe: ______________________

	Yes, 1st born	Yes, 2nd born	Neither
Genetic or chromosomal problems (e.g. Down's Syndrome, PKU)	☐	☐	☐

If Yes in 1st born, please describe: ______________________

If Yes in 2nd born, please describe: ______________________

	Yes, 1st born	Yes, 2nd born	Neither
Any other medical problem after birth	☐	☐	☐

If Yes in 1st born, please describe: ______________________

____

If Yes in 2nd born, please describe: ______________________

____

F11. Sometimes it is difficult to start feeding due to birth-related complications or other medical problems. Straight after birth, did either of your twins experience any complications which made it difficult to start feeding?

Yes, in 1st born ☐ Yes, in 2nd born ☐ No ☐

If Yes in 1st born, please describe: ______________________

____

If Yes in 2nd born, please describe: ______________________

____

F12. Were there any other times when feeding your twins was difficult, e.g. due to illness of the twins, health problems of parent, changes in jobs or moving house.

Yes, in 1st born ☐ Yes, in 2nd born ☐ No ☐

If Yes, please describe for each twin: (Use the back of the questionnaire if you need extra space)

Problem 1 in 1st born ____

At which ages did this influence your twins eating? __to__ weeks or __to__ months

Problem 2 in 1st born ____

At which ages did this influence your twins eating? __to__ weeks or __to__ months

Problem 1 in 2nd born ____

At which ages did this influence your twins eating? __to__ weeks or __to__ months

Problem 2 in 2nd born ____

At which ages did this influence your twins eating? __to__ weeks or __to__ months

THE TWINS' ILLNESSES AND ACCIDENTS

F13. About how many times have your babies seen the doctor due to illness or accidents since birth?

	Number of visits
1st born	________
2nd born	________

F14. Since birth, have your babies been admitted to hospital?

	No	Yes, once	Yes, more than once (write number)
1st born	☐	☐	________
2nd born	☐	☐	________

F15. Please briefly describe each hospital admission (Use the back of the questionnaire if you need more space)

	Age of twin (months)	Number of hospital nights	Reason for admission:
1st born	______	______	______________________
	______	______	______________________
	______	______	______________________
	______	______	______________________
	______	______	______________________
	______	______	______________________
2nd born	______	______	______________________
	______	______	______________________
	______	______	______________________
	______	______	______________________
	______	______	______________________
	______	______	______________________

SOME FINAL QUESTIONS ABOUT YOU AND YOUR FAMILY

G1. What is the main language spoken in the home?

English ☐ Other (please specify) ____________________

G2. Altogether, how many adults live in the same house as the twins (including yourself)?

One ☐ Two ☐ Three ☐ Four or more: ______ (please give number)

G3. How many bedrooms does your household have, including bedsitting rooms and spare rooms?

One ☐ Two ☐ Three ☐ Four or more: ______ (please give number)

G4. How many cars or vans are normally available for use by you or any members of your household?

None ☐ One ☐ Two ☐ Three or more: ______ (please give number)

G5. Do you currently own or rent the accommodation you live in?

Own without mortgage	Own with mortgage	Rent privately	Rent from local authority
☐	☐	☐	☐

G6. Thinking of the income of the household as a whole, which category represents the <u>total</u> income of your <u>whole household</u> before deduction from income tax, National Insurance etc.

Up to £15,000 per year	☐	Between £52,500 and £60,000 per year	☐
Between £15,000 and £22,500 per year	☐	Between £60,000 and £67,500 per year	☐
Between £22,500 and £30,000 per year	☐	Between £67,500 and £75,000 per year	☐
Between £30,000 and £37,500 per year	☐	Between £75,000 and £82,500 per year	☐
Between £37,500 and £45,000 per year	☐	Between £82,500 and £90,000 per year	☐
Between £45, 000 and £52,500 per year	☐	More than £90,000 per year	☐

G7. Do you feel your family income is enough?

More than enough ☐ Enough ☐ Not enough ☐

G8. Please give the date on which you completed this booklet? ___ / ____ / ____ day/month/year

Please continue with BOOKLET 2 to tell us more about your twins

Thank you

for filling out this booklet.

PLEASE continue with BOOKLET 2 to tell us more about your twins

Space for any additional comments you would like to make :

Space for any additional comments you would like to make :

Family ID Number ☐☐☐☐☐☐

WELCOME TO

gemini

health and development in twins

Booklet 2 - Your Twins

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HOW TO FILL IN THIS BOOKLET

Thank you for agreeing to fill out this booklet. Before you start, here is a bit of guidance:

- We realise that parents of twins are very busy! We are especially grateful.
- We know the questionnaire is quite long, but please try to answer *all* the questions you are asked. This will help us to get a full picture of you and your twins' circumstances.
- Please be as honest as you can when answering our questions. We want to know what you really think. Everything you tell us will be kept strictly confidential.
- This may sound obvious, but please write as clearly as possible. This will help us use all the valuable information you have provided.

<u>Here is an example of how a question *could* be answered.</u>

Most of the questions in this booklet will ask you to tick a box next to the answer that is most suitable. Some will also ask you to describe this answer in more detail, for example:

A1. Do you think your twins are identical or non-identical?	Identical ☑		Non-identical ☐
Why do you think this?	...The twins shared the same sac and placenta...		
A2. As your twins grow older, do you have more time for yourself?	Yes ☑		No ☐

THIS QUESTIONNAIRE IS TO BE COMPLETED BY THE <u>MOTHER</u> OF THE TWINS.
IF YOU ARE NOT THE MOTHER, PLEASE CONTACT US AND WE WILL
SEND YOU THE APPROPRIATE QUESTIONNAIRE

THANK YOU FOR YOUR TIME AND ASSISTANCE IN FILLING OUT THIS BOOKLET

YOUR TWINS' GROWTH

First we would like to learn a bit more detail about your twins' growth. This information may be in your child's health record (little red book) or you may have kept your own records.

A1. What were the lengths of the twins at birth and around 6 weeks?

	1st born				2nd born			
At birth	_____ cm	or	_____ inches		_____ cm	or	_____ inches	
Around 6 weeks	_____ cm	or	_____ inches		_____ cm	or	_____ inches	

A2. What were the head circumferences of the twins?

	1st born				2nd born			
At birth	_____ cm	or	_____ inches		_____ cm	or	_____ inches	
Around 6 weeks	_____ cm	or	_____ inches		_____ cm	or	_____ inches	

A3. What were the weights of the twins?

	1st born			2nd born		
At birth	_____ kg	or	____ lbs ___ oz	_____ kg	or	____ lbs ___ oz
Around 6 weeks	_____ kg	or	____ lbs ___ oz	_____ kg	or	____ lbs ___ oz

A4. Please add other weight measurements below together with the date they were taken. Use the back of the questionnaire if you need extra space. Alternatively you can send us a photocopy of the relevant pages from your twins' health records (little red book)

Date measured	1st born				2nd born				These measurements came from…		
	kg		lbs,	oz	Kg		lbs,	oz	Health professional / health record		Own measure-ments
__/__/____ DD MM YYYY	_____	or	____	____	____	or	____	____	☐	or	☐
__/__/____ DD MM YYYY	_____	or	____	____	____	or	____	____	☐	or	☐
__/__/____ DD MM YYYY	_____	or	____	____	____	or	____	____	☐	or	☐
__/__/____ DD MM YYYY	_____	or	____	____	____	or	____	____	☐	or	☐
__/__/____ DD MM YYYY	_____	or	____	____	____	or	____	____	☐	or	☐
__/__/____ DD MM YYYY	_____	or	____	____	____	or	____	____	☐	or	☐
__/__/____ DD MM YYYY	_____	or	____	____	____	or	____	____	☐	or	☐
__/__/____ DD MM YYYY	_____	or	____	____	____	or	____	____	☐	or	☐

Some parents worry about their babies being underweight or overweight for their age and sex.
The following questions explore this in a bit more detail

A5. How would you describe your baby's weight at the moment?

	Very underweight	Slightly underweight	About the right weight	Slightly overweight	Very overweight
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

A6. Have you ever been concerned that your baby wasn't gaining enough weight? (tick all that apply)

	Yes	No
1st born	☐	☐
2nd born	☐	☐

If No, please go straight to A8 on page 5

If yes, how old was your baby when you were concerned?

	0 - 3 months	4-6 months	7-9 months	10-12 months	Older than 1 year
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

A7. How concerned are you that your baby is underweight at the moment?

	Not concerned	Somewhat concerned	Very concerned
1st born	☐	☐	☐
2nd born	☐	☐	☐

If you are concerned about either baby being underweight, why is this? (please tick the most important reasons)

	1st born	2nd born
The health visitor/doctor advised me my baby is not gaining enough weight	☐	☐
Low centile on growth chart	☐	☐
My baby doesn't look as big as other babies of the same age and sex	☐	☐
My baby lost weight recently	☐	☐
My baby has always had a low weight	☐	☐
My baby is not feeding well	☐	☐
Family member(s) think my baby is not heavy enough. If so, who?__________	☐	☐
Other reason. If so, what? ______________________________	☐	☐

A8. Have you ever been concerned that your baby was gaining too much weight?

	Yes	No
1^{st} born	☐	☐
2^{nd} born	☐	☐

If No, please go straight to B1 on page 6

If yes, how old was your baby when you were concerned?

	0 - 3 months	4-6 months	7-9 months	10-12 months	Older than 1 year
1^{st} born	☐	☐	☐	☐	☐
2^{nd} born	☐	☐	☐	☐	☐

A9. How concerned are you that your baby is overweight at the moment?

	Not concerned	Somewhat concerned	Very concerned
1^{st} born	☐	☐	☐
2^{nd} born	☐	☐	☐

If you are concerned about either baby being overweight, why is this? (please tick the most important reasons)

	1^{st} born	2^{nd} born
The health visitor/doctor advised me my baby is gaining too much weight	☐	☐
High centile on growth chart	☐	☐
My baby looks bigger than other babies of the same age and sex	☐	☐
My baby gained weight recently	☐	☐
My baby has always had a high weight	☐	☐
My baby is feeding very vigorously	☐	☐
Family member(s) think my baby is too heavy. If so, who?________________	☐	☐
Other reason. If so, what?________________________________	☐	☐

____

YOUR FEEDING ROUTINE
Parents feed their babies in different ways, and we are interested in learning more about how you feed your twins. In the following questions, please think back to your twins' first three months of life

B1. Which of the following best describes each of your twins' eating routine during their first three months?

	I fed my baby whenever he/she cried, got fussy or seemed hungry	My baby was on a flexible feeding schedule (e.g. about every 3-4 hours)	My baby was on a rigid feeding schedule (e.g. I woke him/her up to eat on time)
1st born	☐	☐	☐
2nd born	☐	☐	☐

B2. Did you or the babies decide how often they should feed?

	Me only	Mostly me	Me and my baby equally	Mostly my baby	My baby only
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

B3. Did you or the babies decide how much milk they should take in a feed?

	Me only	Mostly me	Me and my baby equally	Mostly my baby	My baby only
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

B4. How would you classify your 'feeding philosophy' for each twin during their first three months?

	Feeding on demand (e.g. fed baby when he/she cried)	Feeding on a schedule (e.g. fed baby at set times)
1st born	☐	☐
2nd born	☐	☐

Now we would like to know more about how your feeding patterns have changed over time

By **'breastfeeding'**, we mean any method of feeding breast milk, i.e. feeding directly from breast or giving expressed breast milk in a bottle

By **'bottle-feeding'**, we mean feeding formula milk using a bottle

B5. Which feeding methods did you use in the <u>first three months</u>?

	1st born	2nd born
Entirely breastfeeding	☐	☐
Mostly breastfeeding with some bottle-feeding	☐	☐
Equally breastfeeding and bottle-feeding	☐	☐
Mostly bottle-feeding and some breastfeeding	☐	☐
Almost entirely bottle-feeding (only tried breastfeeding a few times)	☐	☐
Entirely bottle-feeding (never tried breastfeeding)	☐	☐
Other	☐	☐

If other, please describe: ______________________________

____

If you entirely bottle-fed your twins, please go straight to B10 on page 8

B6. How soon after birth did you start breastfeeding?

1st born Within….. _____ minutes or _____ hours or _____ days

2nd born Within….. _____ minutes or _____ hours or _____ days

B7. How easy was it to establish breastfeeding your twins?

	Very easy	Easy	All right	Difficult	Very difficult
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

B8. What was your main method of breastfeeding?

	Mostly fed directly from the breast	Equally fed directly from the breast and gave expressed milk	Mostly gave expressed breast milk
1st born	☐	☐	☐
2nd born	☐	☐	☐

B9. Are you currently breastfeeding your twins? Yes, 1st born ☐ Yes, 2nd born ☐ Neither ☐

If you are no longer breastfeeding, when did you stop?

1st born _______ weeks after birth

2nd born _______ weeks after birth

If you entirely breastfed your twins, please go straight to B17 on page 9

B10. **How soon after birth did you start bottle-feeding your twins?**

1st born	Within…..	_____	minutes	or	_____	hours	or	_____ days
2nd born	Within…..	_____	minutes	or	_____	hours	or	_____ days

B11. **Why did you start bottle-feeding?**

	1st born	2nd born
Following advice from health professional	☐	☐
Following advice from friends or family	☐	☐
Breastfeeding was too difficult	☐	☐
Baby did not gain enough weight on breast milk alone	☐	☐
Easier to fit into daily routine	☐	☐
Allows other people to feed my baby	☐	☐

If other, please describe ____

____

B12. **Are you currently bottle-feeding your twins?**

Yes, 1st born	Yes, 2nd born	Neither
☐	☐	☐

Now we are interested in learning more about <u>how much milk</u> your twins took. Because babies' milk requirements increase as they get older, it is easier to think about how much they took at one specific age. So to answer the questions, please think back to when they were <u>about three months old</u>

If you did not bottle-feed your twins at around 3 months, please go straight to B17 on page 9

B13. **What size bottle did you normally use when the twins were <u>about three months old</u>?**

	125ml / 4oz	250ml / 9oz	390ml / 12oz	Unsure
1st born	☐	☐	☐	☐
2nd born	☐	☐	☐	☐

B14. How full did you normally fill the bottle?

	Completely full	Mostly full	Half full or less	or	How much formula milk per bottle?
1st born	☐	☐	☐		_____ ml or ____oz
2nd born	☐	☐	☐		_____ ml or ____oz

B15. Most of the time, how much of the bottle did your babies drink?

	All of it	Most of it	Half or less	or	How much formula milk?
1st born	☐	☐	☐		_____ ml or ____oz
2nd born	☐	☐	☐		_____ ml or ____oz

B16. What size teat did you use when the twins were <u>about three months old</u>?

	Fast flow	Medium flow	Slow flow	Variable teat	Unsure
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

To answer the following questions, please think back to when your twins were <u>about three months old</u>

B17. On average, how many times did you feed your babies during each 24 hour period (one day and one night) when they were <u>about three months old</u>? Please write 0 if you did not breastfeed or bottle-feed your babies when they were about three months old

	Breastfeeding	and / or	Bottle-feeding
1st born	______ times per day		______ times per day
2nd born	______ times per day		______ times per day

B18. On average, how long did your babies feed for in a typical daytime feed when they were <u>about three months old</u>? Please write 0 if you did not breastfeed or bottle-feed your babies when they were about three months old

	Breastfeeding	and / or	Bottle-feeding
1st born	______ minutes per feed		______ minutes per feed
2nd born	______ minutes per feed		______ minutes per feed

HOW ACTIVE ARE YOUR TWINS

These questions ask about your twins' physical activity in their first three months of life.
For each behaviour, please indicate how often the baby did this

C1.	**During feeding, how often did your babies …**		Very rarely	Less than half the time	About half the time	More than half the time	Almost always
	lie or sit quietly	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
	squirm or kick	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
	wave their arms	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

C2.	**During sleep, how often did your babies …**		Very rarely	Less than half the time	About half the time	More than half the time	Almost always
	toss about in the crib	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
	move from the middle to the end of the crib	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
	sleep in one position only	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

C3.	**When being dressed or undressed, how often did your babies…**		Very rarely	Less than half the time	About half the time	More than half the time	Almost always
	wave or kick	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
	squirm or try to roll away	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

C4.	**<u>When put into the bath water,</u> how often did your babies …**		Very rarely	Less than half the time	About half the time	More than half the time	Almost always
	splash or kick	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
	squirm or turn around	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

C5.	**<u>When placed on his/her back,</u> how often did your babies …**		Very rarely	Less than half the time	About half the time	More than half the time	Almost always
	wave their arms or kick	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
	squirm or turn around	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

C6.	**<u>When placed in a seat</u> (e.g. high chair, push chair, car seat), how often did your babies…**		Very rarely	Less than half the time	About half the time	More than half the time	Almost always
	wave their arms or kick	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
	squirm or turn their body	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
	sit quietly	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

C7. How old were your babies when they first crawled on hands and knees?

1st born ________ months Not yet ☐

2nd born ________ months Not yet ☐

C8. How old were your babies when they could sit up without being supported?

1st born ________ months Not yet ☐

2nd born ________ months Not yet ☐

APPETITE

These questions are about your twins' appetite over their first three months of life. We are specifically interested in the period when your twins were fed milk only, i.e. no solid foods or pre-prepared baby food yet

D1. How would you rate your twins' appetites in their first three months?

	Poor	OK	Good	Very Good	Excellent
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

D2. Did either of your twins generally take more milk than the other in their first three months?

1st born took much more milk	1st born took a little more milk	Each took about the same amount	2nd born took a little more milk	2nd born took much more milk
☐	☐	☐	☐	☐

How would you describe your twins' feeding styles at a typical daytime feed in their first three months?

			Never	Rarely	Sometimes	Often	Always
D3.	**My baby sucked vigorously**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D4.	**My baby sucked steadily and rhythmically**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D5.	**My baby seemed contented while feeding**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D6.	**My baby frequently wanted more milk than I provided**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D7.	**My baby loved milk**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

These are some more questions about how your twins feed. Again thinking back to the first three months, please choose which box is most appropriate for each of your babies

			Never	Rarely	Sometimes	Often	Always
D8.	My baby had a big appetite	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D9.	My baby finished feeding quickly	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D10.	My baby became distressed while feeding	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D11.	My baby got full up easily	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D12.	If allowed to, my baby would take too much milk	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D13.	My baby took more than 30 minutes to finish feeding	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D14.	My baby got full before taking all the milk I thought he/she should have had	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D15.	My baby fed slowly	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

			Never	Rarely	Sometimes	Often	Always
D16.	Even when my baby had just eaten well he/she was happy to feed again if offered	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D17.	My baby found it difficult to manage a complete feed	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D18.	My baby was always demanding a feed	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D19.	My baby sucked more and more slowly during the course of a feed	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D20.	If given the chance, my baby would always be feeding	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D21.	My baby enjoyed feeding time	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D22.	My baby could easily take a feed within 30 minutes of the last one	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

HOW YOU FEED YOUR TWINS

The previous section asked some general questions about your feeding.

Now we are interested in learning more about how you fed your twins day-to-day over the first three months. We are particularly interested in whether you changed feeding in different situations

Again, thinking back to the first three months, please choose which box is most appropriate for each of your babies

			Never	Rarely	Sometimes	Often	Always
E1.	I knew when my baby was hungry	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E2.	I knew when my baby was full	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E3.	If my baby cried it was usually because he/she was hungry	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E4.	I worried if my baby did not feed much on one occasion	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E5.	If my baby wanted to be fed before the next scheduled feed, I fed him/her earlier than usual	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E6.	When my baby got fussy I tried feeding to settle him/her down	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E7.	I worried if my baby fed too much on one occasion	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

Still thinking back to the <u>first three months</u>, please choose for each of your babies which box is most appropriate

			Never	Rarely	Sometimes	Often	Always
E8.	I gave my baby a large feed to get him/her to sleep longer	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E9.	I fed my baby to keep him/her quiet when with others	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E10.	I was careful not to feed my baby too frequently	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E11.	I was careful not to feed my baby too large an amount	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
If my baby stopped feeding, I …							
E12.	… tried other methods to encourage him/her e.g. moved baby into a different position or switched breasts	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E13.	… let him/her have a break then try again a bit later	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
If my baby didn't feed much on one occasion, I …							
E14.	… made sure he/she took a larger amount at the next feed	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E15.	… offered him/her another feed a bit sooner than I normally would	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

Please only answer these questions if you ever bottle-fed either of your twins during the first three months

If you entirely breastfed your twins, please go straight to F1 on page 18

			Never	Rarely	Sometimes	Often	Always
E16.	I tried to make my baby finish everything in the bottle	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E17.	If my baby finished the bottle quickly, I made up another	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E18.	If I worried my baby wasn't eating enough, I added a bit more formula in his/her bottle	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E19.	If I worried my baby was not feeding enough I changed to a more filling formula	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

Please only answer these questions if you fed your twins with a mixture of bottle-feeding and breast-feeding during the first three months

If you entirely bottle-fed your twins, please go straight to F1 on page 18

			Never	Rarely	Sometimes	Often	Always
E20.	If my baby was still hungry after a breast-feed, I fed him/her a bottle	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E21.	I fed my baby by breast, but gave a bottle before bed to help encourage sleep through the night	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

SOLID FOODS

The following section is about solid foods
(i.e. anything other than milk, including mashed up foods and ready prepared baby food)

F1. How old were the twins the very first time solid foods of any kind were eaten (i.e. anything other than milk)?

1st born ____ weeks or ____ months Not yet ☐

If neither of your twins has started solid foods, please go straight to F12 on page 21

F2. How easy was it to wean your twins onto solid food?

	Very easy	Easy	OK	Difficult	Very difficult
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

F3. How did you decide to start the twins on solid foods?

	1st born	2nd born
Following advice from health professional	☐	☐
Following advice from friends or family	☐	☐
Milk alone was not enough	☐	☐
Easier to fit into family routine	☐	☐
Baby showed interest in solid foods	☐	☐
Allergy to milk	☐	☐
Other, please describe:	☐	☐

1st born ____

____

2nd born ____

____

F4. In general how much did your baby enjoy starting solid foods?

	Did not enjoy it at all	Enjoyed it a little	Enjoyed it a lot
1st born	☐	☐	☐
2nd born	☐	☐	☐

F5. Have your twins started taking solid foods <u>every day</u>?

	Yes	No
1st born	☐	☐
2nd born	☐	☐

If No, please go straight to F8 on this page

F6. At what age did your twins start taking solid foods <u>every day</u>?

1st born ________ months old

2nd born ________ months old

F7. At present, how many times per day does your baby have solid foods?

1st born ______ times per day

2nd born ______ times per day

F8. When eating solid food, which of the following statements describes your twins' feeding most accurately?

	Generally needs to be fully fed by an adult	Generally needs to be fed by an adult but also eats with fingers	Generally eats with spoon but needs help	Generally eats with spoon without help
1st born	☐	☐	☐	☐
2nd born	☐	☐	☐	☐

F9. When were your twins first given finger foods (i.e. foods babies can pick up and feed to themselves)?

1st born Age ________ months Not yet ☐

2nd born Age ________ months Not yet ☐

F10. Has either of your twins tried these foods yet? If so, how old were they when they first tried it?

		Age when first tried	Not yet tried
Baby rice, cereal, rusks or bread	1st born	_______ months	☐
	2nd born	_______ months	☐
Vegetables (uncooked, cooked or pureed, fresh, frozen or tinned)	1st born	_______ months	☐
	2nd born	_______ months	☐
Chips (e.g. oven fries, smiley faces, potato waffles or wedges)	1st born	_______ months	☐
	2nd born	_______ months	☐
Potatoes or sweet potatoes	1st born	_______ months	☐
	2nd born	_______ months	☐
Processed meat (e.g. sausages, burger)	1st born	_______ months	☐
	2nd born	_______ months	☐
Other meat (e.g. chicken, lamb, pork, beef)	1st born	_______ months	☐
	2nd born	_______ months	☐
Fish (fresh, frozen, tinned or fish fingers)	1st born	_______ months	☐
	2nd born	_______ months	☐
Eggs	1st born	_______ months	☐
	2nd born	_______ months	☐
Dairy products (e.g. milk, cheese, yoghurt)	1st born	_______ months	☐
	2nd born	_______ months	☐
Fizzy drinks with sugar (e.g. 7up, coke)	1st born	_______ months	☐
	2nd born	_______ months	☐
Low calorie fizzy drinks (e.g. 7up zero, diet coke)	1st born	_______ months	☐
	2nd born	_______ months	☐

F11. Has either of your twins tried these foods yet? If so, how old were they when they first tried it?

		Age when first tried	Not yet tried
Squash and/or fruit drinks with sugar (e.g. ribena, robinsons fruit shoot)	1st born	________ months	☐
	2nd born	________ months	☐
Low calorie squash and/or fruit drinks (e.g. ribena light, robinsons fruit shoot no added sugar)	1st born	________ months	☐
	2nd born	________ months	☐
Pure fruit juice (100% juice)	1st born	________ months	☐
	2nd born	________ months	☐
Savoury snacks (e.g. crisps, cheese biscuits)	1st born	________ months	☐
	2nd born	________ months	☐
Fruit (uncooked, cooked, pureed, fresh, frozen or tinned)	1st born	________ months	☐
	2nd born	________ months	☐
Sweet snacks (e.g. cakes, biscuits, ice cream)	1st born	________ months	☐
	2nd born	________ months	☐
Sweets (e.g. chocolate, fruit sweets)	1st born	________ months	☐
	2nd born	________ months	☐

F12. Please give the date on which you completed this booklet? ___/___/_____ DD MM YYYY

Thank you

very much for filling in this booklet

PLEASE CHECK that you have given details on <u>YOUR TWINS' GROWTH on page 3</u> or send us copies of the relevant pages from your twins health records (little red book)

Space for any additional comments you would like to make

Space for any additional comments you would like to make

Please return both booklets using the freepost envelope and send it to:

Gemini
Health Behaviour Research Centre
Department of Epidemiology & Public Health
UCL
2-16 Torrington Place
London, WC1E 6BT

Appendix 3.2: Gemini 15-month questionnaires

Family ID Number ☐☐☐☐☐☐☐

WELCOME TO

gemini

health and development in twins

15 months booklet

From baby to toddler

Health Behaviour Research Centre
Department of Epidemiology & Public Health
UCL
2-16 Torrington Place
London, WC1E 6BT
gemini@public-health.ucl.ac.uk

HOW TO FILL IN THIS BOOKLET

Thank you for taking part in Gemini and agreeing to fill out this booklet.

- We know that there are a lot of questions, but it's important for us to get a full picture of your twins' circumstances.
- Everything you tell us will be kept strictly confidential.
- It may sound obvious, but please write as clearly as possible to help us use all the valuable information you have provided.

Here is an example of how a question *could* be answered.

Most of the questions in this booklet will ask you to tick a box next to the answer that is most suitable. Some will also ask you to describe this answer in more detail, for example:

1. Do you enjoy being part of Gemini? Yes ☑ No ☐

Why is this? ...My twins are special and I like helping research...

THIS QUESTIONNAIRE IS TO BE COMPLETED WHEN YOUR TWINS ARE

ABOUT 15 MONTHS OLD

IF THEY ARE OLDER, PLEASE COMPLETE THE QUESTIONNAIRE THINKING BACK TO WHEN THEY WERE ABOUT 15 MONTHS

TO START

We are exploring possibilities to use email and online web services for short updates (for example about your twins' growth). Therefore we would like to know how many families participating in Gemini have access to email and online web-services

A1. Do you have easy access to the internet? Yes ☐ No ☐

A2. What is your email address? ______________________ No email ☐

A3. Would you be willing to respond to short questionnaires by email or online? Yes ☐ No ☐

If No, could you tell us why? ______________________

A4. Please confirm the first names and date of birth of your twins

Name 1st born ______________ **Name 2nd born** ______________

Date of birth ____ / ____ / 2007
DD MM

A5. What is your relationship to the twins?

Mother of the twins	Father of the twins	Other, please describe:
☐	☐	______________________

A6. How many days per week do your twins go to nursery?
(please write 0 if they do not go to nursery)

1st born ____ days per week

2nd born ____ days per week

A7. Do you (or your partner) currently have a job?

	On maternity leave	Yes, full time	Yes, part-time	No	Stay at home to look after children	Not applicable
You	☐	☐	☐	☐	☐	
Your partner	☐	☐	☐	☐	☐	☐

YOUR TWINS' GROWTH

We would like to learn about your twins' growth since we last contacted you (February-April 2008). This information might be in your child's health record (little red book) or you may have kept your own records

B1. Please provide any measurements of your twins' length / height taken <u>since we last contacted you (February-April 2008)</u> and indicate whether the measurement was taken while the twins were lying down or standing up

	1st born				2nd born				How was length/height measured?	
Date measured	cms		feet	inches	cms		feet	inches	Lying down	Standing up
__/__/____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
__/__/____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
__/__/____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
__/__/____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐

B2. Do you have scales to weigh your twins at home? Yes ☐ No ☐

If Yes, what kind of weighing scale is it? Mechanical (dial display) ☐ Electronic (digital display) ☐ Unsure ☐

B3. Please provide any measurements of your twins' weight taken <u>since we last contacted you (February-April 2008)</u> and indicate whether measurements came from health professional or your own records. Please give current weights by weighing your twins in indoor clothes without shoes. If you do not have any scales, a neighbour or your GP surgery may have some you can use

	1st born				2nd born				These measurement came from...	
Date measured	kgs		lbs	oz	kgs		lbs	oz	Health professional /health record	Own records
__/__/____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
__/__/____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
__/__/____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
__/__/____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
__/__/____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
__/__/____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐

B4. How would you describe your child's weight at the moment?

	Very underweight	Slightly underweight	About the right weight	Slightly overweight	Very overweight
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

B5. How concerned are you about your child's weight at the moment?

	Not concerned	Somewhat concerned	Very concerned
1st born	☐	☐	☐
2nd born	☐	☐	☐

B6. How likely do you think it is that your child will be overweight in 2 years' time?

	Unlikely	Somewhat likely	Very likely
1st born	☐	☐	☐
2nd born	☐	☐	☐

B7. How concerned would you be if your child was overweight in 2 years' time?

	Not concerned	Somewhat concerned	Very concerned
1st born	☐	☐	☐
2nd born	☐	☐	☐

B8. How likely do you think it is that your child will be underweight in 2 years' time?

	Unlikely	Somewhat likely	Very likely
1st born	☐	☐	☐
2nd born	☐	☐	☐

B9. How concerned would you be if your child was underweight in 2 years' time?

	Not concerned	Somewhat concerned	Very concerned
1st born	☐	☐	☐
2nd born	☐	☐	☐

B10.	**How old were your twins when they could first sit up without being supported?**	1st born	______ months	Not yet ☐
		2nd born	______ months	Not yet ☐
B11.	**How old were your twins when they first crawled on their hands and knees?**	1st born	______ months	Not yet ☐
		2nd born	______ months	Not yet ☐
B12.	**How old were your twins when they could walk a few steps without any support?**	1st born	______ months	Not yet ☐
		2nd born	______ months	Not yet ☐
B13.	**How old were your twins when they said their first word?**	1st born	______ months	Not yet ☐
		2nd born	______ months	Not yet ☐

THE TWINS' ILLNESSES AND ACCIDENTS

C1. Has either of the twins seen a doctor due to a serious illness or accident since we last contacted you (February-April 2008)?

Yes, 1st born	Yes, 2nd born	Neither
☐	☐	☐

C2. If Yes, please describe each illness or accident. Use the back of the questionnaire if you need extra space

		Description of illness or accident	Age of twin (months)	Number of doctor visits (GP or specialist)	Number of hospital nights
1st born	1	______	______	______	______
	2	______	______	______	______
	3	______	______	______	______
	4	______	______	______	______
2nd born	1	______	______	______	______
	2	______	______	______	______
	3	______	______	______	______
	4	______	______	______	______

APPETITE

These questions are about your twins' appetite at the moment. You may recognise some of the questions from the previous questionnaire about when they were only having milk. Now we are interested about the current situation when they are eating solid foods

D1. How would you rate your twins' appetites at the moment?

	Poor	OK	Good	Very Good	Excellent
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

D2. Does one of your twins generally eat more than the other?

1st born eats much more	1st born eats a little more	Each eat about the same amount	2nd born eats a little more	2nd born eats much more
☐	☐	☐	☐	☐

How would you describe your twins' eating styles on a typical day?

			Never	Rarely	Sometimes	Often	Always
D3.	**My child loves food**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D4.	**My child eats more when irritable**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D5.	**My child has a big appetite**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D6.	**My child finishes his/her meal quickly**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D7.	**My child is interested in food**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D8.	**My child cannot eat a meal if he/she has had a snack just before**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D9.	**My child refuses new foods at first**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D10.	**My child eats slowly**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

			Never	Rarely	Sometimes	Often	Always
D11.	My child looks forward to mealtimes	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D12.	My child wants to eat (e.g. reaches out or asks) when he/she <u>smells</u> certain foods	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D13.	My child wants to eat (e.g. reaches out or asks) when he/she <u>sees</u> certain foods	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D14.	My child is always asking for food	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D15.	My child eats more when grumpy	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D16.	If allowed to, my child would eat too much	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D17.	My child eats more when upset	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D18.	My child enjoys a wide variety of foods	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D19.	My child leaves food on his/her plate or in the jar at the end of a meal	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D20.	My child takes more than 30 minutes to finish a meal	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D21.	Given the choice, my child would eat most of the time	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

			Never	Rarely	Sometimes	Often	Always
D22.	**My child enjoys tasting new foods**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D23.	**My child gets full before his/her meal is finished**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D24.	**My child enjoys eating**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D25.	**My child refuses to eat certain types of food (e.g. vegetables, meat)**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D26.	**My child is difficult to please with meals**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D27.	**My child eats more than usual if he/she really enjoys the taste of a food**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D28.	**My child decides that he/she does not like a food, even without tasting it**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D29.	**My child eats more and more slowly during the course of a meal**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D30.	**Even when my child has just eaten well, he/she is happy to eat again if offered**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D31.	**My child wants to eat (e.g. reaches out or asks) when he/she sees others eating**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D32.	**My child gets full up easily**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
D33.	**My child is interested in tasting food he/she has not tasted before**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

HOW ACTIVE ARE YOUR TWINS

These questions ask about your twins' physical activity. For each behaviour, please indicate how often your twins did this <u>during the last two weeks</u>

			Very rarely	Less than half the time	About half the time	More than half the time	Almost always
E1.	**<u>While in the bath,</u> how often did your twins ...**						
	sit quietly	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
	splash, kick or try to jump	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E2.	**<u>During everyday activities,</u> how often did your twins ...**		Very rarely	Less than half the time	About half the time	More than half the time	Almost always
	move quickly from one place to another	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
	seem full of energy, even in the evening	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E3.	**<u>During sleep,</u> how often did your twins...**		Very rarely	Less than half the time	About half the time	More than half the time	Almost always
	toss about in the bed or cot	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
	sleep in one position only	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E4.	**When playing with other <u>children (of the same age),</u> how often did your twins...**		Very rarely	Less than half the time	About half the time	More than half the time	Almost always
	seem to be one of the more active children	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
	sit quietly and watch	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E5.	**<u>When being dressed or undressed</u>, how often did your twins ...**		Very rarely	Less than half the time	About half the time	More than half the time	Almost always
	squirm and try to get away	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
	stay still	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

E6. Compared to other children of the same age and sex, how physically active is your child?

	Much less active	Somewhat less active	About average	Somewhat more active	Much more active
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

E7. How many hours would you estimate your child watches TV or DVDs during the following times on a typical weekday (Monday through Friday) at this time of year?

	Morning (6 am to 12 noon)	Afternoon (12 noon to 6 pm)	Evening (6 pm to midnight)
1st born	_____ hours per day	_____ hours per day	_____ hours per day
2nd born	_____ hours per day	_____ hours per day	_____ hours per day

E8. How many hours would you estimate your child watches TV or DVDs during the following times on a weekend day (Saturday or Sunday) at this time of year?

	Morning (6 am to 12 noon)	Afternoon (12 noon to 6 pm)	Evening (6 pm to midnight)
1st born	_____ hours per day	_____ hours per day	_____ hours per day
2nd born	_____ hours per day	_____ hours per day	_____ hours per day

E9. When does your child usually go to bed in the evening?

1st born _____ : _____ (please write hour : minutes e.g. 6:15 pm or 18:15)

2nd born _____ : _____

E10. When does your child usually wake up in the morning?

1st born _____ : _____ (please write hour : minutes e.g. 6:15 am)

2nd born _____ : _____

E11. How long does you child usually sleep during the daytime?

1st born _____ hours per day

2nd born _____ hours per day

E12. Do either of your twins usually wake up at night? Yes 1st born ☐ Yes 2nd born ☐ Neither ☐

If Yes, how often does your child wake up at night?

1st born _____ times per night _____ times per week

2nd born _____ times per night _____ times per week

If Yes, for how long does your child wake up at night?

1st born _____ hours or _____ minutes per night

2nd born _____ hours or _____ minutes per night

HOW YOU FEED YOUR TWINS

The following questions are about how you feed your twins day-to-day.
If the described behaviour does not apply to you as you never do this, please tick "never"

			Never	Rarely	Sometimes	Often	Always
F1.	**I allow my child to choose which foods to have for meals**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F2.	**I give my child something to eat to make him/her feel better when he/she is feeling upset**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F3.	**I keep track of the high fat foods that my child eats**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F4.	**I ask other people not to feed my child unhealthy foods**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F5.	**I encourage my child to eat a wide variety of foods**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F6.	**I decide how many snacks my child should have**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F7.	**I use foods that my child likes as a way to get him/her to eat "healthy" foods**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F8.	**If my child misbehaves I withhold his/her favourite food**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F9.	**I praise my child if he/she eats fruit or vegetables**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F10.	**I give my child something to eat to make him/her feel better when he/she has been hurt**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F11.	**I let my child decide when he/she would like to have his/her meal**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F12.	**I encourage my child to eat fruit or vegetables**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

			Never	Rarely	Sometimes	Often	Always
F13.	**I use puddings as a bribe to get my child to eat his/her main course**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F14.	**I present fruit or vegetables in an attractive way to my child**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F15.	**I give my child something to eat to make him/her feel better when he/she is grumpy**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F16.	**I try not to eat unhealthy foods when my child is around**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F17.	**I keep track of the sugary foods that my child eats**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F18.	**I reward my child with something to eat when he/she is well-behaved**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F19.	**I let my child eat between meals whenever he/she wants**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F20.	**I give my child something to eat to make him/her feel better when he/she is feeling irritable**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F21.	**I decide what my child eats between meals**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F22.	**I avoid buying unhealthy foods and bringing them into the house**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F23.	**I keep track of the foods my child's been eating when he/she is not with me (e.g. with a childminder or family member)**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F24.	**I praise my child if he/she eats a new food**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

Here are a few more questions about how you feed your twins day-to-day. Remember, if the described behaviour does not apply to you as you never do this, please tick "never"

			Never	Rarely	Sometimes	Often	Always
F25.	I avoid going to cafes or restaurants with my child that sell unhealthy foods	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F26.	I give my child something to eat to occupy him/her (e.g. when in company or travelling)	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F27.	My child should always eat all of the food I give him/her	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F28.	I show my child how much I enjoy eating healthy foods	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F29.	I have to be especially careful to make sure my child eats enough	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F30.	I model healthy eating for my child by eating healthy foods myself	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F31.	If I did not guide or regulate my child's eating, he/she would eat much less than he/she should	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F32.	I try to eat healthy foods in front of my child, even if they are not my favourite	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F33.	I insist my child eats some fruit or vegetables, even if he/she doesn't want them	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F34.	I try to show enthusiasm about eating healthy foods	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F35.	If my child thinks he/she isn't hungry, I try to get him/her to eat anyway	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

			Not at all 1	2	3	4	5	6	Strictly 7
F36.	I limit my child's access to sugary foods	1st born	☐	☐	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐	☐	☐
F37.	I limit my child's access to high fat foods	1st born	☐	☐	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐	☐	☐
F38.	I limit the portion sizes of sugary foods that I give to my child	1st born	☐	☐	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐	☐	☐
F39.	I limit the portion sizes of high fat foods that I give to my child	1st born	☐	☐	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐	☐	☐

F40. If you limit your child's access to some foods, what is the most important reason?

	I do not limit access to food	For physical health	For dental health	For weight control	Other, please describe
1st born	☐	☐	☐	☐	☐ ________________
2nd born	☐	☐	☐	☐	☐ ________________

SOLID FOODS

You may recognise this section from the previous questionnaire. We are repeating it because many babies hadn't tried any solid foods or had only tried some of the foods. We apologise for the duplication, but would like to get a full picture of the foods your twins have tried up to now

		1st born	2nd born
G1.	At what age did your twins start taking solid foods every day?	____ months	____ months
G2.	When were your twins first given finger foods (i.e. foods children can pick up and feed to themselves)?	____ months	____ months

G3. How easy was it to wean your twins onto solid food?

	Very easy	Easy	OK	Difficult	Very difficult
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

G4. In general how much did your twins enjoy starting solid foods?

	Did not enjoy it at all	Enjoyed it a little	Enjoyed it a lot
1st born	☐	☐	☐
2nd born	☐	☐	☐

G5. When eating solid food, which of the following statements describes your twins?

	Generally needs to be fully fed by an adult	Generally needs to be fed by an adult but also eats with fingers	Generally eats with spoon but needs help	Generally eats with spoon without help
1st born	☐	☐	☐	☐
2nd born	☐	☐	☐	☐

As many children had not tried most of the foods listed, we are repeating this section. Please complete the following question to tell us which foods your twins have tried up to now

G6. How old were your twins when they first tried the following foods?

	1st born		2nd born	
	Age when first tried	Never tried	Age when first tried	Never tried
Baby rice, cereal, rusks or bread	____ months	☐	____ months	☐
Vegetables (uncooked, cooked or pureed, fresh, frozen or tinned)	____ months	☐	____ months	☐
Chips (e.g. oven fries, smiley faces, potato waffles or wedges)	____ months	☐	____ months	☐
Potatoes or sweet potatoes	____ months	☐	____ months	☐
Processed meat (e.g. sausages, burger)	____ months	☐	____ months	☐
Other meat (e.g. chicken, lamb, pork, beef)	____ months	☐	____ months	☐
Fish (fresh, frozen, tinned or fish fingers)	____ months	☐	____ months	☐
Eggs	____ months	☐	____ months	☐
Dairy products (e.g. milk, cheese, yoghurt)	____ months	☐	____ months	☐
Fizzy drinks with sugar (e.g. 7up, coke)	____ months	☐	____ months	☐
Low calorie fizzy drinks (e.g. 7up zero, diet coke)	____ months	☐	____ months	☐
Squash or fruit drinks with sugar (e.g. ribena, robinsons fruit shoot)	____ months	☐	____ months	☐
Low calorie squash or fruit drinks (e.g. ribena light, robinsons fruit shoot no added sugar)	____ months	☐	____ months	☐
Pure fruit juice (100% juice)	____ months	☐	____ months	☐
Savoury snacks (e.g. crisps, cheese biscuits)	____ months	☐	____ months	☐
Fruit (uncooked, cooked, pureed, fresh, frozen or tinned)	____ months	☐	____ months	☐
Sweet snacks (e.g. cakes, biscuits, ice cream)	____ months	☐	____ months	☐
Sweets (e.g. chocolate, fruit sweets)	____ months	☐	____ months	☐

G7. How much do your twins like the following foods at the moment?

		Has never tried	Dislikes a lot	Dislikes	Likes	Likes a lot
Baby rice, cereal, rusks or bread	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Vegetables (uncooked, cooked or pureed, fresh, frozen or tinned)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Chips (e.g. oven fries, smiley faces, potato waffles or wedges)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Potatoes or sweet potatoes	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Processed meat (e.g. sausages, burger)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Other meat (e.g. chicken, lamb, pork, beef)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Fish (fresh, frozen, tinned or fish fingers)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Eggs	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Dairy products (e.g. milk, cheese, yoghurt)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Fizzy drinks with sugar (e.g. 7up, coke)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Low calorie fizzy drinks (e.g. 7up zero, diet coke)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐

How much do your twins like the following foods at the moment?

		Has never tried	Dislikes a lot	Dislikes	Likes	Likes a lot
Squash or fruit drinks with sugar (e.g. ribena, robinsons fruit shoot)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Low calorie squash or fruit drinks (e.g. ribena light, robinsons fruit shoot no added sugar)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Pure fruit juice (100% juice)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Savoury snacks (e.g. crisps, cheese biscuits)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Fruit (uncooked, cooked, pureed, fresh, frozen or tinned)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Sweet snacks (e.g. cakes, biscuits, ice cream)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
Sweets (e.g. chocolate, fruit sweets)	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐

G8. Please give the date on which you completed this booklet ___/___/_____
DD MM YYYY

Thank you

very much for filling in this booklet

Space for any additional comments you would like to make

Please return this booklet to:

Gemini
Health Behaviour Research Centre
Department of Epidemiology & Public Health
UCL
2-16 Torrington Place
London, WC1E 6BT
FREEPOST SE64 15

Appendix 3.3: Gemini 24-month questionnaire

Family ID Number ☐☐☐☐☐☐☐

WELCOME TO

gemini

health and development in twins

2 years booklet

Your Twins and You

Health Behaviour Research Centre
Department of Epidemiology & Public Health
UCL
1-19 Torrington Place
London, WC1E 6BT
gemini@public-health.ucl.ac.uk

TO START

A1. Please confirm the first names and date of birth of your twins

Name 1st born ____________________ **Name 2nd born** ____________________

Date of birth ____ / ____ / 2007
DD MM

A2. What is your relationship to the twins?

Mother of the twins ☐ Father of the twins ☐ Other, please describe: ____________________

A3. How many days per week do your twins go to nursery? (please write 0 if they don't go to nursery)

1st born ____ days per week
2nd born ____ days per week

A4. Has either of the twins seen a doctor due to a serious illness or accident since we last contacted you (<u>when your twins were about 15 months</u>)?

Yes, 1st born ☐ Yes, 2nd born ☐ Neither ☐

A5. If Yes, please describe each illness or accident. Use the back of the questionnaire if you need extra space

		Description of illness or accident	Age of twin (months)	Number of doctor visits (GP or specialist)	Number of hospital nights
1st born	1	______	______	______	______
	2	______	______	______	______
	3	______	______	______	______
2nd born	1	______	______	______	______
	2	______	______	______	______
	3	______	______	______	______

YOUR TWINS' GROWTH

We would like to update the information on your twins' growth since we last contacted you.
Please use information from the health record (little red book) if possible or your own records.

Please use the height chart and weighing scales we have sent to add today's measurements.

B1. **Please provide any measurements of the twins' height taken since we last contacted you (when they were about 15 months) and indicate whether measurements came from a health professional or your own records. Please use the height chart and instructions we have sent to add today's heights by measuring the twins without shoes.**

	1st born				2nd born				This measurement came from...	
Date measured	cms		feet	inches	cms		feet	inches	Health professional /health record	Own records
___/___/_____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
___/___/_____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
___/___/_____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
___/___/_____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐

B2. **Please provide any measurements of the twins' weight taken since we last contacted you (when they were about 15 months) and indicate whether measurements came from a health professional or your own records. Please use the scales we have sent to add today's weights by weighing the twins in indoor clothes without shoes.**

	1st born				2nd born				This measurement came from...	
Date measured	kgs		lbs	oz	kgs		lbs	oz	Health professional /health record	Own records
___/___/_____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
___/___/_____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
___/___/_____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
___/___/_____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
___/___/_____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐
___/___/_____ DD MM YYYY	____	or	____	____	____	or	____	____	☐	☐

A FEW QUESTIONS ABOUT YOU
Please tick the box on the scale that you feel is most appropriate in describing you.

C1. In general, I consider myself ...

A very happy person 1	2	3	4	5	6	Not a very happy person 7
☐	☐	☐	☐	☐	☐	☐

C2. Compared to most of my peers, I consider myself ...

Less happy 1	2	3	4	5	6	More happy 7
☐	☐	☐	☐	☐	☐	☐

C3. Some people are generally very happy. They enjoy life regardless of what is going on, getting the most out of everything. To what extent does this characterization describe you?

Not at all 1	2	3	4	5	6	A great deal 7
☐	☐	☐	☐	☐	☐	☐

C4. Some people are generally not very happy. Although they are not depressed, they never seem as happy as they might be. To what extent does this characterization describe you?

Not at all 1	2	3	4	5	6	A great deal 7
☐	☐	☐	☐	☐	☐	☐

C5. What is your date of birth? ___ / ___ / _____ (DD MM YYYY)

C6. About how tall are you? ____ centimetres (cms) OR ____ feet (ft) and ____ inches

C7. About how much do you weigh? (Please give your current weight using the scales we have sent) ____ kilograms (kgs) OR ___ stones (st) and ___ pounds (lbs)

C8. Do you currently have a job?

On maternity / paternity leave	Yes, full-time	Yes, part-time	No	Stay at home to look after children
☐	☐	☐	☐	☐

C9. Do you currently own or rent the accommodation you live in?

Own without mortgage	Own with mortgage	Rent privately	Rent from local authority
☐	☐	☐	☐

C10. What is your marital status?

Married or cohabiting	Divorced	Widowed	Separated	Single
☐	☐	☐	☐	☐

If you are married or cohabiting, please ask you partner to complete the "Partner booklet". Please continue on next page to tell us about your physical activities and eating attitudes.

YOUR PHYSICAL ACTIVITIES

We are interested in finding out about the activities that you do as part of everyday life. This includes activities at work, as part of housework or gardening, to get from place to place, and in your spare time for recreation, exercise or sport.

Please answer each question even if you do not consider yourself to be an active person.

Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal

Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal

D1. During the last 7 days, on how many days did you do <u>vigorous</u> physical activities like heavy lifting, digging, aerobics, or fast bicycling?

Think about *only* those physical activities that you did for at least 10 minutes at a time.

_____ days per week OR ☐ None (→ Go straight to D3)

D2. How much time in total did you usually spend doing vigorous physical activities on one of those days?

_____ hours _____ minutes

D3. Again, think *only* about those physical activities that you did for at least 10 minutes at a time. During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or double tennis? Do not include walking.

_____ days per week OR ☐ None (→ Go straight to D5)

D4. How much time in total did you usually spend doing moderate physical activities on one of those days?

_____ hours _____ minutes

D5. During the last 7 days, on how many days did you <u>walk</u> for at least 10 minutes at a time? This includes walking at work and at home, walking to travel from place to place, and any other walking that you did solely for recreation, sport, exercise or leisure.

_____ days per week OR ☐ None (→ Go straight to E1 on next page)

D6. How much time in total did you usually spend walking on one of those days?

_____ hours _____ minutes

YOUR EATING ATTITUDES
If the described behaviour does not apply to you as you never experience this, please tick "Never".

		Never	Seldom	Sometimes	Often	Very often
E1.	How often do you refuse food or drink offered because you are concerned about your weight?	☐	☐	☐	☐	☐
E2.	Do you have a desire to eat when someone lets you down?	☐	☐	☐	☐	☐
E3.	Do you take into account your weight with what you eat?	☐	☐	☐	☐	☐
E4.	Do you have a desire to eat when things are going against you or when things have gone wrong?	☐	☐	☐	☐	☐
E5.	If you have something delicious to eat, do you eat it straight away?	☐	☐	☐	☐	☐
E6.	Do you have a desire to eat when you are cross?	☐	☐	☐	☐	☐
E7.	Do you deliberately eat foods that are slimming?	☐	☐	☐	☐	☐
E8.	If food smells and looks good, do you eat more than usual?	☐	☐	☐	☐	☐
E9.	How often do you try not to eat between meals because you are watching your weight?	☐	☐	☐	☐	☐
E10.	Do you have a desire to eat when you are disappointed?	☐	☐	☐	☐	☐
E11.	Do you deliberately eat less in order not to become heavier?	☐	☐	☐	☐	☐
E12.	If food tastes good to you, do you eat more than usual?	☐	☐	☐	☐	☐
E13.	Do you have a desire to eat when you are feeling lonely?	☐	☐	☐	☐	☐
E14.	If you see others eating, do you also have a desire (want) to eat?	☐	☐	☐	☐	☐
E15.	If you see or smell something delicious, do you have a desire to eat it?	☐	☐	☐	☐	☐

F1. Please give the date on which you completed this booklet DD / MM / YYYY

THANK YOU

very much for filling in this booklet

If you are married or cohabiting,
please ask your partner to complete the "Partner Booklet"
and send both booklets back in the freepost return envelope

If you are a not married or cohabiting,
please send this completed questionnaire and the non-completed
"partner booklet" back in the freepost return envelope

Space for any additional comments you would like to make

Please return both booklets to:

Gemini
Health Behaviour Research Centre
Department of Epidemiology & Public Health
UCL
1-19 Torrington Place
London, WC1E 6BT
FREEPOST SE64 15

Appendix 3.4: Gemini 5-year questionnaire

Family ID Number ☐☐☐☐☐☐☐

WELCOME TO

gemini

health and development in twins

Five Year Booklet

Your Twins

IF POSSIBLE THIS QUESTIONNAIRE IS TO BE COMPLETED BY THE PARENT WHO HAS COMPLETED PREVIOUS GEMINI QUESTIONNAIRES

Health Behaviour Research Centre
Department of Epidemiology & Public Health
UCL
1-19 Torrington Place
London, WC1E 6BT
gemini@ucl.ac.uk

YOUR TWINS' GROWTH

We would like to update the information on your twins' growth since we last contacted you.

A1. **If you have taken any measurements of your twins' heights or weights <u>since we last contacted you</u> please enter them below.**

If you haven't measured your twins' heights recently please use the height chart and instructions we have sent to <u>add today's heights</u> (no shoes).

Use the scales we sent you to <u>add today's weights</u> (indoor clothes, no shoes).

		Height				Weight			
Date measured		cms		feet	inches	kgs		stones	lbs
__/__/____ DD MM YYYY	1st born	____	or	____	____	____	or	____	____
	2nd born	____	or	____	____	____	or	____	____
__/__/____ DD MM YYYY	1st born	____	or	____	____	____	or	____	____
	2nd born	____	or	____	____	____	or	____	____
__/__/____ DD MM YYYY	1st born	____	or	____	____	____	or	____	____
	2nd born	____	or	____	____	____	or	____	____
__/__/____ DD MM YYYY	1st born	____	or	____	____	____	or	____	____
	2nd born	____	or	____	____	____	or	____	____
__/__/____ DD MM YYYY	1st born	____	or	____	____	____	or	____	____
	2nd born	____	or	____	____	____	or	____	____
__/__/____ DD MM YYYY	1st born	____	or	____	____	____	or	____	____
	2nd born	____	or	____	____	____	or	____	____
__/__/____ DD MM YYYY	1st born	____	or	____	____	____	or	____	____
	2nd born	____	or	____	____	____	or	____	____

A2. How would you describe your twins' weights at the moment?

	Very underweight	Slightly underweight	About the right weight	Slightly overweight	Very overweight
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

A3. How concerned are you about your twins' weights at the moment?

	Not concerned	Somewhat concerned	Very concerned
1st born	☐	☐	☐
2nd born	☐	☐	☐

A4. How likely do you think it is that your twins will be overweight in 2 years' time?

	Unlikely	Somewhat likely	Very likely
1st born	☐	☐	☐
2nd born	☐	☐	☐

A5. How concerned would you be if your twins were overweight in 2 years' time?

	Not concerned	Somewhat concerned	Very concerned
1st born	☐	☐	☐
2nd born	☐	☐	☐

A6. How likely do you think it is that your twins will be underweight in 2 years' time?

	Unlikely	Somewhat likely	Very likely
1st born	☐	☐	☐
2nd born	☐	☐	☐

A7. How concerned would you be if your twins were underweight in 2 years' time?

	Not concerned	Somewhat concerned	Very concerned
1st born	☐	☐	☐
2nd born	☐	☐	☐

A8.	**How old were your twins when they could walk a few steps without any support?**	1st born	_____ months	Not yet ☐
		2nd born	_____ months	Not yet ☐
A9.	**How old were your twins when they said their first word?**	1st born	_____ months	Not yet ☐
		2nd born	_____ months	Not yet ☐

YOUR TWINS' MEDICAL PROBLEMS AND ACCIDENTS

B1. Has either of the twins seen a doctor due to a serious medical problem or accident since we last contacted you?

Yes, 1st born	Yes, 2nd born	Neither
☐	☐	☐

B2. If yes, please describe any serious medical problem or accident. Use the back of the questionnaire if you need extra space

		Description of medical problem or accident	Age of twin (months)	Number of doctor visits (GP or specialist)	Number of hospital nights
1st born	1	________	____	____	____
	2	________	____	____	____
	3	________	____	____	____
	4	________	____	____	____
2nd born	1	________	____	____	____
	2	________	____	____	____
	3	________	____	____	____
	4	________	____	____	____

APPETITE
These questions are about your twins' appetites at the moment.

C1. How would you rate your twins' overall appetites at the moment?

	Poor	OK	Good	Very Good	Excellent
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

C2. How would you rate your twins' appetites for breakfast?

	Poor	OK	Good	Very Good	Excellent
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

C3. How would you rate your twins' appetites for lunch?

	Poor	OK	Good	Very Good	Excellent
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

C4. How would you rate your twins' appetites for dinner/tea (evening meal)?

	Poor	OK	Good	Very Good	Excellent
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

C5. On average, how many days a week do your twins eat breakfast? (Weekly estimates include week days and weekend days)

1st born _________ days per week

2nd born _________ days per week

C6. If your twins could choose, when would they prefer to eat each of their meals? (Please state the exact time and circle am or pm)

Breakfast

1st born	_________ am / pm	Wouldn't eat breakfast	☐
2nd born	_________ am / pm	Wouldn't eat breakfast	☐

	Lunch			
	1st born	_________ am / pm	Wouldn't eat lunch	☐
	2nd born	_________ am / pm	Wouldn't eat lunch	☐
	Dinner/tea/evening meal			
	1st born	_________ am / pm	Wouldn't eat dinner/tea/evening meal	☐
	2nd born	_________ am / pm	Wouldn't eat dinner/tea/evening meal	☐

C7. Do your twins ask for food later in the evening, following their evening meal?

	Never	Rarely	Sometimes	Often	Always
1st born	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐

C8. Does one of your twins generally eat more than the other?

1st born eats much more	1st born eats a little more	Each eat about the same amount	2nd born eats a little more	2nd born eats much more
☐	☐	☐	☐	☐

How would you describe your twins' eating styles on a typical day?

			Never	Rarely	Sometimes	Often	Always
C9.	**My child loves food**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C10.	**My child eats more when worried**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C11.	**My child wants to eat (e.g. asks) when he/she <u>sees</u> certain foods**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C12.	**My child has a big appetite**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C13.	**My child finishes his/her meal quickly**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

			Never	Rarely	Sometimes	Often	Always
C14.	My child is interested in food	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C15.	My child is always asking for a drink	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C16.	My child refuses new foods at first	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C17.	My child eats slowly	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C18.	My child eats less when angry	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C19.	My child enjoys tasting new foods	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C20.	My child wants to eat (e.g. asks) when he/she smells certain foods	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C21.	My child eats less when he/she is tired	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C22.	My child is always asking for food	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C23.	My child eats more when annoyed	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C24.	If allowed to, my child would eat too much	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

			Never	Rarely	Sometimes	Often	Always
C25.	My child eats more when anxious	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C26.	My child enjoys a wide variety of foods	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C27.	My child leaves food on his/her plate at the end of a meal	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C28.	My child takes more than 30 minutes to finish a meal	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C29.	Given the choice, my child would eat most of the time	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C30.	My child looks forward to mealtimes	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C31.	My child gets full before his/her meal is finished	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C32.	My child enjoys eating	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C33.	My child eats more than usual if he/she really enjoys the taste of a food	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C34.	My child eats more when he/she is happy	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C35.	My child is difficult to please with meals	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

			Never	Rarely	Sometimes	Often	Always
C36.	My child eats less when upset	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C37.	My child gets full up easily	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C38.	My child eats more when he/she has nothing else to do	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C39.	Even if my child is full up he/she finds room to eat his/her favourite food	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C40.	If given the chance, my child would drink continuously throughout the day	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C41.	My child cannot eat a meal if he/she has had a snack just before	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C42.	If given the chance, my child would always be having a drink	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C43.	My child is interested in tasting food he/she hasn't tasted before	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C44.	My child wants to eat (e.g. reaches out or asks for food) when he/she sees others eating	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
C45.	My child decides that he/she doesn't like a food without even tasting it	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

		Never	Rarely	Sometimes	Often	Always
C46. If given the chance my child would always have food in his/her mouth	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
C47. My child eats more and more slowly during the course of a meal	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐

C48. How many hours would you estimate your twins watch TV or DVDs on a typical weekday (Monday through Friday)?

	Morning (6 am to 12 noon)	Afternoon (12 noon to 6pm)	Evening (6 pm to midnight)
1st born	_____ hours per day	_____ hours per day	_____ hours per day
2nd born	_____ hours per day	_____ hours per day	_____ hours per day

C49. How many hours would you estimate your twins watch TV or DVDs on a weekend day (Saturday or Sunday)?

	Morning (6 am to 12 noon)	Afternoon (12 noon to 6pm)	Evening (6 pm to midnight)
1st born	_____ hours per day	_____ hours per day	_____ hours per day
2nd born	_____ hours per day	_____ hours per day	_____ hours per day

C50. Do your twins share a bedroom?

Yes ☐ No ☐

C51. Do your twins have a working TV in their bedroom?

1st born:	Yes ☐	No ☐
2nd born:	Yes ☐	No ☐

SLEEP HABITS

The following statements are about your twins' sleep habits. Think about the past week in your child's life when answering the questions. If last week was unusual for a specific reason, choose the most recent typical week. Answer **usually** if something occurs **5 or more times** in a week, **sometimes** if it occurs **2-4 times** in a week, **rarely** if something occurs **never or 1 time** during a week.

D1. What are your twins' bedtimes: 1st born: ________________

2nd born: ________________

D2. Twins' usual amounts of sleep each day: (combining night-time sleep and naps) 1st born: _______ hours

2nd born: _______ hours

			Usually (5-7 nights per week)	Sometimes (2-4 nights per week)	Rarely/Never (0-1 nights per week)	Don't Know
D3.	**Child goes to bed at the same time at night**	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D4.	**Child falls asleep within 20 minutes after going to bed**	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D5.	**Child falls asleep alone in own bed**	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D6.	**Child falls asleep in parent's or sibling's bed**	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D7.	**Child falls asleep with rocking or rhythmic movements**	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D8.	**Child needs special object to fall asleep (doll, special blanket, etc.)**	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D9.	**Child needs parent in the room to fall asleep**	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐

		Usually (5-7 nights per week)	Sometimes (2-4 nights per week)	Rarely/Never (0-1 nights per week)	Don't Know
D10. Child is ready to go to bed at bedtime	1st born	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐
D11. Child resists going to bed at bedtime	1st born	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐
D12. Child struggles at bedtime (cries, refuses to stay in bed, etc.)	1st born	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐
D13. Child is afraid of sleeping in the dark	1st born	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐
D14. Child sleeps with the light on	1st born	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐
D15. Child is afraid of sleeping alone	1st born	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐
D16. Child sleeps too little	1st born	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐
D17. Child sleeps too much	1st born	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐
D18. Child sleeps the right amount	1st born	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐
D19. Child sleeps for about the same amount each night	1st born	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐
D20. Child wets the bed at night	1st born	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐
D21. Child talks during sleep	1st born	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐

			Usually (5-7 nights per week)	Sometimes (2-4 nights per week)	Rarely/Never (0-1 nights per week)	Don't Know
D22.	Child is restless and moves a lot during sleep	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D23.	Child sleepwalks during the night	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D24.	Child moves to someone else's bed during the night (parent, brother, sister, etc.)	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D25.	Child reports body pains during sleep	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
	If so, where?	1st born	....			
		2nd born	....			

			Usually (5-7 nights per week)	Sometimes (2-4 nights per week)	Rarely/Never (0-1 nights per week)	Don't Know
D26.	Child grinds teeth during sleep (your dentist may have told you this)	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D27.	Child snores loudly	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D28.	Child seems to stop breathing during sleep	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D29.	Child snorts and/or gasps during sleep	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D30.	Child has trouble sleeping away from home (visiting relatives, vacation)	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐

			Usually (5-7 nights per week)	Sometimes (2-4 nights per week)	Rarely/Never (0-1 nights per week)	Don't Know
D31.	Child complains about problems sleeping	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D32.	Child awakens during night screaming, sweating, and inconsolable	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D33.	Child awakens alarmed by a frightening dream	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D34.	Child awakes once during the night	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D35.	Child awakes more than once during the night	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D36.	Child returns to sleep without help after waking	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D37.	Write the number of minutes in the night your child is awake	1st born	_________ minutes		Don't know	☐
		2nd born	_________ minutes		Don't know	☐
D38.	Write in the time of day child usually wakes in the morning	1st born	_____ : _____ am		Don't know	☐
		2nd born	_____ : _____ am		Don't know	☐
			Usually (5-7 nights per week)	Sometimes (2-4 nights per week)	Rarely/Never (0-1 nights per week)	Don't Know
D39.	Child wakes up by him/herself	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D40.	Child wakes up with alarm clock	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐

			Usually (5-7 nights per week)	Sometimes (2-4 nights per week)	Rarely/Never (0-1 nights per week)	Don't Know
D41.	Child wakes up in negative mood	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D42.	Adults or siblings wake up child	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D43.	Child has difficulty getting out of bed in the morning	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D44.	Child takes a long time to become alert in the morning	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D45.	Child wakes up very early in the morning	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D46.	Child has a good appetite in the morning	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D47.	Child naps during the day	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D48.	Child suddenly falls asleep in the middle of active behaviour	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐
D49.	Child seems tired	1st born	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐

During the past week, has your child appeared very sleepy or fallen asleep during the following? (Check all that apply)

			Not sleepy	Very sleepy	Falls asleep
D50.	Playing alone	1st born	☐	☐	☐
		2nd born	☐	☐	☐

		Not sleepy	Very sleepy	Falls asleep
D51. Watching TV	1st born			
	2nd born			
D52. Riding in car	1st born			
	2nd born			
D53. Eating meals	1st born			
	2nd born			

D54. We hear about 'morning' and 'evening' types of people. Which of these types do you consider your twins to be?

	Definitely a 'morning' type	Rather more a 'morning' than an 'evening' type	Rather more an 'evening' than a 'morning' type	Definitely an 'evening' type
1st born				
2nd born				

HOW YOU FEED YOUR TWINS

The following questions are about how you feed your twins day-to-day.
If the described behaviour does not apply to you as you never do this, please tick "never".

		Never	Rarely	Sometimes	Often	Always
E1. I allow my child to choose which foods to have for meals	1st born					
	2nd born					
E2. I give my child something to eat to make him/her feel better when he/she is feeling upset	1st born					
	2nd born					
E3. I keep track of the high fat foods that my child eats	1st born					
	2nd born					

			Never	Rarely	Sometimes	Often	Always
E4.	I ask other people not to feed my child unhealthy foods	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E5.	I encourage my child to eat a wide variety of foods	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E6.	I decide how many snacks my child should have	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E7.	I use foods that my child likes as a way to get him/her to eat "healthy" foods	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E8.	If my child misbehaves I withhold his/her favourite food	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E9.	I praise my child if he/she eats fruit or vegetables	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E10.	I give my child something to eat to make him/her feel better when he/she has hurt himself/herself	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E11.	I let my child decide when he/she would like to have his/her meal	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E12.	I encourage my child to eat fruit or vegetables	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E13.	I use puddings as a bribe to get my child to eat his/her main course	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E14.	I present fruit or vegetables in an attractive way to my child	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

			Never	Rarely	Sometimes	Often	Always
E15.	I give my child something to eat to make him/her feel better when he/she is feeling angry	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E16.	I try not to eat unhealthy foods when my child is around	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E17.	I keep track of the sugary foods that my child eats	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E18.	I reward my child with something to eat when he/she is well-behaved	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E19.	I let my child eat between meals whenever he/she wants	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E20.	I give my child something to eat to make him/her feel better when he/she is worried	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E21.	I decide what my child eats between meals	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E22.	I avoid buying unhealthy foods and bringing them into the house	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E23.	I keep track of the foods my child's been eating when he/she is not with me (e.g. with a childminder or family member)	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E24.	I praise my child if he/she eats a new food	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

		Never	Rarely	Sometimes	Often	Always
E25. I avoid going to cafes or restaurants with my child that sell unhealthy foods	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
E26. I give my child something to eat to occupy him/her if he/she is feeling bored	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
E27. My child should always eat all of the food on his/her plate	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
E28. I show my child how much I enjoy eating healthy foods	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
E29. I have to be especially careful to make sure my child eats enough	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
E30. I model healthy eating for my child by eating healthy foods myself	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
E31. If I did not guide or regulate my child's eating, he/she would eat much less than he/she should	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
E32. I try to eat healthy foods in front of my child, even if they are not my favourite	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
E33. I insist my child eats some fruit or vegetables, even if he/she doesn't want them	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
E34. I try to show enthusiasm about eating healthy foods	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐
E35. If my child says "I'm not hungry", I try to get him/her to eat anyway	1st born	☐	☐	☐	☐	☐
	2nd born	☐	☐	☐	☐	☐

			Never	Rarely	Sometimes	Often	Always
E36.	I allow my child to wander around during a meal	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E37.	My child watches TV during meals	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E38.	My child has a set mealtime and snack routine	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E39.	I sit down with my child when he/she eats meals	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
E40.	In order to get my child to behave him/herself I promise him/her something to eat	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

			Not at all 1	2	3	4	5	6	Strictly 7
E41.	I limit my child's access to sugary foods	1st born	☐	☐	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐	☐	☐
E42.	I limit my child's access to high fat foods	1st born	☐	☐	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐	☐	☐
E43.	I limit the portion sizes of sugary foods that I give to my child	1st born	☐	☐	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐	☐	☐
E44.	I limit the portion sizes of high fat foods that I give to my child	1st born	☐	☐	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐	☐	☐

E45. If you limit your child's access to some foods, what is the most important reason?

	I do not limit access to food	For physical health	For dental health	For weight control	Other, please describe
1st born	☐	☐	☐	☐	☐ ______________
2nd born	☐	☐	☐	☐	☐ ______________

YOUR TWINS' CHARACTERISTICS

Here are some statements that describe children's reactions to a number of situations. We would like you to tell us what your twins' reactions are likely to be in these situations. There are of course no "correct" ways of reacting; children differ widely in their reactions, and it is these differences we are trying to learn about. Please read each statement and decide whether it is a "true" or "untrue" description of your child's reaction within the past six months.

			Extremely untrue	Slightly untrue	Neither true nor untrue	Slightly true	Extremely true
F1.	My child seems always in a big hurry to get from one place to another	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F2.	My child usually rushes into an activity without thinking about it	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F3.	My child tends to run, rather than walk, from room to room	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F4.	When outside, my child often sits quietly	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F5.	My child moves about actively (runs, climbs, jumps) when playing in the house	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F6.	My child often rushes into new situations	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F7.	My child prepares for trips and outings by planning things he/she will need	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F8.	My child takes a long time in approaching new situations	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

			Extremely untrue	Slightly untrue	Neither true nor untrue	Slightly true	Extremely true
F9.	My child can wait before entering into new activities if he/she is asked to	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F10.	My child is slow and unhurried in deciding what to do next	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F11.	My child prefers quiet activities to active games	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F12.	My child tends to say the first thing that comes to mind, without stopping to think about it	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F13.	My child has trouble sitting still when he/she is told to (at movies, church, etc.)	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F14.	My child is good at following instructions	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F15.	My child approaches places he/she has been told are dangerous slowly and cautiously	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F16.	My child can easily stop an activity when he/she is told 'no'	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F17.	My child is among the last children to try out a new activity	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F18.	My child is full of energy, even in the evening	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

			Extremely untrue	Slightly untrue	Neither true nor untrue	Slightly true	Extremely true
F19.	My child likes to sit quietly and watch people do things	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F20.	The good prospect of obtaining a reward motivates my child strongly to do some things	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F21.	My child often does things to be praised	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F22.	My child enjoys being the centre of attention	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F23.	When my child is in a group, they try to stand out as the smartest or the funniest	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F24.	When my child gets something they want, they feel excited and energised	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F25.	My child does a lot of things for approval	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F26.	My child generally prefers activities that involve immediate reward	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F27.	My child often complains of headaches, stomach-aches...	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F28.	My child has many worries, and often seems worried	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

			Extremely untrue	Slightly untrue	Neither true nor untrue	Slightly true	Extremely true
F29.	**My child is often unhappy, downhearted, or tearful**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F30.	**My child is nervous or clingy in new situations**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐
F31.	**My child has many fears, and is easily scared**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

			Much less active	Somewhat less active	About average	Somewhat more active	Much more active
F32.	**Compared with other children of the same age and sex, how physically active is your child?**	1st born	☐	☐	☐	☐	☐
		2nd born	☐	☐	☐	☐	☐

F33. In general, I consider my child to be:

	Not a very happy child 1	2	3	4	5	6	A very happy child 7
1st born	☐	☐	☐	☐	☐	☐	☐
2nd born	☐	☐	☐	☐	☐	☐	☐

STARTING SCHOOL

The next few questions are about your twins starting school. Even if your twins have not yet started school please complete this section as much as possible

G1. Do/did your twins attend nursery/preschool?

1st born: Yes, still at nursery ☐ Yes, but no longer at nursery ☐ No, didn't go to nursery ☐

2nd born: Yes, still at nursery ☐ Yes, but no longer at nursery ☐ No, didn't go to nursery ☐

How many hours per week do they/did they attend nursery/preschool? ☐ hours

G2. Have your twins started school?

1st born: Yes ☐ No ☐ If yes, when did they start? ____________ If no, when will they start? ____________

2nd born: Yes ☐ No ☐ If yes, when did they start? ____________ If no, when will they start? ____________

If you answered 'no' to question G2 for both twins please go straight to question G6

G3. Are your twins in the same class? Yes ☐ No ☐

G4. What kind of meal do your twins eat at school?

	Always has a packed lunch	Always has a school dinner	Varies	Doesn't eat at school
1st born	☐	☐	☐	☐
2nd born	☐	☐	☐	☐

G5. What is the most common mode of transport by which the twins get to school?

1st born: Motorised transportation (e.g. car, bus) ☐ Bicycle/Scooter ☐ Walking ☐

2nd born: Motorised transportation (e.g. car, bus) ☐ Bicycle/Scooter ☐ Walking ☐

G6. Could you tell us about any childcare arrangements that you have for the twins (e.g. looked after by grandparents on Saturday mornings)?

G7. Please give the date on which you completed this booklet: __/__/____
dd mm yyyy

Thank you

very much for filling in this booklet

Space for any additional comments you would like to make

Please return this booklet to:

Gemini
Health Behaviour Research Centre
Department of Epidemiology & Public Health
UCL
1-19 Torrington Place
London, WC1E 6BT
FREEPOST SE64 15

Appendix 4.1: Home Environment Interview (HEI)

Highlighted text is text interviewer needs to read out loud, other text is for coding purposes and may not need to be read out loud.

Section A - GENERAL INFORMATION QUESTIONS

Today's date: __ / __ / __

Family ID Number:

A1. Please can I speak to <Named Contact>?

If first phone call:

Hello, this is <researcher name> calling on behalf of the Gemini twin study. Instead of a questionnaire, we are carrying out this part of the study over the phone. Is now a good time to talk?

If not convenient, arrange another time that is convenient and record this in the call attempts excel spreadsheet. If the participant doesn't want to do the interview, also record this in the call attempts spreadsheet.

If yes, proceed as below.

We have the twins' names registered as <twin1 name> and <twin2 name>, is that correct and what you would usually call them? Is <twin1 name> the first born twin and <twin2 name> the second born?

If yes to names and birth order: click 'NEXT' button.
If no to names or birth order: check Gemini ID and insert correct names (in the correct order):

twin 1: ……… twin 2 ……………..

I would like to ask you some questions about <twin1 name> and <twin2 name> and your home. Ideally we need to talk to the person who is responsible for the majority of the food shopping and childcare within the home. Do you think you will be in a position to answer these questions?

If FOLLOW-UP phone call:

Hello, this is <researcher name> calling on behalf of the Gemini twin study. We spoke recently and you agreed to take part in a telephone interview. Is now a good time to talk?

1. If OK to talk and speaking to <named contact>: click 'NEXT button'
2. If OK to talk and NOT speaking to <named contact> fill in name below and click 'NEXT' button.

Could I take your name?

First Name ……………….. Last Name ………………...

3. If NOT OK to talk, arrange a convenient time to call back, make a note of this time and click ‘BACK’.

Thank you for taking the time to talk, the interview should take around 30 minutes to complete. Just to give you some background, the aim of the interview is to get a picture of the environment young children are growing up in. There are no right or wrong answers so please just answer honestly. If there are any questions you need me to clarify, or any other information you think would be relevant then please feel free to stop me at any time. All your responses will be kept confidential and anonymous.

A2. Please could you confirm the twin’s date of birth?
Insert correct date of birth ____ / ____ / _____

A3. Please could you confirm your relationship with <twin1 name> and <twin2 name>?
□ Mother
□ Father
□ Guardian
□ Same sex partner
□ Grandparent
□ Nanny
□ Other, please specify: …………………………………………………

A4. Please could you confirm your home address? Insert correct address.
Address : ……………………………
……………………………
…………………………………
…………………………………
Postcode : ………………………………

A5. How many adults, including yourself, currently live in your home? Only include people who are aged 18 years or older and who live in your home all of the time.
………….. Adults

A6. Does this include…

Your husband?	Yes □	No □
Your wife?	Yes □	No □
Your partner?	Yes □	No □

For female participants ask: Does this include your husband? If yes, select no for wife and partner. If no, then ask ‘your partner?’
For male participants ask: Does this include your wife? If yes, select no for husband and partner. If no, then ask ‘your partner?’

If no to all three, skip G4.5 and G4.6.

A7. How many children, under 18 years of age, not including <twin1 name> and <twin2 name> currently live in your home?
………….. Children

If no other children, skip A8.

A8. Since the birth of <twin1 name> and <twin2 name>, have any additional children joined the household? *If no, skip A9.*
Yes □ No □

A9. Please can you give the name, date of birth and sex of each additional child? Complete the table below accordingly.

	Child's name	Date of Birth	Sex
1			male □ female □
2			male □ female □
3			male □ female □
4			male □ female □

Additional comments about changes to family circumstances.

Section B - CHILDCARE

The first section is about your twin's childcare arrangements.

B1. Are your twins usually looked after together?
Yes □ No □

If looked after together:

B2. What are the regular arrangements for <twin1 name> and <twin2 name> to be looked after, either while you are at work or for any other reasons? For example, do they attend nursery or do you stay at home full time to care for them?

This is an open question. Tick one of the coding options. If the participant says looked after by a relative – clarify whether this is inside or outside the twins' home.

If the participant mentions more than one arrangement here, make sure you ask about each arrangement in turn.

□ Stay at home full time to care for the twins.
□ Partner stays at home full time to care for the twins.

□ In the twins' home by grandparent
□ In the twins' home by other relative
□ In the twins' home by non-relative (including nannies and au pairs)

□ Outside the twins' home by grandparent
□ Outside the twins' home by other relative
□ Outside the twins' home by non-relative (including childminder)

□ Nursery / Preschool / School
□ Other, please specify: …………………………………………………….

B3. In general, about how many hours per week do you use this arrangement for <twin1 name> and <twin2 name>?
ENTER WEEKLY HOURS RANGE 0-80. If the participant says it varies, request she/he estimates the average. If the participant says a number of hours plus a half then round down e.g. 15 and 1/2 hours would be 15 hours. Otherwise, round up or down accordingly e.g. 15 and 3/4 hours would be 16. If 'stay at home full time to care for twins' is selected, enter 0 hours.
………………………… Hours per week

B4. Do you make any <u>other</u> regular arrangements for looking after <twin1 name> and <twin2 name>?
Yes □ No □ If No, continue to Section C.

IF Yes
B5. What is the <u>other</u> arrangement for <twin1 name> and <twin2 name>?
Coding options as above: . …………..

B6. In general, about how many hours per week do you use this arrangement for <twin1 name> and <twin2 name>?
ENTER WEEKLY HOURS RANGE 0-80. If the participant says it varies, request she/he estimates the average. If the participant says a number of hours plus a half then round down e.g. 15 and 1/2 hours would be 15 hours. Otherwise, round up or down accordingly e.g. 15 and 3/4 hours would be 16. If 'stay at home full time to care for twins' is selected, enter 0 hours.
………………………… Hours per week

Do you make any <u>other</u> regular arrangements for looking after <twin1 name> and <twin2 name>?
Yes □ No □ If No, continue to Section C.

Repeat B-5-6 until answer is No.

If looked after separately:

B7. What are the regular arrangements for <twin1 name> to be looked after, either while you are at work or for any other reasons? For example, does <twin1 name> attend nursery or do you stay at home full time to care for <twin1 name>?

This is an open question. Tick one of the coding options. If the participant says looked after by a relative – clarify whether this is inside or outside the twins' home.

If the participant mentions more than one arrangement here, make sure you ask about each arrangement in turn.

□ Stay at home full time to care for <twin1 name>.
□ Partner stays at home full time to care for <twin1 name>.

□ In the twins' home by grandparent
□ In the twins' home by other relative
□ In the twins' home by non-relative (including nannies and au pairs)

□ Outside the twins' home by grandparent

□ Outside the twins' home by other relative
□ Outside the twins' home by non-relative (including childminder)

□ Nursery / Preschool / School
□ Other, please specify: ………………………………………………….

B8. What are the regular arrangements for <twin2 name> to be looked after, either while you are at work or for any other reasons? For example, does <twin2 name> attend nursery or do you stay at home full time to care for <twin2 name>?

This is an open question. Tick one of the coding options. If the participant says looked after by a relative – clarify whether this is inside or outside the twins' home.

If the participant mentions more than one arrangement here, make sure you ask about each arrangement in turn.

□ Stay at home full time to care for <twin2 name>.
□ Partner stays at home full time to care for <twin2 name>.

□ In the twins' home by grandparent
□ In the twins' home by other relative
□ In the twins' home by non-relative (including nannies and au pairs)

□ Outside the twins' home by grandparent
□ Outside the twins' home by other relative
□ Outside the twins' home by non-relative (including childminder)

□ Nursery / Preschool / School
□ Other, please specify: ………………………………………………….

B9. In general, about how many hours per week do you use this arrangement for <twin1 name>?
ENTER WEEKLY HOURS RANGE 0-80. If the participant says it varies, request she/he estimates the average. If the participant says a number of hours plus a half then round down e.g. 15 and 1/2 hours would be 15 hours. Otherwise, round up or down accordingly e.g. 15 and 3/4 hours would be 16. If 'stay at home full time to care for twins' is selected, enter 0 hours.
………………………… Hours per week

In general, about how many hours per week do you use this arrangement for <twin2 name>?
………………………… Hours per week

B10. Do you make any <u>other</u> regular arrangements for looking after <twin1 name>?
Yes □ No □

Do you make any <u>other</u> regular arrangements for looking after <twin2 name>?
Yes □ No □ If both no, continue to Section C.

IF Yes
B11. What is the arrangement for <twin1 name>?
Coding options as above: . …………..

What is the arrangement for <twin2 name>?
Coding options as above: . …………..

B12. In general, about how many hours per week did you use this arrangement for <twin1 name>?

………………………… Hours per week

In general, about how many hours per week did you use this arrangement for <twin2 name>?

………………………… Hours per week

Repeat B10-B11-B12 until answer to B10 is No for both twins.

Section C – HOUSE AND NEIGHBOURHOOD

The next few questions are about where you live.

C1. Which of the following options best describes the type of home you live in?

Read out each of the options below.

- □ Flat (which floor……)
- □ Semi-detached house
- □ Terraced house
- □ Detached house
- □ Or other, please describe: …………..…………………………………

C2. Do you have stairs in your home?

Yes □ No □

C3. Would you say that your home is on a busy street with lots of traffic?

Yes □ No □

Any comments on this section (C1-C3): ……………………………

I'm now going to ask some questions about how satisfied you are with where you live. For each question please choose a score from 1 to 5. A score of 1 means strongly dissatisfied, 2 means somewhat dissatisfied, 3 means neither satisfied nor dissatisfied, 4 means somewhat satisfied and 5 means strongly satisfied.

To make sure the participant is ranking correctly, for the first question of each set of questions where there are a number of response options, repeat their response back to them e.g. if participant says 5, interviewer says 'so that's 5, strongly satisfied?' etc. If the participant asks what we mean by neighbourhood, say that it is what they perceive their neighbourhood/local area to be.

C4. How satisfied are you with the quality of schools in your neighbourhood? This includes preschool and nursery.

If the participant says that they are strongly satisfied with the preschools in their neighbourhood but strongly dissatisfied with the secondary schools in their neighbourhood, get them to consider this with their response. For example, they may give a neutral score of 3 when taking this into account.

1 2 3 4 5

C5. How satisfied are you with access to entertainment in your neighbourhood such as restaurants and cinemas?
If participants say there aren't any restaurants/cinemas in their neighbourhood, ask them how satisfied they are with this.
1 2 3 4 5

C6. How satisfied are you with the safety of your neighbourhood? By this we mean safety from threat of crime.
1 2 3 4 5

C7. How satisfied are you with the level of traffic in your neighbourhood?
1 2 3 4 5

C8.1 How satisfied are you with the number of food shops in your neighbourhood?
1 2 3 4 5

C8.2 How satisfied are you with the quality of food shops in your neighbourhood?
1 2 3 4 5

C9.1 How satisfied are you with the number of restaurants in your neighbourhood? This includes all types of restaurants, sit-in or take-away.
If participants say there aren't any restaurants in their neighbourhood, ask them how satisfied they are with this.
1 2 3 4 5

C9.2 How satisfied are you with the quality of restaurants in your neighbourhood? Again this includes all types of restaurants, sit-in or take-away.
1 2 3 4 5

C10. How satisfied are you with your neighbourhood as a place to raise children?
1 2 3 4 5

C11. How satisfied are you with your neighbourhood as a place to live?
1 2 3 4 5

C12. How easy it is to walk in your neighbourhood, with 1 being not at all easy and 5 being very easy?
1 2 3 4 5

C13. How easy it is to bicycle in your neighbourhood, with 1 being not at all easy and 5 being very easy?
1 2 3 4 5

Section D – PHYSICAL ACTIVITY ENVIRONMENT

The next section is about activity facilities available to you.

D1. Are there any parks or outdoor recreation areas close to your home?
If the participant asks what we mean by 'close' say that we mean parks or outdoor recreation areas that they believe are within a reasonable walking distance from their home or a short drive away.
Yes □ No □ Don't know □ *If no or don't know skip D2.*

D2. Do you use any of these with <twin1 name> and <twin2 name> on a regular basis?
If the participant asks what we mean by regular say that we mean at least every other week.
Yes □ No □

D3. Are there any in-door recreation centres, for example a gym or indoor soft play close to your home?
If the participant asks what we mean by 'close' say that we mean indoor recreation centres that they believe are within a reasonable walking distance from their home or a short drive away.
Yes □ No □ Don't know □ *If no or don't know skip D4.*

D4. Do you use any of these with <twin1 name> and <twin2 name> on a regular basis?
If the participant asks what we mean by regular say that we mean at least every other week.
Yes □ No □

D5. Do you take <twin1 name> and <twin2 name> to any other regular play sessions where they can be physically active, for example activity classes or play areas?
Activity classes such as ballet, swimming and other places where the twins can be active such as adventure parks, woods etc are included.
Yes □ No □

D6. Do you have a garden or outdoor space that <twin1 name> and <twin2 name> can play in?
This includes shared garden space for people living in flats, but does not include park space, even if it is very close to home.
Yes □ No □

If no skip D7, D8, D10 and D12.

D7. Would you say that your garden or (outdoor space) is small, medium or large?
This is a subjective question. The participant should say what they feel the size of their garden is.
small □ medium □ large □

D8. Do you have any usable play equipment such as swings, slides, climbing frames, trampolines in your garden or (outdoor space)?
This includes sandpits. Usable means that it is ready to use. For example, swings are well grounded and have chairs.
Yes ◻ No ◻

If yes, what types of play equipment do you have in your garden or (outdoor space)?

D9. Do <twin1 name> and <twin2 name> each have a usable tricycle, bike, scooter or wheeled toy?
Usable means that it is ready to use. For example, bikes have tires that are pumped up and chains that are not broken.
Yes (both) ◻ No ◻ Yes <twin1 name> ◻ Yes <twin2 name> ◻

For the next two questions, please choose a score from 1 to 5: 1 means strongly disagree, 2 means somewhat disagree, 3 means neither agree nor disagree, 4 means somewhat agree, 5 means strongly agree.

D10. To what extent would you agree that <twin1 name> and <twin2 name> have adequate room to play actively in your garden or outdoor space?
If the participant asks what we mean by 'actively' say we mean anything that involves physically moving about during playing such as running, jumping, or climbing on things.
For the first question, to make sure the participant is ranking correctly, repeat their response back to them e.g. if participant says 5, interviewer says 'so that's 5, strongly agree?' etc.
1 2 3 4 5 (5=strongly agree)

D11. To what extent would you agree that <twin1 name> and <twin2 name> have adequate room to play actively inside the home?
Again, if the participant asks what we mean by actively say anything that involves physically moving about during playing such as running, jumping or climbing on things.
A possible response may be that there is space in some rooms, but not in others. Get the participant to consider this with their response. For example, if there is only space in one room, the answer might be 4, somewhat agree.
1 2 3 4 5 (5=strongly agree)

For the next two questions, again please choose a score from 1 to 5: 1 means never, 2 means rarely, 3 means some of the time, 4 means most of the time, 5 means all of the time.

D12. How often would you say that <twin1 name> and <twin2 name> are allowed to play actively in your garden or outdoor space?
For the first question, to make sure the participant is ranking correctly, repeat their response back to them e.g. if participant says 5, interviewer says 'so that's 5, all of the time?' etc.
A potential response may be that the child is only allowed to play outside if an adult is present. If play is never restricted within that parameter, tick 5 all of the time.
Explanations for D12 and D13 are irrelevant. It might be that participants rarely allow play in the garden because they do not feel that it is safe. This response should remain as 2, rarely.
1 2 3 4 5

D13. How often would you say that <twin1 name> and <twin2 name> are allowed to play actively inside the home?
1 2 3 4 5

Section E – CHILDREN'S ACTIVITY

The next section is about your twin's activity.

E1. Compared to other children of the same age and sex, how physically active are <twin1 name> and <twin2 name>? Please choose a score from 1 to 5: 1 means much less active, 2 means somewhat less active, 3 means about average, 4 means somewhat more active, 5 means much more active.
<twin1 name>: 1 2 3 4 5

<twin2 name>: 1 2 3 4 5

E2. Do you think <twin1 name> gets enough physical activity?
Yes □ No □

Do you think <twin2 name> gets enough physical activity?
Yes □ No □

E3. Do you know how many minutes of physical activity per day health professionals recommend for young children?
____ mins (enter 99 if Don't know)

If the participant asks, the answer is 60 minutes per day.

E4. Do you know how many minutes of physical activity per day health professionals recommend for adults?
____ mins (enter 99 if Don't know)

If the participant asks, the answer is 30 minutes per day.

Your twins' free time choices

The next questions are about how much <twin1 name> and <twin2 name> enjoy specific activities.

For each activity, please choose a score from 1 to 5: 1 means does not enjoy it at all, 2 means enjoys it a little, 3 means neither likes nor dislikes, 4 means enjoys it a lot, and 5 means loves it. Say not applicable if <twin1 name> or <twin2 name> never does the activity.

How much does <twin1 name> enjoy the following or similar activities?
Read each activity choice in turn. Wait for the participant's response before reading out the next activity choice. For the first question, to make sure the participant is ranking correctly, repeat their response back to them e.g. if participant says 5, interviewer says 'so that's 5, loves it?' etc.

E5.1. Doing jigsaws or puzzles:	1	2	3	4	5	NA
E5.2. Drawing and making things:	1	2	3	4	5	NA
E5.3. Watching TV:	1	2	3	4	5	NA
E5.4. Playing computer games:	1	2	3	4	5	NA
E5.5. Riding a bicycle or playing with wheeled toy:	1	2	3	4	5	NA
E5.6. Walking:	1	2	3	4	5	NA
E5.7. Playing ball games such as catch, football, tennis:	1	2	3	4	5	NA
E5.8. Climbing on things:	1	2	3	4	5	NA
E5.9. Running:	1	2	3	4	5	NA
E5.10. Dancing:	1	2	3	4	5	NA

How much does <twin2 name> enjoy the following or similar activities? Again, for each question, please choose a score from 1 to 5 (1 means does not enjoy it at all, 2 means enjoys it a little, 3 means neither likes nor dislikes, 4 means enjoys it a lot, and 5 means loves it) and say not applicable if <twin2 name> never does the activity.
Read each activity choice in turn. Wait for the participant's response before reading out the next activity choice.

E6.1. Doing jigsaws or puzzles:	1	2	3	4	5	NA
E6.2. Drawing and making things:	1	2	3	4	5	NA
E6.3. Watching TV:	1	2	3	4	5	NA
E6.4. Playing computer games:	1	2	3	4	5	NA
E6.5. Riding a bicycle or playing with wheeled toy:	1	2	3	4	5	NA
E6.6. Walking:	1	2	3	4	5	NA
E6.7. Playing ball games such as catch, football, tennis:	1	2	3	4	5	NA

E6.8. Climbing on things: 1 2 3 4 5 NA

E6.9. Running: 1 2 3 4 5 NA

E6.10. Dancing: 1 2 3 4 5 NA

Section F – PARENTAL MODELLING OF ACTIVITY

For the next section, again please choose a score from 1 to 5. 1 means never, 2 means rarely, 3 means sometimes, 4 means often, 5 means very often. For each question, please indicate whether your response is the same or different for <twin1 name> and <twin2 name>.
Throughout this section, physical activity means any kind of physical activity including moderate e.g. walking and vigorous e.g. running.

Note that scores of <twin1 name> are automatically copied to <twin2 name>. If parent indicates a difference between twins, score can be adjusted for <twin2 name>. Always score <twin1 name> first and then <twin2 name>.

F1. How often do you or your <husband/wife/partner> encourage <twin1 name> and <twin2 name> to do physical activity?
For the first question, to make sure the participant is ranking correctly, repeat their response back to them e.g. if participant says 5, interviewer says 'so that's 5, very often?' etc. If parents say 1 because they don't need to as their child is already physically active, still keep response as 1. In other words, it doesn't matter what the reason is.
1 2 3 4 5
If different arrangement for twins: <twin2 name>: 1 2 3 4 5

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

F2. How often do you or your <husband/wife/partner> do physical activity or play sports with <twin1 name> and <twin2 name>?
1 2 3 4 5
If different arrangement for twins: <twin2 name>: 1 2 3 4 5

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

F3. How often do you or your <husband/wife/partner> provide transport to a place where <twin1 name> and <twin2 name> can do physical activity? By this we mean provide transport by car (or other vehicle) rather than by foot.
1 2 3 4 5
If different arrangement for twins: <twin2 name>: 1 2 3 4 5

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

F4. How often do you or your <husband/wife/partner> watch <twin1 name> and <twin2 name> participate in physical activity?
1 2 3 4 5
If different arrangement for twins: <twin2 name>: 1 2 3 4 5

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

F5. How often do you or your <husband/wife/partner> tell <twin1 name> and <twin2 name> that being physically active is good for their health?
1 2 3 4 5
If different arrangement for twins: <twin2 name>: 1 2 3 4 5

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

F6. How often do you or your <husband/wife/partner> try to be active in front of <twin1 name> and <twin2 name>?
This includes occasions where the child sees their parent(s) preparing to exercise, even if they are not able to actually see them exercise.
1 2 3 4 5
If different arrangement for twins: <twin2 name>: 1 2 3 4 5

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

F7. How often do you or your <husband/wife/partner> try to show enthusiasm about being active?
1 2 3 4 5
If different arrangement for twins: <twin2 name>: 1 2 3 4 5

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

F8. How often do you or your <husband/wife/partner> show <twin1 name> and <twin2 name> how much you enjoy being active?
1 2 3 4 5
If different arrangement for twins: <twin2 name>: 1 2 3 4 5

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

Section G - MEDIA

The next section is about the media equipment you have in your home

G1. How many working TV's do you have in your home?
Include TV's that are temporarily broken if there is a plan to get them fixed.
…….. (enter 99 if Don't know, enter 0 if none) *If 0, skip G2 and G6*

G2. Do you have cable or satellite?
This does not include freeview.
Yes □ No □

G3. How many working VCR or DVD players do you have in your home?
Include VCR's or DVD players that are temporarily broken if there is a plan to get them fixed. Also include DVD players within computers if they are used to watch films on.
…... (enter 99 if Don't know, enter 0 if none, if 0 to G1 and 0 to G3, skip G4)

G4.1 On average, how long do <twin1 name> and <twin2 name> watch TV or DVDs during the following times of a typical weekday (Monday to Friday), at this time of year?
Only include TV viewing in the home. Write hours and minutes. If less than one hour e.g. 15 minutes put 0 hours and 15 minutes. If 1 hour, put 1 hour and 0 minutes. Note that scores of <twin1 name> are automatically copied to <twin2 name>. If parent indicates a difference between twins, score can be adjusted for <twin2 name>. Always score <twin1 name> first and then <twin2 name>. If participants say that the TV is on for a prolonged period e.g. all morning, but the twins are not always watching it, check whether the twins are in the same room as the TV during this time and record the number of hours that it is on whilst they are in the room. If this happens, make a note in the database changes sheet. For G4.1 – G4.6, read out each of the times (e.g. morning (6am to 12 noon)) in turn and wait for the participant's response before reading out the next time.

Morning (6am to 12 noon) ……. hours ……. minutes per day
Afternoon (12am to 6pm) …….. hours ……. minutes per day
Evening (6pm to midnight) ……. hours ……. minutes per day

If different arrangement for twins, enter answers for <twin1 name> above and for <twin2 name> below:

Morning (6am to 12 noon) ……. hours ……. minutes per day
Afternoon (12am to 6pm) …….. hours ……. minutes per day
Evening (6pm to midnight) ……. hours ……. minutes per day

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

G4.2 On average, how long do <twin1 name> and <twin2 name> watch TV or DVDs during the following times of a typical weekend day, at this time of year?
Only include TV viewing in the home. Write hours and minutes. If less than one hour e.g. 15 minutes put 0 hours and 15 minutes. If 1 hour, put 1 hour and 0 minutes. Note that scores of <twin1 name> are automatically copied to <twin2 name>. If parent indicates a difference between twins, score can be adjusted for <twin2 name>. Always score <twin1 name> first and then <twin2 name>. If participants say that the TV is on for a prolonged period e.g. all morning, but the twins are not always watching it, check whether the twins are in the same room as the TV during this time and record the number of hours that it is on whilst they are in the room. If this happens, make a note in the database changes sheet.

Morning (6am to 12 noon) ……. hours ……. minutes per day
Afternoon (12am to 6pm) …….. hours ……. minutes per day
Evening (6pm to midnight) ……. hours ……. minutes per day

If different arrangement for twins, enter answers for <twin1 name> above and for <twin2 name> below:

Morning (6am to 12 noon) ……. hours ……. minutes per day
Afternoon (12am to 6pm) …….. hours ……. minutes per day
Evening (6pm to midnight) ……. hours ……. minutes per day

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

G4.3 On average, how long do you watch TV or DVDs during the following times of a typical weekday (Monday to Friday), at this time of year?
Only include TV viewing in the home. Write hours and minutes. If less than one hour e.g. 15 minutes put 0 hours and 15 minutes. If 1 hour, put 1 hour and 0 minutes.

Morning (6am to 12 noon) ……. hours ……. minutes per day
Afternoon (12am to 6pm) …….. hours ……. minutes per day
Evening (6pm to midnight) ……. hours ……. minutes per day

G4.4 On average, how long do you watch TV or DVDs during the following times of a typical weekend day, at this time of year?
Only include TV viewing in the home. Write hours and minutes. If less than one hour e.g. 15 minutes put 0 hours and 15 minutes. If 1 hour, put 1 hour and 0 minutes.

Morning (6am to 12 noon) ……. hours ……. minutes per day
Afternoon (12am to 6pm) …….. hours ……. minutes per day
Evening (6pm to midnight) ……. hours ……. minutes per day

G4.5 On average, how long does your <husband/wife/partner> watch TV or DVDs during the following times of a typical weekday (Monday to Friday), at this time of year?
Only include TV viewing in the home. Write hours and minutes. If less than one hour e.g. 15 minutes put 0 hours and 15 minutes. If 1 hour, put 1 hour and 0 minutes.

Morning (6am to 12 noon) ……. hours ……. minutes per day
Afternoon (12am to 6pm) …….. hours ……. minutes per day
Evening (6pm to midnight) ……. hours ……. minutes per day

G4.6 On average, how long does your <husband/wife/partner> watch TV or DVDs during the following times of a <u>typical weekend</u> day, at this time of year?
Only include TV viewing in the home. Write hours and minutes. If less than one hour e.g. 15 minutes put 0 hours and 15 minutes. If 1 hour, put 1 hour and 0 minutes.

Morning (6am to 12 noon) ……. hours ……. minutes per day
Afternoon (12am to 6pm) …….. hours ……. minutes per day
Evening (6pm to midnight) ……. hours ……. minutes per day

G4.7 On average, how long do you watch TV or DVDs as a family on a <u>typical weekday</u>, at this time of year? **This includes occasions when it is just** <twin1 name> and <twin2 name> **and yourself or** <twin1 name> and <twin2 name> **and your** <husband/wife/partner>**.**
A possible response is that they sit down with the twins or are in the same room as the twins whilst they are watching TV but they are not watching the TV themselves. This is not included. Parents must also be watching the TV.
Morning (6am to 12 noon) ……. hours ……. minutes per day
Afternoon (12am to 6pm) …….. hours ……. minutes per day
Evening (6pm to midnight) ……. hours ……. minutes per day

G4.8 On average, how long do you watch TV or DVDs as a family on a <u>typical weekend</u> day, at this time of year? **This includes occasions when it is just** <twin1 name> and <twin2 name> **and yourself or** <twin1 name> and <twin2 name> **and your** <husband/wife/partner>**.**
A possible response is that they sit down with the twins or are in the same room as the twins whilst they are watching TV but they are not watching the TV themselves. This is not included. Parents must also be watching the TV.

Morning (6am to 12 noon) ……. hours ……. minutes per day
Afternoon (12am to 6pm) …….. hours ……. minutes per day
Evening (6pm to midnight) ……. hours ……. minutes per day

G5. Do <twin1 name> and <twin2 name> share a bedroom?
Yes □ No □

G6. Do <twin1 name> and <twin2 name> have a working TV in their bedroom?
Include TV's if it is a shared bedroom and the TV belongs to another child.
Yes □ No □
If different arrangement for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name> (and the twins do not share a bedroom), prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

G7. How many working computers or laptops do you have in your home?
Include computers or laptops that are temporarily broken if there is a plan to get them fixed.
…….. (enter 0 if none) *If 0, skip G8*

G8. Do <twin1 name> and <twin2 name> have a computer or laptop in his/her bedroom?
Include computers if it is a shared bedroom and the computer belongs to another child.
Yes □ No □

If different arrangement for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name> (and the twins do not share a bedroom), prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

G9. How many working games consoles, such as Play Station, Nintendo DS, Wii do you have in your home? I
nclude game consoles that are temporarily broken if there is a plan to get them fixed. This includes hand held games consoles.

…….. (enter 0 if none) *If 0, skip G10, if 0 to G1, G7, and G9, skip G11-G13*

G10. Do <twin1 name> and <twin2 name> have a games console in their bedroom?
Include games consoles if it is a shared bedroom and the games console belongs to another child.
Yes □ No □

If different arrangement for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name> (and the twins do not share a bedroom), prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

G11. Do you have any rules around TV watching or computer use for <twin1 name> and <twin2 name>?
Yes □ No □

If yes, please could you describe these rules?

G12. Do you ever reward good behaviour with extra TV or computer time?
Yes □ No □

If different arrangement for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

G13. Do you ever reduce TV or computer time if <twin1 name> or <twin2 name> is naughty?
Yes □ No □

If different arrangement for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

G14. Do <twin1 name> and <twin2 name> ever eat while watching TV? This includes meals and snacks that are eaten in front of the TV.
If the participant says sometimes, check whether this is on a weekly basis. If not on a weekly basis, enter no.
Yes □ No □ *If No skip G15-G18*

If different arrangement for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

G15. How many days per week do <twin1 name> and <twin2 name> eat breakfast while watching TV?
Note that for G15-G18 the scores of <twin1 name> are automatically copied to <twin2 name>. If parent indicates a difference between twins, score can be adjusted for <twin2 name>. Always score <twin1 name> first and then <twin2 name>.

0 1 2 3 4 5 6 7

If different arrangement for twins: <twin2 name>: 0 1 2 3 4 5 6 7

G16. How many days per week do <twin1 name> and <twin2 name> eat a midday meal while watching TV?

0 1 2 3 4 5 6 7

If different arrangement for twins: <twin2 name>: 0 1 2 3 4 5 6 7

G17. How many days per week do <twin1 name> and <twin2 name> eat an evening meal while watching TV?
0 1 2 3 4 5 6 7

If different arrangement for twins: <twin2 name>: 0 1 2 3 4 5 6 7

G18. How many days per week do <twin1 name> and <twin2 name> eat snacks while watching TV?

0 1 2 3 4 5 6 7

If different arrangement for twins: <twin2 name>: 0 1 2 3 4 5 6 7

The next section is about your twin's sleep.

G19. When do <twin1 name> and <twin2 name> usually go to bed in the evening?
Write hour : minutes e.g. 6:15pm or 18:15pm. Note that for G19-G21 the scores of <twin1 name> are automatically copied to <twin2 name>. If parent indicates a difference between twins, score can be adjusted for <twin2 name>. Always score <twin1 name> first and then <twin2 name>.
<twin1 name>: …….. : ……..
<twin2 name>: …….. : ……..

G20. How long does it take to put <twin1 name> and <twin2 name> to sleep in the evening? By this we mean how long it takes for the twins to fall asleep once they are in bed and ready to sleep.
Write hours and minutes. If less than one hour e.g. 15 minutes put 0 hours and 15 minutes. If 1 hour, put 1 hour and 0 minutes.
<twin1 name>: …….. hours …….. minutes
<twin2 name>: …….. hours …….. minutes

G21. When do <twin1 name> and <twin2 name> usually wake up in the morning?
Write hour : minutes using the 24 hour clock e.g. 6:15am should be 6:15.
<twin1 name>: …….. : ……..
<twin2 name>: …….. : ……..

G22. How long does <twin1 name> usually sleep during the daytime?
Write hours and minutes. If less than one hour e.g. 15 minutes put 0 hours and 15 minutes. If 1 hour, put 1 hour and 0 minutes.

…….. hours …….. minutes per day

G23. How long does <twin2 name> usually sleep during the daytime?
Write hours and minutes. If less than one hour e.g. 15 minutes put 0 hours and 15 minutes. If 1 hour, put 1 hour and 0 minutes.

…….. hours …….. minutes per day

G24. Does <twin1 name> usually wake up at night?
If the participant says the child wakes up sometimes or occasionally, check whether this is usually on a weekly basis. If they say yes, select yes.
Yes □ No □

G25. Does <twin2 name> usually wake up at night?
If the participant says the child wakes up sometimes or occasionally, check whether this is usually on a weekly basis. If they say yes, select yes.
Yes □ No □

If no for G24 and G25 skip to G28 and G29.

If yes for G24:

G26.1 How many nights in a normal week does <twin1 name> wake up?
0 1 2 3 4 5 6 7

G26.2 On the nights when <twin1 name> wakes up how many times does this happen?
……..

G26.3 How long per wake-up time does <twin1 name> stay awake at night?
Write hours and minutes. If less than one hour e.g. 15 minutes put 0 hours and 15 minutes. If 1 hour put 1 hour and 0 minutes.
…….. hours ……..minutes

If yes for G25:

G27.1 How many nights in a normal week does <twin2 name> wake up?
0 1 2 3 4 5 6 7

G27.2 On the nights when <twin2 name> wakes up how many times does this happen?
……..

G27.3 How long per wake-up time does <twin2 name> stay awake at night?
Write hours and minutes. If less than one hour e.g. 15 minutes put 0 hours and 15 minutes. If 1 hour put 1 hour and 0 minutes.
…….. hours ……..minutes

G28. Do you consider <twin1 name>'s sleep as a problem? The response options are 1 not at all, 2 a small problem, or 3 a serious problem.
Not at all □ A small problem □ or A serious problem □

G29. Do you consider <twin2 name>'s sleep as a problem? The response options are 1 not at all, 2 a small problem, or 3 a serious problem.
Again, the response options are 1 not at all, 2 a small problem, or 3 a serious problem (read this sentence aloud again if necessary).
Not at all □ A small problem □ or A serious problem □

Sections H - N: FOOD AVAILABLILTY

The next section is about food and drink that is currently in your home. For the food and drink that we ask about, please include all items that are in your home even if **<twin1 name> and <twin2 name>** don't eat or drink them. If you are unsure of any of the answers, please have a look to see what is in your home. If you have a phone in the kitchen and would like to move there now, that may help. Please answer as accurately as possible.

Fruit

H.1.1. Do you have any fresh fruit in your home now?
Yes □ No □

H.1.2. If yes, what types of fresh fruit do you have in your home now?
This is an open question. As the participant lists the fresh fruit they have, tick the matching options in the table or add any other fresh fruit to the free entry box which says other.
When the participant finishes, prompt her/him by reminding her/him of places she/he may have forgotten: Have you remembered fresh fruit in your fridge, in a fruit bowl and in your cupboards?

Fresh fruit

List of standard fruits to choose from (see below) as well as a free-entry box for less common items.

	Yes/No
Apples	
Bananas	
Cherries	
Grapefruit	
Grapes	
Kiwi	
Mangoes	
Melon	
Nectarines	
Oranges/tangerines/clementines/mandarins	
Peaches	
Pears	
Pineapple	
Plums	
Strawberries	

Other fresh fruit	Number of other items

H.2.1. Do you have any tinned or jarred fruit in your home now?
Yes □ No □

H.2.2. If yes, what types of tinned or jarred fruit do you have in your home now?
This is an open question. As the participant lists the tinned or jarred fruit they have, tick the matching options in the table or add any other tinned or jarred fruit to the free entry box which says other.
When the participant finishes, prompt her/him by reminding her/him of places she/he may have forgotten: Have you remembered tinned or jarred fruit in your fridge and in your cupboards?

Tins / jars of fruit
List of standard fruits to choose from as well as a free-entry box for less common items.

	Yes/ No
Cherries	
Fruit salad/cocktail	
Grapefruit	
Mandarin orange	
Peaches	
Pears	
Pineapple	
Plums	
Raspberries	
Strawberries	
Other	

Other tinned fruit	Number of other items

H.3.1. Do you have any dried fruit, such as raisins, dried apricots, or dates in your home now?
Yes □ No □

H.3.2. If yes, what types of dried fruit do you have in your home now?
This is an open question. As the participant lists the dried fruit they have, tick the matching options in the table or add any other dried fruit to the free entry box which says other.
When the participant finishes, prompt her/him by reminding her/him of places she/he may have forgotten: Have you remembered dried fruit in a fruit bowl and in your cupboards?

Dried fruit
List of standard fruits to choose from as well as a free-entry box for less common items.

	Yes/ No
Apples	
Apricots	
Banana chips	
Currants	
Dates	
Dried mixed fruit	
Prunes	
Raisins	
Sultanas	

Other dried fruit	Number of other items

H.4.1. Do you have any frozen fruit in your home now?
Yes □ No □

H.4.2. If yes, what types of frozen fruit do you have in your home now?
This is an open question. As the participant lists the frozen fruit they have, tick the matching options in the table or add any other frozen fruit to the free entry box which says other.

Frozen fruit

List of standard fruits to choose from as well as a free-entry box for less common items.

	Yes/ No
Mixed berries	
Raspberries	
Strawberries	

Other frozen fruit	Number of other items

H.5.1. Would you say that the amount of fruit you currently have in your home is more than usual, less than usual, or about the same?
Less than usual □ The same □ More than usual □

H.5.2. Without opening any fridge or cupboard doors, is there any kind of fruit in your home now; displayed out in the open?
A possible response may be that some fruit is behind a door, but it is a glass door and the fruit can be seen. If so, report YES. Another response could be that some fresh fruit is out, but that it is stored very high and can only be viewed with a stool. Is so, report NO.
Yes □ No □

H.5.3. Would it be possible for <twin1 name> and <twin2 name> to get any fruit by themselves, without your help? By this, we mean whether it would be physically possible for <twin1 name> and <twin2 name> to get any fruit by themselves, without your help.
Yes □ No □

If different for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

H.5.4 Are <twin1 name> and <twin2 name> allowed to get any fruit by themselves, without asking you first?
Yes ◻ No ◻

If different for twins: <twin2 name>: Yes ◻ No ◻

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

H.5.5 Do <twin1 name> and <twin2 name> ever get any fruit by themselves, without asking you first?
Yes ◻ No ◻

If different for twins: <twin2 name>: Yes ◻ No ◻

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

H.6. On average, how often do <twin1 name> and <twin2 name> eat fruit? This includes fruit that is eaten between meals and fruit that is eaten as part of a meal. Fruit juice is not included.
This is an open question. Do not read the response options aloud but categorize the response accordingly. If the participant does not provide enough information e.g. they may say ‘everyday’, prompt for a fuller response e.g. ‘so is that once a day, 2-3 times a day or 4 or more times a day?’

	Never or less than once a month	1-3 times a month	Once a week	2-4 times a week	5-6 times a week	Once a day	2-3 times a day	4 or more times a day
<twin1 name>	☐	☐	☐	☐	☐	☐	☐	☐
<twin2 name>	☐	☐	☐	☐	☐	☐	☐	☐

If the participant does not indicate whether their response is the same or different for <twin1name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Vegetables

K.1.1. Do you have any fresh vegetables in your home now? This includes salad items such as lettuce, cucumber, and tomato but not potatoes.
Yes □ No □

K.1.2. If yes, what types of fresh vegetables do you have in your home now?
This is an open question. As the participant lists the fresh vegetables they have, tick the matching options in the table or add any other fresh vegetables to the free entry box which says other.
When the participant finishes, prompt her/him by reminding her/him of places she/he may have forgotten: Have you remembered fresh vegetables in your fridge and in your cupboards?

Fresh vegetables

List of standard vegetables to choose from as well as a free-entry box for less common items.

	Yes/ No
Broccoli	
Brussel sprouts	
Cabbage	
Carrots	
Cauliflower	
Celery	
Corn on the cob	
Cucumber	
Lettuce	
Mushrooms	
Onions	
Peppers	
Runner beans/green beans	
Swede	
Tomatoes	

Other fresh vegetables	Number of other items

K.2.1. Do you have any tinned or jarred vegetables for example tinned tomatoes, sweetcorn, or jarred beetroot, in your home now? This includes tinned pulses such as chickpeas, kidney beans and lentils.
Yes □ No □

K.2.2. If yes, what types of tinned or jarred vegetables do you have in your home now?
This is an open question. As the participant lists the tinned or jarred vegetables they have, tick the matching options in the table or add any other tinned or jarred vegetables to the free entry box which says other.
When the participant finishes, prompt her/him by reminding her/him of places she/he may have forgotten: Have you remembered tinned or jarred vegetables in your fridge and in your cupboards?

Tins of vegetables

List of standard vegetables to choose from as well as a free-entry box for less common items.

	Yes/ No
Baked beans	
Bamboo shoots	
Beetroot	
Broad beans	
Carrots	
Mixed vegetables	
Mushrooms	
Peas	
Pease pudding	
Pickled onion	
Pickled gherkins	
Runner beans/green beans	
Sweetcorn	
Tomatoes	

Other tinned vegetables	Number of other items

K.3.1. Do you have any frozen vegetables in your home now?
Yes □ No □

K.3.2. If yes, what types of frozen vegetables do you have in your home now?
This is an open question. As the participant lists the frozen vegetables they have, tick the matching options in the table or add any other frozen vegetables to the free entry box which says other.

Frozen vegetables
List of standard vegetables to choose from as well as a free-entry box for less common items.

	Yes/ No
Broad beans	
Brussel sprouts	
Cabbage	
Cauliflower	
Mange tout	
Mixed vegetables	
Peas	
Peppers	
Runner beans/green beans	
Spinach	
Sweet corn	

Other frozen vegetables	Number of other items

K.4.1. Would you say that the amount of vegetables you currently have in your home is more than usual, less than usual, or about the same?
Less than usual □ The same □ More than usual □

K.4.2. Do you have any ready to eat fresh vegetables on a shelf in the fridge or on the kitchen counter now? These include baby carrots, cherry tomatoes, or vegetables that you have sliced to make them ready to eat.
Yes □ No □

K.4.3. Would it be possible for <twin1 name> and <twin2 name> to get any vegetables by themselves without your help? By this, we mean whether it would be physically possible for <twin1 name> and <twin2 name> to get any vegetables by themselves, without your help.
Yes □ No □
If different for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

K.4.4. Are <twin1 name> and <twin2 name> allowed to get any vegetables by themselves, without asking you first?
Yes □ No □
If different for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

K.4.5. Do <twin1 name> and <twin2 name> ever get any vegetables by themselves, without asking you first?
Yes ☐ No ☐
If different for twins: <twin2 name>: Yes ☐ No ☐

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

K.5. On average, how often do <twin1 name> and <twin2 name> eat vegetables? This includes salad items such as cucumber, lettuce and tomato but not potatoes. Vegetables that are eaten between meals and vegetables that are eaten as part of a meal are included.
This is an open question. Do not read the response options aloud but categorize the response accordingly. If the participant does not provide enough information e.g. they may say 'everyday', prompt for a fuller response e.g. 'so is that once a day, 2-3 times a day or 4 or more times a day?'

	Never or less than once a month	1-3 times a month	Once a week	2-4 times a week	5-6 times a week	Once a day	2-3 times a day	4 or more times a day
<twin1 name>	☐	☐	☐	☐	☐	☐	☐	☐
<twin2 name>	☐	☐	☐	☐	☐	☐	☐	☐

If the participant does not indicate whether their response is the same or different for <twin1name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Savoury snacks

L.1.1. Do you have any savoury snacks for example peanuts, crisps, tortillas and cheesy biscuits in your home now?
Yes ☐ No ☐

L.1.2. If yes, what types of savoury snacks do you have in your home now? Snacks like plain rice cakes, oatcakes, and breadsticks are not included.
This is an open question. As the participant lists the savoury snacks they have, tick the matching options in the table or add any other savoury snacks to the free entry box which says other.
When the participant finishes, prompt her/him by reminding her/him of places she/he may have forgotten: Have you remembered savoury snacks in your fridge and in your cupboards?

Savoury snacks
List of standard Savoury snacks to choose from as well as a free-entry box for less common items.

	Yes/ No
Cheese biscuits	
Cheese straws	
Crisps	
Peanuts	
Pork scratchings	
Tortilla chips	

Other savoury snacks	Number of other items

L.1.3. Would you say that the amount of savoury snacks you currently have in your home is more than usual, less than usual, or about the same?
Less than usual □ The same □ More than usual □

L.2.1. Without opening any fridge or cupboard doors, are there any kind of savoury snacks in your home now; displayed out in the open?
If yes, check that the participant is referring to snacks like crisps, peanuts and cheesy biscuits rather than snacks like plain rice cakes, oatcakes, and breadsticks. A possible response may be that some savoury snacks are behind a door, but it is a glass door and the snacks can be seen. If so, report YES. Another response could be that some savoury snacks are out, but that they are stored very high and can only be viewed with a stool. Is so, report NO.
Yes □ No □

L.2.2. Would it be possible for <twin1 name> and <twin2 name> to get any savoury snacks by themselves, without your help? By this, we mean whether it would be physically possible for <twin1 name> and <twin2 name> to get any savoury snacks by themselves, without your help.
If yes, check that the participant is referring to snacks like crisps, peanuts and cheesy biscuits rather than snacks like plain rice cakes, oatcakes, and breadsticks. If no, enter no for L2.3 and L2.4 and don't ask these two questions.
Yes □ No □
If different for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

L.2.3. Are <twin1 name> and <twin2 name> allowed to get any savoury snacks by themselves, without asking you first?
If yes, check that the participant is referring to snacks like crisps, peanuts and cheesy biscuits rather than snacks like plain rice cakes, oatcakes, and breadsticks.
Yes □ No □
If different for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

L.2.4. Do <twin1 name> and <twin2 name> ever get any savoury snacks by themselves, without asking you first?

If yes, check that the participant is referring to snacks like crisps, peanuts and cheesy biscuits rather than snacks like plain rice cakes, oatcakes, and breadsticks.

Yes □ No □

If different for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

L.2.5. On average, how often do <twin1 name> and <twin2 name> eat savoury snacks such as peanuts, crisps, tortillas and cheesy biscuits? This includes savoury snacks that are eaten between meals and savoury snacks that are eaten as part of a meal such as crisps with lunch. Again make sure that the participant is referring to snacks like crisps, peanuts and cheesy biscuits. This is an open question. Do not read the response options aloud but categorize the response accordingly. If the participant does not provide enough information e.g. they may say 'everyday', prompt for a fuller response e.g. 'so is that once a day, 2-3 times a day or 4 or more times a day?'

	Never or less than once a month	1-3 times a month	Once a week	2-4 times a week	5-6 times a week	Once a day	2-3 times a day	4 or more times a day
<twin1 name>	☐	☐	☐	☐	☐	☐	☐	☐
<twin2 name>	☐	☐	☐	☐	☐	☐	☐	☐

If the participant does not indicate whether their response is the same or different for <twin1name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

Any comments about savoury snacks

Sweet snacks

M.3.1. Do you have any sweet snacks for example cakes, biscuits or ice-cream in your home now?

Yes □ No □

M.3.2. If yes, what types of sweet snacks do you have in your home now? Do not include sweets or chocolate.
This is an open question. As the participant lists the sweet snacks they have, tick the matching options in the table or add any other sweet snacks to the free entry box which says other.
When the participant finishes, prompt her/him by reminding her/him of places she/he may have forgotten: Have you remembered sweet snacks in your fridge and in your cupboards?

Sweet snacks

List of standard sweet snacks to choose from as well as a free-entry box for less common items.

	Yes/ No
Biscuits	
Buns	
Cakes	
Ice-cream	
Ice-lollies	
Pastries	

Other sweet snacks	Number of other items

M.3.3. Would you say that the amount of sweet snacks you currently have in your home is more than usual, less than usual, or about the same?
Less than usual □ The same □ More than usual □

M.4.1. Without opening any fridge or cupboard doors, are there any kind of sweet snacks in your home now displayed out in the open?
If yes, check that the participant is referring to snacks like cakes, biscuits and ice cream. A possible response may be that some sweet snacks are behind a door, but it is a glass door and the snacks can be seen. If so, report YES. Another response could be that some sweet snacks are out, but that they are stored very high and can only be viewed with a stool. Is so, report NO.
Yes □ No □

M.4.2. Would it be possible for <twin1 name> and <twin2 name> to get any sweet snacks by themselves, without your help? By this, we mean whether it would be physically possible for <twin1 name> and <twin2 name> to get any sweet snacks by themselves, without your help.
If yes, check that the participant is referring to snacks like cakes, biscuits and ice cream. If no, enter no for M4.3 and M4.4 and don't ask these two questions.
Yes □ No □
If different for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

M.4.3. Are <twin1 name> and <twin2 name> allowed to get any sweet snacks by themselves, without asking you first?
If yes, check that the participant is referring to snacks like cakes, biscuits and ice cream.
Yes ☐ No ☐
If different for twins: <twin2 name>: Yes ☐ No ☐

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

M.4.4. Do <twin1 name> and <twin2 name> ever get any sweet snacks by themselves, without asking you first?
If yes, check that the participant is referring to snacks like cakes, biscuits and ice cream.
Yes ☐ No ☐
If different for twins: <twin2 name>: Yes ☐ No ☐

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

M.4.5. On average, how often do <twin1 name> and <twin2 name> eat sweet snacks such as cakes, biscuits, and ice-cream? This includes sweet snacks that are eaten between meals and sweet snacks that are eaten as part of a meal such as ice-cream for dessert.
Again make sure that the participant is referring to snacks such as biscuits, cake, and ice cream. This is an open question. Do not read the response options aloud but categorize the response accordingly. If the participant does not provide enough information e.g. they may say ‘everyday’, prompt for a fuller response e.g. ‘so is that once a day, 2-3 times a day or 4 or more times a day?’

	Never or less than once a month	1-3 times a month	Once a week	2-4 times a week	5-6 times a week	Once a day	2-3 times a day	4 or more times a day
<twin1 name>	☐	☐	☐	☐	☐	☐	☐	☐
<twin2 name>	☐	☐	☐	☐	☐	☐	☐	☐

If the participant does not indicate whether their response is the same or different for <twin1name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Any comments about sweet snacks

Confectionery

N.1.1. Do you have any confectionery in your home now? This includes sweets and chocolate.
Yes □ No □

N.1.2. If yes, what types of confectionery do you have in your home now?
This is an open question. As the participant lists the confectionery they have, tick the matching options in the table or add any other confectionery to the free entry box which says other.
When the participant finishes, prompt her/him by reminding her/him of places she/he may have forgotten: Have you remembered confectionery in your fridge, in a bowl and in your cupboards?

Confectionery

List of standard confectionery to choose from as well as a free-entry box for less common items.

	Yes/ No
Chocolate	
Sweets	

Other confectionery	Number of other items

N.1.3. Would you say that the amount of confectionery you currently have in your home is more than usual, less than usual, or about the same?
Less than usual □ The same □ More than usual □

N.2.1. Without opening any fridge or cupboard doors, is there any kind of confectionery in your home now displayed out in the open?
A possible response may be that some confectionery is behind a door, but it is a glass door and the confectionery can be seen. If so, report YES. Another response could be that some confectionery is out, but that it is stored very high and can only be viewed with a stool. Is so, report NO.
Yes □ No □

N.2.2. Would it be possible for <twin1 name> and <twin2 name> to get any confectionery by themselves, without your help? By this, we mean whether it would be physically possible for <twin1 name> and <twin2 name> to get any confectionery by themselves, without your help.
Yes □ No □
If different for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

N.2.3. Are <twin1 name> and <twin2 name> allowed to get any confectionery by themselves, without asking you first?

Yes □ No □

If different for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

N.2.4. Do <twin1 name> and <twin2 name> ever get any confectionery by themselves, without asking you first?

Yes □ No □

If different for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

N.2.5. On average, how often do <twin1 name> and <twin2 name> eat confectionery such as chocolate and fruit sweets? This is an open question. Do not read the response options aloud but categorize the response accordingly. If the participant does not provide enough information e.g. they may say 'everyday', prompt for a fuller response e.g. 'so is that once a day, 2-3 times a day or 4 or more times a day?'

	Never or less than once a month	1-3 times a month	Once a week	2-4 times a week	5-6 times a week	Once a day	2-3 times a day	4 or more times a day
<twin1 name>	☐	☐	☐	☐	☐	☐	☐	☐
<twin2 name>	☐	☐	☐	☐	☐	☐	☐	☐

If the participant does not indicate whether their response is the same or different for <twin1name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

Section O – FAST FOOD

O.1.1. On average, how often do <twin1 name> and <twin2 name> eat fast food from places such as McDonald's, KFC, Burger King, and Subway…? This includes both eating in and taking food away from fast food places. This is an open question. Do not read the response options aloud but categorize the response accordingly. If the participant does not provide enough information e.g. they may say 'everyday', prompt for a fuller response e.g. 'so is that once a day, 2-3 times a day or 4 or more times a day?'

	Never or less than once a month	1-3 times a month	Once a week	2-4 times a week	5-6 times a week	Once a day	2-3 times a day	4 or more times a day
<twin1 name>	☐	☐	☐	☐	☐	☐	☐	☐
<twin2 name>	☐	☐	☐	☐	☐	☐	☐	☐

If the participant does not indicate whether their response is the same or different for <twin1name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

O.1.2. On average, how often do <twin1 name> and <twin2 name> eat other convenience foods for his/her main meal? This includes food that requires no preparation such as ready-made pizza, microwaveable meals, and takeaway food such as fish and chips, Chinese, and Indian… Other convenience food such as fish fingers and chicken nuggets are included. This is an open question. Do not read the response options aloud but categorize the response accordingly. If the participant does not provide enough information e.g. they may say 'everyday', prompt for a fuller response e.g. 'so is that once a day, 2-3 times a day or 4 or more times a day?'

	Never or less than once a month	1-3 times a month	Once a week	2-4 times a week	5-6 times a week	Once a day	2-3 times a day	4 or more times a day
<twin1 name>	☐	☐	☐	☐	☐	☐	☐	☐
<twin2 name>	☐	☐	☐	☐	☐	☐	☐	☐

If the participant does not indicate whether their response is the same or different for <twin1name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Section P - DRINKS

P.1.1. Do you have any *non-alcoholic* drinks other than water in your home now? Examples are fruit juice, squash, fizzy pop, ready-made fruit flavoured drinks, smoothies, and milk.

If no to P1.1, skip P1.2. and P1.4. – P2.1. (but do ask P1.3. and P2.2.)

Yes ☐ No ☐

P.1.2. If yes, what types of non-alcoholic drinks do you have in your home now?
This is an open question. As the participant lists the drinks they have, tick the matching options in the table. May need to prompt to determine whether each drink is sugar sweetened or not.
When the participant finishes, prompt her/him by reminding her/him of places she/he may have forgotten: Have you remembered non-alcoholic drinks in your fridge and in your cupboards?

<table>
<tr><td colspan="2"></td><td colspan="2">Sugar sweetened:
(Yes/ No)</td><td colspan="2">Pure juice/No added sugar/diet:
(Yes/ No)</td></tr>
<tr><td colspan="2">Fruit juice e.g. orange, apple</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Squash/cordial e.g. Robinson's blackcurrant cordial</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Fizzy pop e.g. coke, lemonade</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Ready made fruit flavoured drinks e.g. Ribena, Oasis</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Smoothies</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Milk</td><td colspan="2">Skimmed:
(yes/ no)</td><td>Semi-skimmed:
(yes/ no)</td><td colspan="2">Full-fat:
(yes/ no)</td></tr>
</table>

P.1.3. Would you say that the amount of non-alcoholic drinks you currently have in your home is more than usual, less than usual, or about the same?
Less than usual □ The same □ More than usual □

P.1.4. Without opening any fridge or cupboard doors, are there any non-alcoholic drinks in your home now; displayed out in the open?
A possible response may be that some drinks are behind a door, but it is a glass door and the drinks can be seen. If so, report YES. Another response could be that some drinks are out, but that they are stored very high and can only be viewed with a stool. Is so, report NO.
Yes □ No □

P.1.5. If yes, what types of non-alcoholic drinks are displayed out in the open?
This is an open question. As the participant lists the drinks they have, tick the matching drink type in the table. May need to prompt the participant to determine whether each drink is sugar sweetened or not. For example, if the participant just says 'coke' interviewer says 'is that diet coke?' If the participant just says 'orange juice' interviewer says 'is that with added sugar?' etc.

<table>
<tr><td colspan="2"></td><td colspan="2">Sugar sweetened:
(Yes/ No)</td><td colspan="2">Pure juice/No added sugar/diet:
(Yes/ No)</td></tr>
<tr><td colspan="2">Fruit juice e.g. orange, apple</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Squash/cordial e.g. Robinson's blackcurrant cordial</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Fizzy pop e.g. coke, lemonade</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Ready made fruit flavoured drinks e.g. Ribena, Oasis</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Smoothies</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Milk</td><td colspan="2">Skimmed:
(yes/ no)</td><td colspan="2">Semi-skimmed:
(yes/ no)</td><td>Full-fat:
(yes/ no)</td></tr>
</table>

P.1.6. Would it be possible for <twin1 name> and <twin2 name> to get any drinks by themselves, without your help? By this, we mean whether it would be physically possible for <child's name> to get any drinks by him/herself, without your help.
We are referring to non-alcoholic drinks other than water.
Yes □ No □ *If no, skip P1.7 – P2.1 and enter no for P1.8 and P2.*
If different for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

P.1.7. If yes, what types of drinks could <twin1 name> and <twin2 name> get by themselves, without your help?
We are referring to non-alcoholic drinks other than water.
This is an open question. As the participant lists the drinks they have, tick the matching drink type in the table. May need to prompt the participant to determine whether each drink is sugar sweetened or not).

<table>
<tr><td></td><td colspan="2">Sugar sweetened:
(Yes/ No)</td><td colspan="2">Pure juice/No added sugar/diet:
(Yes/ No)</td></tr>
<tr><td>Fruit juice e.g. orange, apple</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Squash/cordial e.g. Robinson's blackcurrant cordial</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Fizzy pop e.g. coke, lemonade</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Ready made fruit flavoured drinks e.g. Ribena, Oasis</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Smoothies</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Milk</td><td>Skimmed:
(yes/ no)</td><td colspan="2">Semi-skimmed:
(yes/ no)</td><td>Full-fat:
(yes/ no)</td></tr>
</table>

P.1.8. Are <twin1 name> and <twin2 name> allowed to get any drinks by themselves, without asking you first? We are referring to non-alcoholic drinks other than water.
Yes □ No □
If different for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

P.1.9. If yes, what types of drinks are <twin1 name> and <twin2 name> allowed to get by themselves, without asking you first?
We are referring to non-alcoholic drinks other than water. This is an open question. As the participant lists the drinks they have, tick the matching drink type in the table. May need to prompt the participant to determine whether each drink is sugar sweetened or not.

	Sugar sweetened: (Yes/ No)	Pure juice/No added sugar/diet: (Yes/ No)
Fruit juice e.g. orange, apple		
Squash/cordial e.g. Robinson's blackcurrant cordial		
Fizzy pop e.g. coke, lemonade		
Ready made fruit flavoured drinks e.g. Ribena, Oasis		
Smoothies		

Milk	Skimmed: (yes/ no)	Semi-skimmed: (yes/ no)	Full-fat: (yes/ no)

P.2.0. Do <twin1 name> and <twin2 name> ever get any drinks by themselves, without asking you first?

We are referring to non-alcoholic drinks other than water.

Yes □ No □

If different for twins: <twin2 name>: Yes □ No □

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.

Is that for <twin1 name> or <twin2 name> or both?

P.2.1. If yes, what types of drinks do <twin1 name> and <twin2 name> get by themselves, without asking you first?

We are referring to non-alcoholic drinks other than water. This is an open question. As the participant lists the drinks they have, tick the matching drink type in the table. May need to prompt the participant to determine whether each drink is sugar sweetened or not.

<table>
<tr><th></th><th colspan="2">Sugar sweetened:
(Yes/ No)</th><th>Pure juice/No added sugar/diet:
(Yes/ No)</th></tr>
<tr><td>Fruit juice e.g. orange, apple</td><td colspan="2"></td><td></td></tr>
<tr><td>Squash/cordial e.g. Robinson’s blackcurrant cordial</td><td colspan="2"></td><td></td></tr>
<tr><td>Fizzy pop e.g. coke, lemonade</td><td colspan="2"></td><td></td></tr>
<tr><td>Ready made fruit flavoured drinks e.g. Ribena, Oasis</td><td colspan="2"></td><td></td></tr>
<tr><td>Smoothies</td><td colspan="2"></td><td></td></tr>
<tr><td>Milk</td><td>Skimmed:
(yes/ no)</td><td>Semi-skimmed:
(yes/ no)</td><td>Full-fat:
(yes/ no)</td></tr>
</table>

P.2.2. On average, how often do <twin1 name> and <twin2 name> drink… Read each drink type (with examples) in turn and wait for the participant's response before moving onto the next drink type: sugar-sweetened drinks such as original coke, squash with sugar, or ready-made fruit flavoured drinks with sugar such as original ribena or fruit shoots; sugar-free drinks such as diet coke, squash with no added sugar, or ready-made fruit flavoured drinks with no added sugar such as ribena light or fruit shoots with low sugar; fruit juice such as orange or apple juice; milk (this includes milk on cereal).
Ask for all drinks whether they are in the home or not. This is an open question. Do not read the response options aloud but categorize the response accordingly. If the participant does not provide enough information e.g. they may say 'everyday', the interviewer should prompt for a fuller response e.g. 'so is that once a day, 2-3 times a day or 4 or more times a day?'

	Never or less than once a month	1-3 times a month	Once a week	2-4 times a week	5-6 times a week	Once a day	2-3 times a day	4 or more times a day
<twin1 name>	☐	☐	☐	☐	☐	☐	☐	☐
<twin2 name>	☐	☐	☐	☐	☐	☐	☐	☐
<twin1 name>	☐	☐	☐	☐	☐	☐	☐	☐
<twin2 name>	☐	☐	☐	☐	☐	☐	☐	☐
<twin1 name>	☐	☐	☐	☐	☐	☐	☐	☐
<twin2 name>	☐	☐	☐	☐	☐	☐	☐	☐
<twin1 name>	☐	☐	☐	☐	☐	☐	☐	☐
<twin2 name>	☐	☐	☐	☐	☐	☐	☐	☐

Section Q – MEALTIMES

Note that for Q1.1 – Q5 the scores of <twin1 name> are automatically copied to <twin2 name>. If parent indicates a difference between twins, score can be adjusted for <twin2 name>. Always score <twin1 name> first and then <twin2 name>.

Q1.1. How many days a week do <twin1 name> and <twin2 name> eat breakfast at home?
Weekly estimates include week days and weekend days. Breakfasts that are prepared at home, but not eaten at home do not count.
If 7 days, skip Q1.2. If the participant gives a number less than 7 e.g. 4, make sure they are always asked Q1.2 as it cannot be assumed that the twins eat breakfast on each of the remaining days elsewhere.
0 1 2 3 4 5 6 7 (days a week)
If different for twins: <twin2 name>: 0 1 2 3 4 5 6 7

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Q1.2. How many days a week do <twin1 name> and <twin2 name> eat breakfast elsewhere for example at nursery or preschool?
This includes food prepared at home, foods purchased on the way to nursery or preschool and food prepared by the nursery or preschool – provided they are eaten outside the home.
0 1 2 3 4 5 6 7 (days a week)
If different for twins: <twin2 name>: 0 1 2 3 4 5 6 7

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Q1.3. How many days a week do your family sit at a table to eat breakfast together? This includes occasions when it is just <twin1 name> and <twin2 name> and yourself or just <twin1 name> and <twin2 name> and your <husband/wife/partner>. Only include occasions where you or your <husband/wife/partner> actually eat with your twins.
A possible response might be that they sit down as a family to eat breakfast, but not at a dining table. This is not included. Another possible response is that the twins sit at a table to eat breakfast with their nanny or other siblings, but not their parent(s). This is not included.
0 1 2 3 4 5 6 7 (days a week)
If different for twins: <twin2 name>: 0 1 2 3 4 5 6 7

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Q2.1. How many days a week do <twin1 name> and <twin2 name> eat a midday meal at home?
Midday meals that are prepared at home, but not eaten at home do not count.
If 7 days, skip Q2.2. If the participant gives a number less than 7 e.g. 4, make sure they are always asked Q2.2 as it cannot be assumed that the twins eat a midday meal on each of the remaining days elsewhere.
0 1 2 3 4 5 6 7 (days a week)
If different for twins: <twin2 name>: 0 1 2 3 4 5 6 7

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Q2.2. How many days a week do <twin1 name> and <twin2 name> eat a midday meal elsewhere for example at nursery or preschool?
This includes food prepared at home, foods purchased on the way to nursery or preschool and food prepared by the nursery or preschool – provided they are eaten outside the home.
0 1 2 3 4 5 6 7 (days a week)
If different for twins: <twin2 name>: 0 1 2 3 4 5 6 7

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Q2.3. How many days a week do your family sit at a table to eat a midday meal together? This includes occasions when it is just <twin1 name> and <twin2 name> and yourself or just <twin1 name> and <twin2 name> and your <husband/wife/partner>. Only include occasions where you or your <husband/wife/partner> actually eat with your twins.
A possible response might be that they sit down as a family to eat a midday meal, but not at a dining table. This is not included. Another possible response is that the twins sit at a table to eat a midday meal with their nanny or other siblings, but not their parent(s). This is not included.
0 1 2 3 4 5 6 7 (days a week)
If different for twins: <twin2 name>: 0 1 2 3 4 5 6 7

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Q3.1. How many days a week do <twin1 name> and <twin2 name> eat an evening meal at home?
Evening meals that are prepared at home, but not eaten at home do not count.
If 7 days, skip Q3.2. If the participant gives a number less than 7 e.g. 4, make sure they are always asked Q3.2 as it cannot be assumed that the twins eat an evening meal on each of the remaining days elsewhere.
0 1 2 3 4 5 6 7 (days a week)
If different for twins: <twin2 name>: 0 1 2 3 4 5 6 7

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Q3.2. How many days a week do <twin1 name> and <twin2 name> eat an evening meal elsewhere for example at nursery or preschool?
This includes food prepared at home, foods purchased on the way to nursery or preschool and food prepared by the nursery or preschool – provided they are eaten outside the home.
0 1 2 3 4 5 6 7 (days a week)
If different for twins: <twin2 name>: 0 1 2 3 4 5 6 7

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Q3.3. How many days a week do your family sit at a table to eat an evening meal together? This includes occasions when it is just <twin1 name> and <twin2 name> and yourself or just <twin1 name> and <twin2 name> and your <husband/wife/partner>. Only include occasions where you or your <husband/wife/partner> actually eat with your twins.
A possible response might be that they sit down as a family to eat an evening meal, but not at a dining table. This is not included. Another possible response is that the twins sit at a table to eat an evening meal with their nanny or other siblings, but not their parent(s). This is not included.
0 1 2 3 4 5 6 7 (days a week)
If different for twins: <twin2 name>: 0 1 2 3 4 5 6 7

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Q4.1. How many days a week do <twin1 name> and <twin2 name> eat snacks at home?
Snacks that are prepared at home, but not eaten at home do not count.
0 1 2 3 4 5 6 7 (days a week)
If different for twins: <twin2 name>: 0 1 2 3 4 5 6 7

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Q4.2. How many days a week do <twin1 name> and <twin2 name> eat snacks elsewhere for example at nursery or preschool?
This includes snacks prepared at home, snacks purchased on the way to nursery or preschool and snacks prepared by the nursery or preschool – provided they are eaten outside the home.
0 1 2 3 4 5 6 7 (days a week)
If different for twins: <twin2 name>: 0 1 2 3 4 5 6 7

If the participant does not indicate whether their response is the same or different for <twin1 name> and <twin2 name>, prompt them to check.
Is that for <twin1 name> or <twin2 name> or both?

Section R – FOOD SHOPPING

R1.1. How often do you shop for food?
This is an open question. Do not read the response options aloud but categorize the response accordingly. If the participant does not provide enough information the interviewer should prompt for a fuller response. For example, if the participant says 'monthly big trip', the interviewer should say 'so is that with few small trips or no small trips?' If participants say they do online shopping, also categorize their response according to the following options.

□ Monthly, big trip, no small trips
□ Monthly, big trip, few small trips
□ Every other week, big trip, no small trips
□ Every other week, big trip, few small trips
□ Weekly, big trip, no small trips
□ Weekly, big trip, few small trips
□ As and when, no big trip, all small trips as needed
□ Twice each week, big trips, no small trips
□ Twice each week, big trips, few small trips

R1.2. How often do <twin1 name> and <twin2 name> go food shopping with you? Please choose a score from 1 to 5: 1 means never, 2 means rarely, 3 means some of the time, 4 means most of the time, 5 means all of the time?
Participants may respond before you get a chance to read them the options. Let them finish and then say, 'ok, can you tell me whether this happens 1 never, 2 rarely…etc.'
1 2 3 4 5 (5=all of the time)
If different arrangement for twins: <twin2 name>: 1 2 3 4 5

R1.3. How many days has it been since you last shopped for food?
If participants only do online shopping, which is then delivered, make sure they are asked about how many days it has been since food was last *delivered* to their house. Participants may say that they have done their next online shop recently but we want to know how many days it has been since food shopping came into the house.
…… days

R1.4. Was the last shop small or big?
Small □ Big □ Medium □

Section S – ADDITIONAL GENERAL INFORMATION QUESTIONS

Finally, the last few questions are about your twin's growth.

Height and Weight

S1. Do you have any recent height or weight measurements for <twin1 name> and <twin2 name>?
The most recent measurements we have were taken on …...
Yes □ No □

S4. Would now be a convenient time to take the twins' height and weight measurements?

If yes, Using the height chart and scales we have sent, please can you take today's heights and weights for each of the twins and then read them out to me? Please remember to measure and weigh the twins in indoor clothes without shoes.

Once the twins have been measured and weighed add the measurements to the table at the bottom of the page.

If no, Would you be able to take these measurements tomorrow?

If yes, Please use the height chart and scales we have sent to take the twins heights and weights. Remember to measure and weigh the twins in indoor clothes without shoes. Once you have taken these measurements, please send them to us by email, give them over the telephone, or add them on the Gemini website.

How would you like to give these measurements?

If email, please email to Gemini@.ucl.ac.uk

(make sure participant includes their Gemini ID number and the date the measurements were taken).

If telephone, please call 020 7679 1723.

If Gemini website, please go to www.attitudestohealth.co.uk/gemini and click where it says enter height/weight measurements.

If no, when would be a convenient time for you to take these measurements? Repeat the text beneath tomorrow's measurements, making sure you record how participants will give the measurements and when they will give them.

	Twin 1		Twin 2	
Date measured (day/month/year)	kgs or lbs, oz	cm	kgs or lbs, oz	cm

That's the end of the interview now. Thank you very much for your time. Do you have any questions or comments?

Add any comments here.

Appendix 4.2: food lists for the HEI

Sweet snack examples

Cakes
Biscuits (plain, flavoured, cream filled, chocolate)
Ice-cream
Ice-lollies (do not include if homemade from pure fruit juice or yoghurt)
Pastries
Doughnuts
Flapjacks
Brownies
Buns
Scones
Pie
Tarts
Crumbles
Sponge pudding
Dairy desserts e.g. mousse, angel delight
Custard
Cereal bars
***Yoghurt, fromage frais is not included**

Confectionery examples

Chocolate (bars, pieces)
Sweets (mints, toffee, fudge, liquorice, fruit flavour)
Sweet popcorn e.g. toffee flavoured

Savoury snack examples

Crisps (potato, corn or tortilla crisps)
Pretzels
Cheesy biscuits (e.g. mini cheddars, tuc) or other flavoured savoury biscuits
Nuts or nut products e.g. peanut butter
Salted popcorn
Bombay mix
Prawn crackers
***Snacks like plain crackers, rice cakes, breadsticks and oatcakes are not included**
*** Dairy based snacks e.g. cheese products are not included**

Appendix 4.3: email and survey sent to the expert panel

Dear Dr/Professor (surname),

I am investigating the role of the home environment in risk of weight gain in pre-school children. Using a modified version of an existing measure, I have collected home environment data using telephone interviews from 1113 families with twins.

The item selection was research-based but the published evidence is not always strong and I would like to reinforce the choices with an estimate of the expert consensus.

As you are an expert in the field, I would very much appreciate your contribution. I realise there are many calls on your time, but all I ask here is whether you could indicate for each of the listed home environment variables whether you believe it to be related to increased or decreased risk for weight gain. There is also an option to select 'not sure'. Please use the link below to make your responses.

https://www.surveymonkey.com/s/HomeEnvironment

Responses will be anonymised and there will not be any follow-up on your individual answers; though I will send round the consensus conclusions for your interest.

Many thanks and kind regards,

Stephanie Schrempft

Stephanie Schrempft
Health Behaviour Research Centre
University College London
1-19 Torrington Place
London
WC1E 6BT

Tel: 020 7679 1723

For each home environment variable, please indicate whether you think it is related to increased or decreased risk for weight gain in childhood.

Home environment variable	Probably/definitely INCREASED risk for weight gain	Probably/definitely DECREASED risk for weight gain	Not sure
More types of fruit in the home	□	□	□
More types of vegetable in the home	□	□	□
More types of energy-dense snack in the home	□	□	□
Sugar-sweetened drinks in the home	□	□	□
Sugar-free drinks in the home (excluding water)	□	□	□
Fruit juice in the home	□	□	□
Full-fat milk in the home	□	□	□
Semi-skimmed milk in the home	□	□	□
Skimmed milk in the home	□	□	□
Fruit on display (visible)	□	□	□
Child is allowed to help themself to fruit	□	□	□
Ready-to-eat vegetables in the fridge or on the kitchen counter	□	□	□
Child is allowed to help themself to vegetables	□	□	□
Energy-dense snacks on display (visible)	□	□	□
Child is allowed to help themself to energy-dense snacks	□	□	□
Sugar-sweetened drinks on display (visible)	□	□	□
Child is allowed to help themself to sugar-sweetened drinks	□	□	□
Sugar-free drinks on display (visible)	□	□	□
Child is allowed to help themself to sugar-free drinks	□	□	□

Home environment variable	Probably/definitely INCREASED risk for weight gain	Probably/definitely DECREASED risk for weight gain	Not sure
Fruit juice on display (visible)	□	□	□
Child is allowed to help themself to fruit juice	□	□	□
Child is allowed to help themself to milk	□	□	□
Family meals at the table	□	□	□
Maternal modelling of healthy eating	□	□	□
Parental encouragement for the child to eat	□	□	□
Parental restriction of unhealthy foods	□	□	□
Parental use of food as a reward	□	□	□
Parental pressure for the child to eat	□	□	□
Parental monitoring of the child’s unhealthy food intake	□	□	□
Parental control of the child’s food intake	□	□	□
Parental use of food to make the child feel better	□	□	□
Parental covert restriction of the child’s unhealthy food intake	□	□	□
Indoor recreation centres close to the home	□	□	□
Garden/yard that the child can play in	□	□	□
Larger garden/yard that the child can play in vs. smaller garden/yard	□	□	□
Play equipment in the garden/yard	□	□	□
Greater frequency that the child is allowed to play actively in the garden/yard	□	□	□
Greater frequency that the child is allowed to play actively inside the home	□	□	□

Home environment variable	Probably/definitely INCREASED risk for weight gain	Probably/definitely DECREASED risk for weight gain	Not sure
Parental support of physical activity	□	□	□
Parental modelling of physical activity	□	□	□
Parental satisfaction with their home neighbourhood	□	□	□
Greater amount of media equipment in the home (i.e. TVs, DVD players, games consoles)	□	□	□
TV in the child’s bedroom	□	□	□
Greater maternal TV watching	□	□	□
Greater paternal TV watching	□	□	□
Rules around media use	□	□	□
Child eats while watching TV	□	□	□

Appendix 5.1: letter of ethical approval for the SenseCam study

UCL RESEARCH ETHICS COMMITTEE
GRADUATE SCHOOL OFFICE

UCL

Professor Jane Wardle
HBRC, Department of Epidemiology and Public Health
1-19 Torrington Place
UCL

17 May 2012

Dear Professor Wardle

Notification of Ethical Approval
Project ID: 3792/001: Using SenseCam in the home environment

I am pleased to confirm that your study has been approved by the UCL Research Ethics Committee for the duration of the project i.e. until June 2013 on condition that:

(a) in the case of divorced parents not living together, consent must be obtained from both parents if residency and access arrangements are in place;

(b) you state in the Information Sheet that any illegal activities (criminal, harm to self or others) captured while wearing SenseCam would have to be disclosed to the appropriate authorities.

Approval is also subject to the following conditions:

1. You must seek Chair's approval for proposed amendments to the research for which this approval has been given. Ethical approval is specific to this project and must not be treated as applicable to research of a similar nature. Each research project is reviewed separately and if there are significant changes to the research protocol you should seek confirmation of continued ethical approval by completing the 'Amendment Approval Request Form'.

The form identified above can be accessed by logging on to the ethics website homepage: http://www.grad.ucl.ac.uk/ethics/ and clicking on the button marked 'Key Responsibilities of the Researcher Following Approval'.

2. It is your responsibility to report to the Committee any unanticipated problems or adverse events involving risks to participants or others. Both non-serious and serious adverse events must be reported.

Reporting Non-Serious Adverse Events
For non-serious adverse events you will need to inform Helen Dougal, Ethics Committee Administrator (ethics@ucl.ac.uk), within ten days of an adverse incident occurring and provide a full written report that should include any amendments to the participant information sheet and study protocol. The Chair or Vice-Chair of the Ethics Committee will confirm that the incident is non-serious and report to the Committee at the next meeting. The final view of the Committee will be communicated to you.

Reporting Serious Adverse Events
The Ethics Committee should be notified of all serious adverse events via the Ethics Committee Administrator immediately the incident occurs. Where the adverse incident is unexpected and serious, the

Chair or Vice-Chair will decide whether the study should be terminated pending the opinion of an independent expert. The adverse event will be considered at the next Committee meeting and a decision will be made on the need to change the information leaflet and/or study protocol.

On completion of the research you must submit a brief report (a maximum of two sides of A4) of your findings/concluding comments to the Committee, which includes in particular issues relating to the ethical implications of the research.

With best wishes for the research.

Yours sincerely

Appendix 5.2: SenseCam loan application form

Vicon Revue / SenseCam Loan Award

The SenseCam Steering Committee will make available a pool of Vicon Revues for use in research for free, on a loan basis, and for a fixed period of time. Applicants can apply for the award using the attached form.

In particular, the loan pool is intended to support larger-scale group studies and studies conducted by early career researchers and postgraduates, where other funding streams may not be (yet) possible. Priority will be given to larger-scale projects which will advance our understanding of SenseCam and its usability. Projects which use SenseCams in novel populations and/or to answer new research questions are particularly encouraged. Single case studies with brain damaged populations will be considered if these criteria are met.

The over-riding principle in loaning out SenseCams is that a specific and realistic project should be identified. Applications should specify how the loan of SenseCams will lead to applications for further research funding, have an impact on user groups and researchers, and they should also specify any likely outputs (conference presentations, publications, publicity, etc.). Applicants should also briefly describe their research design, give a supporting statement, and whether or not they have applied for (and/or received) ethical approval. We would normally expect recipients of the SenseCam loan award to play a part in the proceedings of the Annual SenseCam Symposium following completion of their award.

Those who have been loaned the SenseCams will be responsible for their safekeeping and returning the SenseCams in a suitable condition (i.e. with adequate packaging and with the original chargers, straps and instructions) and for erasing all data from the SenseCams.

SenseCams will be loaned on an ad-hoc rolling basis. According to supply and demand, there may be a delay in making the SenseCams available.

In preparing the application, it is suggested that applicants consult previous research using SenseCam, provided here,
http://research.microsoft.com/cambridge/projects/sensecam/default.htm

Informal enquiries about the scheme can be sent to Aiden Doherty (aiden.doherty@dph.ox.ac.uk)

Completed applications should be sent as a pdf (using the attached form) to aiden.doherty@dph.ox.ac.uk . Applications will then be quickly reviewed by the SenseCam Steering committee, with 4 votes needed for acceptance.

SenseCam Steering Committee members:

Dr. Steve Hodges (Microsoft Research)

Dr. Siân Lindley (Microsoft Research)

Prof. Alan F. Smeaton (Dublin City University)

Dr. Emma Berry (Hertfordshire University)

Dr. Chris Moulin (Leeds University)

Dr. Charlie Foster (University of Oxford)

Dr. Aiden R. Doherty (University of Oxford)

Vicon Revue / SenseCam Loan Award

Lead Applicant:	Miss Stephanie Schrempft
Email address:	s.schrempft@ucl.ac.uk
Title of Project:	Using SenseCam in the home environment
Institution:	University College London (UCL)
Full postal address:	Health Behaviour Research Centre Department of Epidemiology and Public Health UCL 1-19 Torrington Place London WC1E 6BT
Status:	PhD student

Loan Period:	27th July – 30th November (4 months); 14th January – 30th April (3.5 months)
Number of SenseCams Requested:	2

Co-Applicants (and institutions)	Dr Abigail Fisher, Health Behaviour Research Centre, UCL
Academic/Clinical Supervisor (where applicable)	Professor Jane Wardle, Health Behaviour Research Centre, UCL

Brief description of proposed study (500 words)

A dramatic increase in obesity rates has called for a research focus on identifying early risk factors for weight gain. The home food and activity environment has been identified as particularly important in early childhood, providing a promising avenue for long-term obesity prevention (1).

A number of measures have been used to assess the home food and activity environment but few are comprehensive, have been psychometrically tested, or have considered the role of individual factors such as appetite, which may modify any relationship between the home environment and weight (2). We have developed a comprehensive measure of the home food and activity environment based on the Healthy Home Survey (3). Our measure has recently been administered as a telephone interview with mothers in the Gemini twin birth cohort. Gemini's unique focus will help to provide insight into the extent to which appetitive traits are expressed in different rearing environments (4).

Consistent with the Healthy Home Survey, our measure has shown generally moderate to high test-retest reliability but has yet to be validated. Validity of the Healthy Home Survey was generally good but social and behavioural aspects of the interview, such as mealtime and media policies, could not be validated by an observer carrying out individual home visits. The home food environment was also difficult to capture in a single home visit, with natural changes in food availability likely contributing to lower validity results. Multiple home visits can provide some further insight (5) but they are costly and labour intensive.

We propose to use SenseCam in an exploratory study to validate aspects of our home environment interview. Using SenseCam may be a more ecologically valid way of capturing the home environment than in-home observation. Participants can go about their daily activities while wearing SenseCam. When worn, SenseCam is reasonably close to the wearer's eye line and the wide-angle lens captures everything within the wearer's view. Each image is time-stamped so duration of specific events can be deduced.

20 UK mothers of young children (aged 3 – 5 years) will be invited to take part. The proposed sample size is based on a previous pilot study conducting similar validation work (6). The researcher will contact participants by telephone to complete the home environment interview and to arrange a time to visit participants in their home to give them the SenseCam and instructions on how to use it. The home visits will take place one to two weeks after completion of the home environment interview to minimise the chance of demand effects. The mother will be asked to wear SenseCam for four consecutive days during waking hours while at home. At the end of data collection, the researcher will return to collect the camera. Participants will be able to view and delete any or all images they do not wish to have stored for analysis. After the home visit, another researcher will contact participants by telephone to carry out a semi-structured interview. Participants will be asked about their experience of wearing SenseCam.

Supporting Statement (200 words)	As Stephanie Schrempft's PhD supervisor, I am pleased to support her application for a SenseCam loan. Stephanie is extremely enthusiastic about taking forward this research and I am confident that she will do a good job. She is a very reliable and responsible person, so you can be sure she will take good care of the instruments. I am also confident that she will be conscientious in writing up the results for publication. [Professor Jane Wardle].
Expected benefits and outputs (200 words)	We expect that the results of this study will have benefits for health researchers and other members of the research community. The findings will show whether SenseCam can be useful for validating aspects of the home food and activity environment, as a stand-alone tool or complementary aid for usual home visits. SenseCam may highlight limits of self-report measures of the home environment and ways in which these measures can be improved. Hearing mothers' experiences on wearing SenseCam will also provide insight for future research. In future work, SenseCam could be used to assess the home

environments of families at high and low risk for weight gain, and help develop interventions targeting the family environment. It is possible that SenseCam could be used as an intervention tool in its own right, perhaps partly by prompting self-reflection (7, 8). We hope to use SenseCam to examine these possibilities. The results of this study will be written as part of a PhD thesis and submitted for publication in a scientific journal. We also hope to present the findings at the next SenseCam conference. In the long-term, we expect that this research will advance understanding of and efforts towards obesity prevention.

Has ethical approval been given for the proposed study? YES (approved by the UCL Research Ethics Committee; project ID number: 3792/001)

Is the study being conducted as part of an educational qualification? YES (it will form a PhD thesis chapter)

References

1) Dietz, W. H., & Gortmaker, S. L. (2001). Preventing obesity in children and adolescents. Annual Review of Public Health, 22, 337 – 353

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(6) Kelly, P., Doherty A., Berry E., et al. (2011). Can we use digital life-log images to investigate active and sedentary travel behaviour? Results from a pilot study. International Journal of Behavioral Nutrition and Physical Activity, 8, 1 – 9

(7) Lindley, S. E., Glancy, M., & Harper R., et al. (2011). ''Oh and how things don't change, the more things stay the same'': Reflections on SenseCam images 18 months after capture. International Journal of Human-Computer Studies, 69, 311 – 323

(8) Fleck, R., & Fitzpatrick, G. (2009). Teachers' and tutors' social reflection around SenseCam images. International Journal of Human-Computer Studies, 67, 1024 – 1036

Appendix 5.3: participant information sheets and consent forms for the SenseCam study

Information Sheet for Participants in Research Studies

Title of Project: Using SenseCam in the home environment

This study has been approved by the UCL Research Ethics Committee (Project ID Number): 3792/001

Name	Stephanie Schrempft
Work Address	Department of Epidemiology and Public Health University College London 1-19 Torrington Place London WC1E 6BT
Contact Details	**Email:** s.schrempft@ucl.ac.uk **Telephone:** 020 7679 1723

We would like to invite you to participate in this research study. The aim of this study is to see whether a wearable camera provides useful information about the home food and activity environment of mothers and young children. The most common way of gathering information about the home environment is by asking people to fill in questionnaires or complete interviews. We would like to see if using a wearable camera is an informative and acceptable way to gain information about the home environment.

We have approached you because we would like mothers of young children to take part.

You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, it is important for you to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or you would like more information.

If you decide to take part in this study, a member of our research team will contact you by telephone to ask some questions about your home food and activity environment. The telephone interview will take around 30 minutes to complete. One to two weeks later, at a convenient time for you, the researcher will visit you at home to provide the camera and instructions on how to use it. The camera takes pictures automatically so it is straightforward to use. It does not record sound. We will ask you to wear the camera during waking hours while at home as you go about your daily activities for four consecutive days. You will be free to take off the camera any time you wish while at home. You will be asked to take off the camera whenever you go outside your home.

While wearing the camera, it is possible that visitors to your home will ask you about it. If this happens, we recommend saying the following:

'I am volunteering for a research project looking at my home environment. The device is called SenseCam and it takes pictures of my daily activities.'

Once you have finished wearing the camera, the researcher will come to collect it, at a convenient time for you. You will then be able to see and delete any or all of your images, without giving reason. Any images can be deleted without the researcher seeing them. At the end of the study, we will ask you some questions about your experience of wearing the camera.

All data will be collected and stored in accordance with the Data Protection Act 1998. Any illegal activities captured while wearing SenseCam would have to be disclosed to the appropriate authorities. The results of this study will be submitted for publication in an academic journal and used to inform health researchers interested in the home environment. It will not be possible to identify you or your children from any publications. You will be sent a letter summarising the findings of the study.

If you would like to take part in this study or if you would like any more information, please contact **Stephanie Schrempft** using the contact details provided at the top of the front page.

If you do decide to take part you are still free to withdraw at any time and without giving a reason.

SenseCam Protocol

Thank you for agreeing to take part in this study. If you have any further questions please contact Stephanie Schrempft by email (s.schrempft@ucl.ac.uk) or telephone (020 7679 1723).

Wearing SenseCam:

- Make sure the SenseCam is turned on, the lens is not covered, and that the unit is worn correctly, around your neck at chest height and with the lens facing outward, as shown in the image overleaf
- The height can be adjusted using the black cord
- Wear the camera outside of your clothes
- Use the fashion tape provided to prevent the camera from swinging about
- Put the camera on in the morning when you wake up, go about your daily activities as normal, and take it off when you go to bed at night
- Please remove the camera whenever you go outside your home.
- Do not get the camera wet
- When the SenseCam is not in use, cover the lens with the supplied cap

What if someone asks me what SenseCam is for?

It is unusual for somebody to be questioned about SenseCam. However, if you are asked, we recommend saying the following;

'I am volunteering for a research project looking at my home environment. The device is called SenseCam and it takes pictures of my daily activities.'

If people are interested in this study and would like more information they may contact Stephanie Schrempft (s.schrempft@ucl.ac.uk).

Where should and shouldn't I wear SenseCam?

We are interested in recording your home environment so we would like you to wear SenseCam as much as possible during waking hours while at home for the 4 day period.

Please remove the camera whenever you go outside of your home. Please be aware that in some places, such as airports, hospitals, banks, and courts of law, photography is prohibited. SenseCam should not be worn in these places.

For any other situations where you don't feel comfortable wearing SenseCam, please feel free to remove it.

On-off button: You can turn the SenseCam on or off by pressing the button on the top of the device for a few seconds. When the camera is turning on you will hear a rising tone and an amber light will appear beside the on-off button. The green power light will also come on. When the camera is turning off you will hear a falling tone.

Turn the SenseCam off when you are not wearing it to save the battery. You will most likely only need to turn it off when you are going to bed or if you decide you do not want to record anything for an extended period.

Status lights: The green 'power' light indicates whether the SenseCam is turned on or not. If the battery is charged, the green power light is on continuously. If the battery is getting low, the green light blinks occasionally to let you know that you need to recharge soon. An amber flashing light will indicate every time an image is captured. The amber light will flash continuously throughout normal operation. A red light indicates that the privacy button has been pressed and the device is not taking images at this time.

Charging: You will be given a charger lead with a plug on one end and a small square plug on the other end. It is recommended that you charge SenseCam at night when you are sleeping so that the battery will be full for the next day.

Make sure the SenseCam is turned on before you charge it. To charge the SenseCam, put the small end of the plug into the SenseCam in the slot on its side (see picture below right) and plug the other end into your domestic plug socket. If the battery is completely flat (so it won't turn on), connect the SenseCam to the charger for 15 minutes, then disconnect it and turn it on before resuming to charge it. A flashing green light indicates that the battery is charging. When the light changes to solid green, the battery is fully charged.


On/Off Button
Status Lights
Privacy Button
Activate Button
Plug Charger in Here

Informed Consent Form for Mothers living in the home

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Project: Using SenseCam in the home environment

This study has been approved by the UCL Research Ethics Committee (Project ID Number): **3792/001**

Thank you for your interest in taking part in this research. Before you agree to take part, the person organising the research must explain the project to you.

If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you to decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time.

Participant's Statement

I…………………………………………………………

- have read the notes written above and the Information Sheet, and understand what the study involves.
- understand that if I decide at any time that I no longer wish to take part in this project, I can notify the researchers involved and withdraw immediately.
- consent to the processing of my and my child's personal information for the purposes of this research study.
- understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.
- I understand that my daily activities and my children will be photographed and I consent to use of this material as part of the project.
- understand that the information I have submitted will be published as a report and I will be sent a copy. Confidentiality and anonymity will be maintained and it will not be possible to identify me or my child(ren) from any publications.
- agree that the research project named above has been explained to me to my satisfaction and I agree to take part in this study, with my child.

Signed: Date:

Informed Consent Form for other adults (aged 18 years and over) living in the home

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Project: Using SenseCam in the home environment

This study has been approved by the UCL Research Ethics Committee (Project ID Number): **3792/001**

Thank you for your interest in taking part in this research. Before you agree to take part, the person organising the research must explain the project to you.

If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you to decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time.

Participant's Statement

I……………………………………………………………

- have read the notes written above and the Information Sheet, and understand what the study involves.
- understand that if I decide at any time that I no longer wish to take part in this project, I can notify the researchers involved and withdraw immediately.
- consent to the processing of my personal information for the purposes of this research study.
- understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.
- I understand that I will be photographed and I consent to use of this material as part of the project.
- understand that the information I have submitted will be published as a report and I will be sent a copy. Confidentiality and anonymity will be maintained and it will not be possible to identify me from any publications.
- agree that the research project named above has been explained to me to my satisfaction and I agree to take part in this study.

Signed: Date:

Appendix 5.4: topics included in the semi-structured interview of the SenseCam study

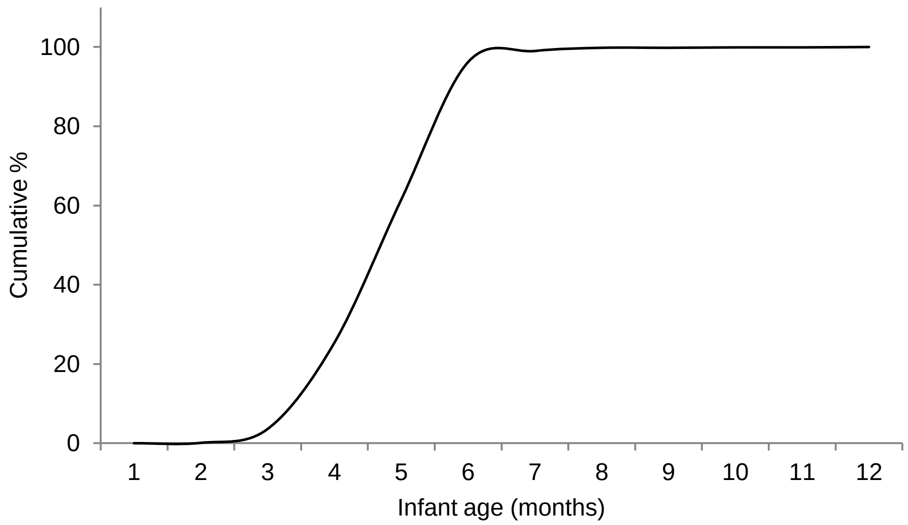
General strengths and limitations of the camera

- Ease of use (remembering to wear the camera and charge it
- Awareness of the camera (overall awareness, particular situations where attention was drawn to the camera
- Reactions from other people (other family members, visitors)
- Instances where participants did/did not feel comfortable wearing the camera
- General attitudes towards the camera and associated reasons

Home environment specific topics

- Use of interview vs. SenseCam to examine home environment (which did participants prefer, which do they think would be more informative/representative)
- Potential of SenseCam to influence the household routine/help families change aspects of their home environment and daily activities

Appendix 6.1: cumulative percentage of infants introduced to solid foods by infant age



Appendix 6.2: maternal eating traits and early parenting practices associated with living in a higher risk home environment[1] (N = 899)

	Univariate results		Multivariate results[1]	
	OR	**95% CI (p value)**	**OR**	**95% CI (p value)**
Maternal traits				
BMI (per unit increase)	1.07	1.04 – 1.10 (<0.001)	1.05	1.02 – 1.08 (0.002)
DEBQ restraint[2]	0.97	0.86 – 1.10 (0.659)	0.91	0.79 – 1.04 (0.167)
DEBQ emotional eating[2]	1.23	1.08 – 1.40 (0.001)	1.05	0.91 – 1.21 (0.537)
DEBQ external eating[2]	1.34	1.11 – 1.61 (0.002)	1.38	1.13 – 1.69 (0.002)
Happiness[3]	0.68	0.60 – 0.77 (<0.001)	0.71	0.62 – 0.80 (<0.001)
Early parental feeding practices[4]				
Breastfeeding duration				
≥ 3 months	1	–	1	–
< 3 months	2.11	1.64 – 2.72 (<0.001)	1.56	1.19 – 2.05 (0.001)
Timing of solid food introduction				
Later	1	–	1	–
Average	1.06	0.80 – 1.40 (0.702)	0.95	0.71 – 1.28 (0.755)
Earlier	2.32	1.69 – 3.17 (<0.001)	1.64	1.17 – 2.29 (0.004)

OR = odds ratio; 95% CI = 95% confidence interval; 1 denotes the reference group; DEBQ = Dutch Eating Behaviour Questionnaire.
[1] Each model adjusted for core demographics (maternal age, education level, and household income) and maternal BMI.
[2] Multivariate models additionally adjusted for happiness and early parental feeding practices.
[3] Multivariate model additionally adjusted for the DEBQ subscales (entered separately; the values marginally differed between the three models so just one is presented here), early parental feeding practices, and the presence of a spouse/partner.
[4] For the multivariate analyses, breastfeeding duration and timing of solid food introduction were entered in the same model. The model additionally adjusted for the DEBQ subscales (entered separately; the values marginally differed between the three models so just one is presented here) and maternal happiness.

Appendix 7.1: descriptive statistics for original energy-balance behaviour variables (N = 1113)

	Mean (SD)
Food	
Fruit consumption (1 = never or less than once a month; 8 = 4 or more times a day)	6.74 (.90)
Vegetable consumption	6.25 (1.08)
Savoury snack consumption	4.31 (1.33)
Sweet snack consumption	5.04 (1.26)
Confectionery consumption	4.12 (1.16)
Fast food consumption	1.54 (0.66)
Convenience food consumption	2.71 (1.10)
Sugar-sweetened drink consumption	2.35 (1.77)
Sugar free drink consumption	4.52 (2.65)
Milk consumption	6.48 (1.07)
Fruit juice consumption	4.47 (2.06)
Physical activity	
Activity level (1 = much less active; 5 = much more active)	3.79 (0.79)
Media	
TV viewing (hours per week)	13.55 (8.64)

Appendix 7.2: univariate associations between the home environment tertiles and energy-balance behaviours (N = 1096)

	OR (95% CI), P value % (n)		
	Lower risk food environment	**Mid risk food environment**	**Higher risk food environment**
Outcome variables			
Fruit (≥ twice a day)	1.00 85.5 (312)	0.71 (0.48 – 1.04), 0.080 80.6 (295)	0.35 (0.24 – 0.50), <0.001 67.1 (245)
Vegetables (≥ twice a day)	1.00 60.5 (221)	0.71 (0.53 – 0.95), 0.023 52.2 (191)	0.45 (0.33 – 0.60), <0.001 40.8 (149)
Energy-dense snacks (≥ once a day)	1.00 7.7 (28)	1.65 (1.00 – 2.71), 0.050 12.0 (44)	3.11 (1.96 – 4.94), <0.001 20.5 (75)
Convenience food (≥ twice a week)	1.00 19.7 (72)	1.29 (0.91 – 1.83), 0.159 24.0 (88)	2.31 (1.65 – 3.22), <0.001 36.2 (132)
Fast food (≥ once a week)	1.00 5.2 (19)	0.62 (0.30 – 1.29), 0.200 3.3 (12)	2.89 (1.67 – 5.01), <0.001 13.7 (50)
Sugar-sweetened drinks (≥ once a day)	1.00 6.6 (24)	1.22 (0.70 – 2.14), 0.483 7.9 (29)	3.02 (1.84 – 4.95), <0.001 17.5 (64)
Artificially-sweetened drinks (≥ once a day)	1.00 52.9 (193)	0.91 (0.68 – 1.22), 0.528 50.5 (185)	1.05 (0.78 – 1.40), 0.767 54.0 (197)

	OR (95% CI), P value % (n)		
	Lower risk food environment	**Mid risk food environment**	**Higher risk food environment**
Fruit juice (≥ once a day)	1.00 49.0 (179)	1.01 (0.75 – 1.34), 0.970 49.2 (180)	0.93 (0.69 – 1.24), 0.604 47.1 (172)
Milk (≥ twice a day)	1.00 93.7 (342)	1.47 (0.76 – 2.83), 0.248 95.6 (350)	0.92 (0.51 – 1.64), 0.765 93.2 (340)
	Lower risk activity environment	**Mid risk activity environment**	**Higher risk activity environment**
Physical activity (more active)	1.00 70.7 (258)	0.65 (0.48 – 0.88), 0.006 61.0 (224)	0.44 (0.32 – 0.59), <0.001 51.4 (187)
	Lower risk media environment	**Mid risk media environment**	**Higher risk media environment**
TV viewing (≥ 2 hours per day)	1.00 15.4 (56)	3.38 (2.37 – 4.82), <0.001 38.1 (139)	9.56 (6.70 – 13.64), <0.001 63.5 (233)

95% CI = 95% confidence interval; 1.00 denotes the reference group.

Appendix 8.1: partially-adjusted associations between the individual home environment variables and BMI at 4 years[1] and BMI change from 4 to 5 years[2]

	BMI SDS at 4 years (N = 915)	BMI change, 4 – 5 years (N = 503)
	F_{df}, p value / B (95% CI), p value[3]	
Food environment variables		
More types of fruit in the home	0.01 (-0.01 – 0.03), 0.453	-0.01 (-0.05 – 0.02), 0.456
More types of vegetable in the home	0.00 (-0.02 – 0.02), 0.945	-0.02 (-0.05 – 0.01), 0.146
More types of energy-dense snack in the home	0.02 (-0.01 – 0.05), 0.209	-0.02 (-0.08 – 0.04), 0.468
Sugar-sweetened drinks in the home	$3.44_{1, 910}$, 0.064	$1.46_{1, 498}$, 0.228
Fruit on display (visible)	$5.09_{1, 910}$, 0.024	$0.86_{1, 498}$, 0.353
Child is allowed to help themself to fruit	$1.16_{1, 910}$, 0.282	$0.03_{1, 498}$, 0.873
Ready-to-eat vegetables in the fridge or on the kitchen counter	$0.32_{1, 910}$, 0.571	$1.39_{1, 498}$, 0.239
Child is allowed to help themself to vegetables	$0.10_{1, 910}$, 0.750	$0.02_{1, 498}$, 0.896
Energy-dense snacks on display (visible)	$0.42_{1, 910}$, 0.520	$0.04_{1, 498}$, 0.836
Child is allowed to help themselves to energy-dense snacks	$0.09_{1, 910}$, 0.760	$0.03_{1, 498}$, 0.867
Sugar-sweetened drinks on display (visible)	$0.30_{1, 910}$, 0.581	$0.34_{1, 498}$, 0.558
Family meals at the table	0.02 (-0.02 – 0.06), 0.433	-0.02 (-0.09 – 0.05), 0.553
Maternal modelling of healthy eating	0.03 (-0.06 – 0.12), 0.513	0.09 (-0.07 – 0.25), 0.281
Parental encouragement for the child to eat	0.06 (-0.06 – 0.18), 0.317	0.03 (-0.19 – 0.25), 0.804

	BMI SDS at 4 years (N = 915)	BMI change, 4 – 5 years (N = 503)
	F_{df}, p value / B (95% CI), p value[3]	
Parental use of food as a reward	0.01 (-0.09 – 0.11), 0.842	0.00 (-0.17 – 0.18), 0.972
Parental use of food to make the child feel better	0.11 (0.01 – 0.22), 0.034	0.11 (-0.09 – 0.30), 0.285
Parental covert restriction of the child's unhealthy food intake	0.09 (0.02 – 0.17), 0.019	0.03 (-0.11 – 0.17), 0.689
Parental monitoring of the child's unhealthy food intake	0.09 (0.02 – 0.16), 0.011	0.05 (-0.08 – 0.18), 0.430
Parental restriction of unhealthy foods	0.08 (0.03 – 0.14), 0.005	0.13 (0.02 – 0.23), 0.017
Home activity environment variables		
Play equipment in the garden	$0.76_{1, 901}$, 0.382	$0.01_{1, 494}$, 0.932
Greater frequency that the child is allowed to play actively in the garden	-0.03 (-0.11 – 0.05), 0.483	0.04 (-0.10 – 0.18), 0.558
Greater frequency that the child is allowed to play actively inside the home	-0.04 (-0.14 – 0.07), 0.489	-0.06 (-0.24 – 0.12), 0.501
Parental support of physical activity	0.04 (-0.07 – 0.15), 0.462	0.09 (-0.10 – 0.28), 0.376
Parental modelling of physical activity	0.04 (-0.04 – 0.13), 0.311	0.12 (-0.03 – 0.26), 0.118
Home media environment variables		
Greater amount of media equipment in the home	-0.01 (-0.03 – 0.02), 0.541	0.01 (-0.03 – 0.05), 0.659
TV in the child's bedroom	$0.09_{1, 910}$, 0.759	$0.55_{1, 498}$, 0.460
Greater maternal TV watching	-0.01 (-0.01 – 0.00), 0.155	-0.00 (-0.02 – 0.01), 0.521
Greater paternal TV watching	-0.01 (-0.02 – -0.00), 0.026	-0.00 (-0.01 – 0.01), 0.810
Rules around media use	$0.19_{1, 910}$, 0.663	$0.46_{1, 498}$, 0.498

Child eats while watching TV	0.02 (-0.02 – 0.07), 0.254	0.02 (-0.05 – 0.09), 0.596

[1] Adjusting for the child's age at weight measurement, age at home environment measurement, and sex.
[2] Weight at baseline (4 years) was an additional covariate.
[3] ANCOVAs were used for categorical individual home environment variables (F_{df}, p value); linear regressions were used for the continuous home environment variables (B (95% CI), p value).

Appendix 8.2: partially-adjusted associations between energy-balance behaviours and BMI at 4 years[1] and BMI change from 4 to 5 years[2]

	BMI SDS at 4 years (N = 915)	BMI change, 4 – 5 years (N = 503)
	B (95% CI), p value	
Fruit consumption	0.04 (-0.03 – 0.11), 0.286	-0.13 (-0.22 – -0.04), 0.004
Vegetable consumption	0.01 (-0.06 – 0.07), 0.816	-0.08 (-0.16 – -0.01), 0.030
Energy-dense snack consumption	-0.02 (-0.21 – 0.18), 0.868	-0.04 (-0.29 – 0.20), 0.728
Fast food consumption	0.07 (-0.03 – 0.17), 0.150	0.04 (-0.07 – 0.16), 0.457
Convenience food consumption	0.03 (-0.03 – 0.08), 0.388	0.08 (0.01 – 0.14), 0.032
Sugar-sweetened drink consumption	0.04 (-0.00 – 0.07), 0.054	-0.01 (-0.05 – 0.04), 0.805
Artificially-sweetened drink consumption	-0.03 (-0.05 - -0.00), 0.027	0.00 (-0.03 – 0.03), 0.859
Fruit juice consumption	-0.01 (-0.04 – 0.02), 0.679	0.01 (-0.03 – 0.05), 0.579
Milk consumption	0.04 (-0.02 – 0.11), 0.203	-0.11 (-0.19 – -0.04), 0.003
Physical activity	0.04 (-0.04 – 0.13), 0.294	0.04 (-0.06 – 0.14), 0.433
TV viewing	0.00 (-0.01 – 0.01), 0.981	0.01 (-0.00 – 0.02), 0.091

[1] Adjusting for the child's age at the time of the BMI measurement, home environment measurement, and sex.
[2] BMI at baseline (4 years) was an additional covariate.

My contributions to the research in this thesis

I developed the Home Environment Interview (HEI), along with contributions from other members of the Gemini team; carried out the home environment telephone interviews, along with two research assistants; cleaned the home environment data; designed and carried out the SenseCam study, including the ethics and SenseCam applications, data collection, and coding; and carried out all of the analyses (with assistance from a behavioural-genetics expert in the G x E study). Throughout my PhD, I wrote and sent out birthday cards for the Gemini twins.

Papers that I have worked on and conferences that I have attended during my PhD

Published:

Schrempft, S., van Jaarsveld C. H. M., Fisher A., & Wardle, J. (2013). Family and infant characteristics associated with the timing of core and non-core food introduction. *European Journal of Clinical Nutrition* (67), 652 – 657.

In preparation:

Schrempft, S., van Jaarsveld C. H. M., Fisher A., & Wardle, J. (2014). Associations between composite measures of the home environment, energy-balance behaviours, and weight in early childhood.

Sawyer, A., Smith, G., **Schrempft, S**., McDonald, L., van Jaarsveld, C. H. M., Wardle, J., Llewellyn, C., Fildes, A., Fisher, A., (2014). Parental knowledge of physical activity recommendations in the United Kingdom: an observational study.

Conference presentations:

Schrempft, S., van Jaarsveld C. H. M., Fisher A., & Wardle, J. Family and infant characteristics associated with the timing of core and non-core food introduction. Oral presentation at the **International Society for Behavioral Nutrition and Physical Activity (ISBNPA)**, Ghent, Belgium, May 2013.

Schrempft, S., van Jaarsveld C. H. M., Fisher A., & Wardle, J. Using SenseCam to examine the home food and activity environment. Poster presentation at the **SenseCam Third Annual Symposium**, Oxford, UK, April 2012.

Schrempft, S., van Jaarsveld C. H. M., Fisher A., & Wardle, J. Gemini – health and development in twins: an investigation of the home food and activity environment. Poster presentation at the **Physical Activity Research Group Symposium (PARG)**, London, UK, November 2011.

Other conferences attended:

Cumberland Lodge, June 2012. Three day conference for PhD students in the department of Epidemiology and Public Health at UCL, entitled ‘From science to society: Translating evidence into policy and programmes for the 21st Century’.

Cumberland Lodge, July 2011. Three day conference for PhD students of the Epidemiology and Public Health department at UCL, entitled ‘Paving the way to health and wellbeing: exploring the role of behaviours and the social environment’.