Perceived and objective measures of the neighbourhood environment and overweight in preschool children and their mothers

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Abstract

Objectives: The primary aim was to examine the relationships between perceived and objective measures of the neighbourhood environment, measured in late infancy, and subsequent overweight (including obesity) in 3-year-old children and their mothers. The secondary aim was to assess whether moving residence confounded these relationships.

Methods: We analysed data on 8154 children and their mothers from the UK Millennium Cohort Study who had participated since birth and were living in England. At the first contact (late infancy), mothers reported their perceptions of their neighbourhood environment and objective measures of the neighbourhood environment were obtained by linking national deprivation data to each child's postcode. We conducted logistic and multilevel regression analyses to examine perceived and objective measures of the neighbourhood environment, respectively, and overweight at the second contact (3 years) in children and their mothers. All analyses were adjusted for moving residence.

Results: There were few consistent patterns between measures of the neighbourhood environment (perceived or objective) and early childhood overweight. However, mothers' risk of overweight increased with increasingly poor neighbourhood conditions (perceived) or residence in areas of increasing deprivation (objective), after adjustment for individual socio-demographic factors. All relationships were maintained after adjustment for moving residence.

Conclusions: While area-level factors have limited influence on the development of overweight in preschool children, they are likely to affect overweight in their mothers. Policies need to address both individual and environmental factors to tackle obesity and its determinants across the lifecourse.

Introduction

The increasing prevalence of obesity among children and adults has been attributed to changes in the environment, characterised by fewer opportunities to engage in physical activity and access healthy foods (1-4). Despite high levels of obesity in young children from resource-rich countries (5,6), only a few studies have examined whether community-level factors influence obesity in preschool children (7). These studies have reported no associations between early childhood overweight and mothers' perceptions of access to neighbourhood facilities (8), neighbourhood conditions (8), or safety (9) nor with objective measures of the environment, including police-reported crime, and proximity to playgrounds or fast food restaurants (10). A recent study from Australia found few differences in perceived measures of the environment between overweight and normal weight children (11). An additional study in Canadian preschool children found that girls were less likely to be overweight if they lived in walkable neighbourhoods with high intersection density, but no relationships were evident among boys (12). In contrast, obesity in school-age children has been inversely associated with parental perceptions of neighbourhood safety (13) and directly associated with perceptions of heavy traffic and concerns about road safety (8). Neighbourhood deprivation (an area-level indicator based on socioeconomic position of residents or neighbourhood factors, such as crime or housing) has also been directly associated with obesity in older children (14-16). However, these studies were all cross-sectional and only one study in school-age

children was nationally representative (16), limiting the ability to make causal inferences and the generalisability of findings. Furthermore, none of the research in children has examined both perceived and objective measures of the environment in the same study sample.

There is a substantial body of evidence on the neighbourhood environment and adult obesity. Adults are more likely to be obese if they perceive their neighbourhood to be unsafe (17,18) or have facilities, such as sidewalks, that are poor or lacking (19,20). Obesity in adults has also been directly associated with neighbourhood deprivation (21-23) or residence in areas with poor infrastructure (17,19) or neighbourhood characteristics, such as presence of garbage (20). Studies that have examined perceived and objective measures of the environment in the same study sample have reported that both measures are related to overweight (17,19,20). Research in adults has also been cross-sectional and only one study was nationally representative (21). Although the impact of the neighbourhood environment on obesity has been investigated separately among children and adults, little is known about how the environment could be related to obesity in children and their parents.

We aimed to address these gaps in the evidence base. Our primary aim was to examine the relationship between perceived and objective measures of the neighbourhood environment, measured in late infancy, and subsequent overweight (including obesity) in a nationally representative cohort of 3-year-olds from England and their mothers. Since the Millennium Cohort Study (MCS) is longitudinal, our secondary aim was to assess whether moving residence confounded these relationships.

Methods

Study population

The MCS is a UK-wide prospective study of children born in the new century. Families eligible for Child Benefit (a universal benefit for families with children) and resident in England, Wales, Scotland, or Northern Ireland when their child was aged 9 months were invited to participate (24). The original cohort comprised 18819 children (n=18553 families) born between September 2000 and January 2002 (72% response rate) (25). Approximately 80% (n=14630) participated in the second contact, which occurred between September 2003 and January 2005, when the children were approximately 3 years old (26). At both contacts, information was collected through interviews of main respondents (over 99% were natural mothers) in the home. Data were accessed through the UK Data Archive, University of Essex. The MCS received ethical approval from the South West and London Multi-Centre Research Ethics Committees for the first and second contacts, respectively (27).

Objective measures of the neighbourhood environment, from the Office for National Statistics, were only available for England. Among the 11375 singleton infants from England at the first contact, 81% (n=9184) participated at the second. 8154 singleton children participated at both contacts and were included in the analyses. Families were excluded if the main respondent was not female (n=145), there were two cohort children from the same family (n=8), information was missing on whether the family moved between contacts (n=136), the family originally lived in England but relocated to Scotland, Wales, or Northern Ireland (n=53), or the child had a missing height or weight (n=480) or a height-for-age, weight-for-age, or body mass index-for-age z-

score $\leq$-5 or $\geq$5 (BMI; weight/height^2) (n=295). Some participants satisfied more than one exclusion criterion. In the final sample, 68% (n=5600) of families lived at the same residence at both contacts, 25% (n=1975) moved once between contacts, and the remaining 7% (n=579) moved more than once.

Outcome variables

At the second contact children (approximately 3 years old) were weighed and measured, without shoes or outdoor clothing, by trained interviewers. Weights were collected using Tanita HD-305 scales (Tanita UK Ltd, Middlesex, UK) and recorded to the nearest 0.1 kg. Heights were measured by a Leicester Height Measure Stadiometer (Seca Ltd, Birmingham, UK) and recorded to the nearest 0.1 cm. Childhood overweight (including obesity) was defined by the International Obesity TaskForce cut-offs for BMI (28).

Mothers reported their current height at the first contact and current weight at the second contact. Mothers with a BMI$\geq$25 kg/m^2 were considered overweight (including obesity). Among mothers, 6874 had complete and plausible BMI data; the remaining were missing (n=1259) or implausible (height, weight, or BMI z-score $\leq$-5 or $\geq$5) (n=21). Nearly half of mothers with missing data (n=610) were pregnant and weight data were not collected.

Perceived measures of the neighbourhood environment

At the first contact, mothers were asked questions about the family's neighbourhood environment. Mothers reported on "how common are food shops and supermarkets that are easy to get to", "how satisfied or dissatisfied are you with the area you live in.

By your area, I mean within about a mile or 20 minutes walk of here", "are there any places where children can play safely", and "do you have access to a garden". Mothers also reported on their family's neighbourhood conditions and how common the following were (coded as 1 'very common', 2 'fairly common', 3 'not very common', 4 'not at all common'): "noisy neighbours or loud parties"; "rubbish or litter lying around"; "vandalism and deliberate damage to property"; "pollution, grime or other environmental problems". The scores of these four questions were summed and divided into the following groups: 'very common' (summed score 1-7), 'fairly common' (8-10), 'not very common' (11-13), 'not at all common' (14-16).

Objective measures of the neighbourhood environment

Objective measures of the neighbourhood environment were based on Indices of Deprivation data, from the Office for National Statistics (http://www.neighbourhood.statistics.gov.uk), and linked to each child's postcode from their residence at the first contact. The Index of Multiple Deprivation (IMD) at the ward level (unit based on 1998 boundaries) is a weighted sum of the following indices derived from the 2001 Census: income (25%); employment (25%); health deprivation and disability (15%); education, skills and training (15%); housing (10%); geographical access to services (10%). Each ward received an IMD rank from 1 (most deprived) to 8,414 (least deprived). The IMD at the super output area level (SOA; an average of 1,500 people and equivalent to approximately a quarter of a ward) is a weighted sum of the following indices derived from the 2001 Census: income deprivation (22.5%); employment deprivation (22.5%); health deprivation and disability (13.5%); education, skills and training deprivation (13.5%); barriers to housing and services (9.3%); crime (9.3%); living environment deprivation (9.3%).

Each SOA received an IMD rank from 1 (most deprived) to 32,482 (least deprived). The ward and SOA ranks were each divided into fifths.

Individual risk factors for overweight

Risk factors were chosen based on prior research on childhood obesity (7, 29). Children's individual risk factors for overweight were based on maternal self-report at the first contact, unless specified. The child's ethnicity was categorised according to guidelines from the Office for National Statistics (30), maternal socioeconomic circumstances were classified according to the National Statistics Socio-economic Classification (31), maternal education was defined as the highest academic qualification attained, and lone motherhood status was defined as being a lone mother at 9 months postpartum. The child's gender and the mother's age at the cohort member's birth were also recorded. Mothers reported the following: 1) whether they smoked any cigarettes throughout pregnancy, 2) their child's birthweight, 3) duration of breastfeeding, and 4) when the infant was introduced to solid foods. Household income at the second contact was included as a measure of mothers' current socioeconomic circumstances. If missing, values from the first contact were substituted (n=903). At the second contact, mothers also reported the number of hours the child watched television or videos daily. Maternal overweight (including obesity) at the second contact was as previously defined.

Mothers' individual risk factors for overweight were: maternal ethnicity, socioeconomic circumstances, household income, highest academic qualification, age at MCS birth, lone motherhood status (all previously defined).

Data analysis

All analyses were conducted using STATA statistical software, version 9.2 SE (Stata Corporation, Texas), with survey commands to account for the clustered sampling design and obtain robust standard errors. Weighted percentages were derived and analyses were conducted using sample and non-response weights to allow for the clustered sampling and attrition between contacts. Children's individual risk factors for overweight and perceived measures of the neighbourhood environment were compared between non-movers and those who moved between contacts. Proportions were compared using Pearson's chi-squared tests with the Rao and Scott second order correction (32). Means were compared using an adjusted Wald test.

Univariable logistic regression analyses were conducted to calculate odds ratios for childhood and maternal overweight, separately, for each perceived measure of the neighbourhood environment. Analyses were repeated separately for each perceived measure with adjustment for the individual risk factors already listed for each, then adjustment for moving residence.

Two-level regression models were developed to examine the relationships between childhood and maternal overweight and objective measures of the neighbourhood environment, taking into account the hierarchical structure of the data (families clustered within wards or SOAs). Children or their mothers were included at level 1, the lowest level, and the area (ward or SOA) was included at level 2. Two multilevel logistic regression models were conducted to calculate odds ratios for childhood and maternal overweight, separately, by the ward and SOA IMD. Analyses were repeated separately for the ward and SOA IMD with adjustment for the individual risk factors

already listed for each, then adjustment for moving residence. The multilevel models

were analysed using gllamm software, a program in STATA that fits generalised

linear latent and mixed models using an adaptive quadrature method (33).

Results

At age 3, 17.5% (n=1387) of children were overweight and 5.0% (n=412) were obese.

There was no difference in overweight (including obesity) between children who

moved between contacts (prevalence 22%) and those who did not (23%). Among

mothers, 25.5% (n=1781) were overweight and an additional 13.8% (n=1001) were

obese. Mothers who moved were less likely to be overweight (including obesity) than

mothers who did not (Table 1).

A comparison between families who were non-movers and those who moved between

contacts revealed that non-movers had more advantaged socio-demographic profiles

than families who had moved (Table 1). Overall, at the first contact most families

reported good access to food shops, places to play and a garden; poor neighbourhood

conditions were not very common; and they were generally satisfied with where they

lived. However, families who moved subsequently were more likely to report poor

neighbourhood conditions, to be dissatisfied with where they lived, and to not have

access to a garden (all p<.001; data not shown).

Preschool children – perceived measures

In unadjusted analyses, there were few consistent patterns between early childhood

overweight and perceived measures of the neighbourhood environment (Table 2).

After adjustment for individual risk factors and moving residence, children were more

likely to be overweight if their mother reported that the child did not have access to a garden (compared to those who did). However, after adjustment, children were less likely to be overweight if their mother reported that poor neighbourhood conditions were very common (compared to not at all common).

Preschool children – objective measures

Relationships between objective measures of the neighbourhood environment and early childhood overweight were evident in unadjusted analyses only (Table 2). At the ward and SOA level, children from the most deprived areas were more likely to be overweight than children from the least deprived areas.

Mothers – perceived measures

Mothers' risk of overweight was greater if they perceived their neighbourhood environment to be more disadvantaged (Table 3). After adjustment for individual risk factors and moving residence, mothers were more likely to be overweight if they reported that poor neighbourhood conditions were very or not very common (compared to not at all common) (test for trend; p=.002); were fairly satisfied, neither satisfied nor dissatisfied, or very dissatisfied with the area where they lived (compared to very satisfied) (test for trend; p=.007); or the child did not have any places to play safely (compared to those who did).

Mothers – objective measures

Mothers' risk of overweight increased with increasing deprivation at both the ward and SOA level (Table 3). After adjustment for individual socio-demographic

characteristics and moving residence, the effect sizes attenuated, but the trends remained statistically significant.

Among the 1280 mothers with missing or implausible BMI data from the second contact, 931 had complete and plausible data from the first contact. Analyses were repeated for 7805 mothers using BMI data from the first (n=931) or second (n=6874) contacts to check the validity of the results. Relationships were similar to those presented in Table 3 (data not shown).

Discussion

Patterns of associations between measures of the neighbourhood environment and overweight differed for mothers and preschool children. Children were more likely to be overweight if they did not have access to a garden. Mothers' risk of overweight increased with their perception of increasingly poor neighbourhood conditions and with objective measures of increasing area deprivation. These relationships were independent of individual socio-demographic factors, indicating that the effect of the neighbourhood environment was not simply a reflection of the individual characteristics of the residents who lived there. Although families who moved residence between contacts had worse socio-demographic profiles and perceptions of their neighbourhood environment than non-movers, all relationships were maintained after adjustment for moving residence.

To our knowledge this is the first study of preschool children that was nationally representative, examined both perceived and objective measures of the neighbourhood environment, and investigated the impact of these measures on overweight in their

mothers. Since the MCS is longitudinal, we were able to assess how exposure to the neighbourhood environment at the first contact influenced early childhood and maternal overweight at the second contact as well as whether moving residence between contacts confounded these relationships. The perceived measures of the neighbourhood environment were not from a validated questionnaire or developed to be analysed in this way, so it is unknown whether the questions were fully understood by mothers or if they interpreted the questions/responses in the same way. Perceptions of the neighbourhood were only asked to mothers and there was low partner self-reporting of weight (66%), so we were not able to examine these relationships among fathers.

Although we found limited evidence for a relationship between environmental factors and early childhood overweight, other studies in preschool children have also reported few associations between perceived (8,9,11) or objective (10,12) measures and overweight. The large MCS sample has adequate power to detect relationships, so our findings suggest that the neighbourhood environment is likely to have a limited influence on the development of early childhood overweight. We also found that children were less likely to be overweight if their mother reported that poor neighbourhood conditions were very common. The MCS is longitudinal and these relationships can be re-examined when the children are school-age and older.

Mothers' perceptions of their neighbourhood environment and objective measures of the neighbourhood environment were associated with overweight, which is consistent with other research in adults (17-23). Studies that have examined perceived and objective measures in the same study sample have also reported that both factors were

related to obesity (17,19,20). We found that the SOA IMD had a slightly stronger relationship with maternal overweight than ward IMD, suggesting that mothers immediate environment may be more likely to influence their health behaviours and obesity than the wider surrounding area.

Families who moved residence between contacts tended to have worse socio-demographic profiles and perceptions of their neighbourhood environment than non-movers, which is consistent with previous research (34). Mothers reported that the main reasons for moving residence were to live in a larger home (47%), in a better area (22%), and in a better home (21%). Since the relationships between measures of the neighbourhood environment and overweight were maintained after adjustment for moving residence between contacts, this suggests that longitudinal studies on preschool children and mothers may not need to exclude families who have recently moved residence.

There was some evidence that mothers' perceptions of their neighborhood were related to objective measures of the environment. 62% of mothers who lived in the most deprived areas, based on SOA IMD, reported that poor neighborhood conditions were very common, while only 1% of mothers who lived in the least deprived areas reported these conditions. The strength of the associations between maternal overweight and perceived neighborhood conditions and IMD were also similar, suggesting that they may be measuring related constructs. Future studies that explore perceptions of the neighborhood and the physical environment in the same study sample may help determine whether perceived and objective measures are assessing similar constructs as well as whether one measure is more important than the other.

Further understanding of these measures can inform whether policies and interventions should focus on changing the environment, perceptions of the environment, or both.

There is some evidence on how the neighbourhood environment may influence the determinants of obesity in children and adults. Research has found that the physical environment (35,36) and parental perceptions of the neighbourhood environment (37,38) are related to children's physical activity levels. We found some evidence that 3-year-old children were more likely to be overweight if they did not have access to a garden, suggesting that limited opportunities to be outdoors in close proximity to their home may reduce young children's physical activity levels. Parents' perceived safety of their neighbourhood is also inversely associated with television use in preschool children (9). However, there is little known about how the neighbourhood environment influences children's dietary patterns. In adults, area deprivation is also directly related to physical inactivity (21,39) and poor diet (40). We found that mothers' risk of overweight increased if they reported there were not any places for children to play safely, suggesting that limited access to these facilities may have affected mothers' engagement with the neighbourhood and participation in physical activity. Parents' health behaviours have also been found to influence children's physical activity (7,36,41), sedentary behaviours (7,41), and dietary patterns (7,41).

Addressing the rising prevalence of obesity is a priority for government in England (42) and worldwide (43,44). Ecological models (1,2,41) can help inform whether policies and interventions targeting obesity should be implemented at the individual or community level. Although we found limited evidence for a relationship between

perceived and objective measures of the neighbourhood environment and overweight in young children, our findings in mothers and other research in school-age children (8,13-16) and adults (17-23) suggest that community-level factors may be more important when children are older and have greater exposure to the neighbourhood environment. For younger children, policies and interventions that focus on individual risk factors (1,7), such as supporting breastfeeding (45), may be beneficial for addressing early childhood obesity. Targeting the environment is likely to be more effective at tackling obesity in school-age children and adults.

Acknowledgements

Ethical approval

The Millennium Cohort Study was approved by the South West and London Multi Centre Research Ethics Committees. The present analyses did not require additional ethics approval.

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Table 1. Risk factors for overweight for families who had the same residence at both

contacts (non-movers) and those who moved between contacts.

	All families (N=8154), n (weighted %)	Non-movers (N=5600), n (weighted %)	Moved between contacts (N=2554), n (weighted %)
Child's ethnic group			
White	6256 (85)	4218 (85)	2038 (87)
Mixed	310 (4)	196 (3)	114 (4)
Indian	319 (2)	249 (3)	70 (2)
Pakistani or Bangladeshi	747 (5)	557 (5)	190 (4)
Black Caribbean or Black African	355 (3)	264 (3)	91 (3)
Other ethnic group	146 (1)	104 (1)	42 (1)
Missing	21	12	9
		p<.001	
Child's gender			
Male	4106 (50)	2850 (51)	1256 (49)
Female	4048 (50)	2750 (49)	1298 (51)
Missing	0	0	0
		p=.09	
Maternal socioeconomic circumstances			
Managerial & professional occupations	2278 (31)	1598 (32)	680 (28)
Small employers & own account workers	313 (4)	222 (5)	91 (4)
Intermediate occupations	1423 (19)	984 (19)	439 (18)
Lower supervisory & technical occupations	404 (5)	268 (5)	136 (6)
Semi-routine & routine occupations	2763 (34)	1836 (33)	927 (38)
Never worked & long-term unemployed	875 (7)	628 (7)	247 (7)
Missing	98	64	34
		p<.001	
Household income			
£33000+ per annum	2005 (28)	1404 (29)	601 (25)
£22000-33000 per annum	1739 (23)	1273 (25)	466 (19)
£11000-22000 per annum	2334 (28)	1618 (28)	716 (28)
£0-11000 per annum	1882 (22)	1155 (19)	727 (28)
Missing	194	150	44
		p<.001	
Maternal highest academic qualification			
GCSE grades A-C or higher[1]	5828 (74)	4005 (75)	1823 (73)
GCSE grades D-G or lower	2310 (26)	1581 (26)	729 (27)
Missing	16	14	2
		p=.2	
Lone motherhood status			
Lone mother	1122 (13)	669 (11)	453 (18)
Non-lone mother	7032 (87)	4931 (89)	2101 (82)
Missing	0	0	0
		p<.001	
Mean age at MCS birth (years; mean [SE])	29 (0.1)	30 (0.1)	27 (0.2)
Missing	5	4	1
		p<.001	
Maternal overweight			
Overweight (including obesity)	2782 (39)	1973 (40)	809 (37)
Normal weight	4092 (61)	2760 (60)	1332 (63)
Missing	1280	867	413
		p=.02	
Smoked during pregnancy			
Yes	2548 (34)	1580 (30)	968 (41)
No	5569 (66)	3992 (70)	1577 (59)

	Missing	37	28	9
				p<.001
Mean birthweight (kg; [SE])		3.37 (0.01)	3.38 (0.01)	3.35 (0.01)
	Missing	17	15	2
				p=.05
Breastfeeding duration				
	≥ 4 months	2393 (29)	1728 (31)	665 (26)
	< 4 months	3544 (43)	2402 (42)	1142 (43)
	Never breastfed	2208 (28)	1461 (27)	747 (31)
	Missing	9	9	0
				p<.001
Introduction of solid foods				
	< 4 months	2639 (35)	1816 (35)	823 (34)
	≥ 4 months	5508 (65)	3777 (65)	1731 (66)
	Missing	7	7	0
				p=.5
Television viewing daily				
	Less than 1 hour	1898 (23)	1294 (23)	604 (24)
	1-2 hours	4768 (60)	3282 (60)	1486 (59)
	3+ hours	1488 (17)	1024 (17)	464 (18)
	Missing	0	0	0
				p=.7

[1]A General Certificate of Secondary Education (GCSE) is a qualification taken by

secondary school students aged approximately 14-16 years.

Table 2. Odds ratios for overweight in children aged 3 years by perceived and objective measures of the neighbourhood environment (N=8154).

	n (weighted % overweight)	Unadjusted OR	Adjusted OR[1]	Adjusted OR[1,2]
Perceived measures of the neighbourhood environment				
Easy access to food shops and supermarkets				
Very common	4725 (22)	1	1	1
Fairly common	2343 (22)	1.04 (0.92, 1.17)	1.02 (0.89, 1.17)	1.02 (0.89, 1.17)
Not very common	696 (27)	1.30 (1.04, 1.61)	1.23 (0.98, 1.54)	1.23 (0.98, 1.54)
Not at all common	374 (24)	1.12 (0.87, 1.45)	1.17 (0.88, 1.55)	1.17 (0.88, 1.55)
Missing	16			
Neighbourhood conditions – noisy neighbours, rubbish, vandalism, pollution				
Not at all common	2645 (22)	1	1	1
Not very common	3331 (22)	1.00 (0.88, 1.14)	0.96 (0.83, 1.11)	0.96 (0.83, 1.12)
Fairly common	1565 (25)	1.17 (0.99, 1.37)	1.12 (0.92, 1.38)	1.13 (0.92, 1.39)
Very common	600 (21)	0.93 (0.74, 1.17)	0.73 (0.54, 0.97)	0.73 (0.55, 0.98)
Missing	13			
Satisfaction with area where family lives				
Very satisfied	3159 (21)	1	1	1
Fairly satisfied	3353 (23)	1.13 (1.00, 1.27)	1.09 (0.95, 1.25)	1.09 (0.95, 1.25)
Neither satisfied nor dissatisfied	661 (26)	1.31 (1.06, 1.63)	1.15 (0.90, 1.48)	1.16 (0.91, 1.49)
Fairly dissatisfied	618 (23)	1.11 (0.88, 1.39)	1.02 (0.78, 1.34)	1.03 (0.79, 1.35)
Very dissatisfied	348 (21)	0.98 (0.73, 1.31)	0.91 (0.64, 1.28)	0.92 (0.65, 1.30)
Missing	15			
Whether there are any places where children can play safely				
Yes	5002 (22)	1	1	1
No	3020 (23)	1.08 (0.95, 1.22)	1.02 (0.88, 1.18)	1.02 (0.88, 1.18)
Missing	132			
Access to a garden				
Yes	7200 (22)	1	1	1
No	945 (27)	1.31 (1.08, 1.60)	1.30 (1.02, 1.64)	1.31 (1.04, 1.66)
Missing	9			
Objective measures of the neighbourhood environment				
Ward - Indices of Multiple Deprivation				
(Least deprived) 1	1013 (21)	1	1	1
2	735 (22)	1.09 (0.86, 1.37)	0.96 (0.73, 1.28)	0.96 (0.73, 1.28)
3	1111 (23)	1.15 (0.94, 1.42)	1.08 (0.85, 1.37)	1.08 (0.85, 1.37)
4	1745 (21)	1.03 (0.84, 1.25)	0.90 (0.72, 1.14)	0.91 (0.72, 1.15)
(Most deprived) 5	3550 (24)	1.23 (1.02, 1.49)	1.11 (0.87, 1.42)	1.12 (0.88, 1.42)
Test for trend		p=.06	p=.5	p=.5
Area level variance (SE)		0.03 (0.02)	0.03 (0.02)	0.03 (0.02)
Super Output Area – Indices of Multiple Deprivation				
(Least deprived) 1	1151 (21)	1	1	1
2	1182 (22)	1.06 (0.85, 1.31)	1.10 (0.87, 1.40)	1.11 (0.88, 1.40)
3	1456 (22)	1.10 (0.89, 1.34)	0.96 (0.76, 1.20)	0.96 (0.77, 1.20)
4	1809 (23)	1.15 (0.95, 1.40)	1.12 (0.89, 1.40)	1.12 (0.89, 1.40)
(Most deprived) 5	2556 (24)	1.20 (1.00, 1.44)	1.11 (0.87, 1.41)	1.11 (0.87, 1.41)
Test for trend		p=.03	p=.4	p=.4
Area level variance (SE)		0.11 (0.04)	0.08 (0.05)	0.08 (0.05)

CI=confidence interval; OR=odds ratio; SE=standard error

[1]Adjusted for child's ethnic group, child's gender, socioeconomic circumstances, household income, highest academic qualification, lone motherhood status, age at

MCS birth, maternal overweight, smoked during pregnancy, birthweight,

breastfeeding duration, introduction of solid foods, television viewing

[2]Adjusted for moving residence between contacts

Table 3. Odds ratios for overweight in mothers by perceived and objective measures of the neighbourhood environment (N=6874).

	n (weighted % overweight)	Unadjusted OR	Adjusted OR[1]	Adjusted OR[1,2]
Perceived measures of the neighbourhood environment				
Easy access to food shops and supermarkets				
Very common	3991 (39)	1	1	1
Fairly common	1971 (39)	1.01 (0.90, 1.15)	1.02 (0.90, 1.15)	1.02 (0.90, 1.15)
Not very common	600 (40)	1.03 (0.85, 1.25)	1.01 (0.83, 1.22)	1.00 (0.83, 1.22)
Not at all common	304 (40)	1.03 (0.78, 1.36)	1.05 (0.80, 1.38)	1.05 (0.80, 1.37)
Missing	8			
Neighbourhood conditions – noisy neighbours, rubbish, vandalism, pollution				
Not at all common	2300 (35)	1	1	1
Not very common	2784 (41)	1.29 (1.14, 1.46)	1.24 (1.10, 1.41)	1.25 (1.11, 1.42)
Fairly common	1310 (42)	1.31 (1.11, 1.53)	1.18 (1.00, 1.40)	1.20 (1.01, 1.42)
Very common	473 (46)	1.56 (1.22, 1.99)	1.40 (1.08, 1.80)	1.43 (1.11, 1.84)
Missing	7			
Satisfaction with area where family lives				
Very satisfied	2729 (37)	1	1	1
Fairly satisfied	2781 (41)	1.20 (1.06, 1.35)	1.13 (1.00, 1.28)	1.14 (1.01, 1.29)
Neither satisfied nor dissatisfied	544 (43)	1.33 (1.08, 1.65)	1.30 (1.05, 1.62)	1.33 (1.06, 1.66)
Fairly dissatisfied	519 (42)	1.26 (1.02, 1.55)	1.15 (0.93, 1.43)	1.18 (0.95, 1.47)
Very dissatisfied	294 (45)	1.41 (1.08, 1.84)	1.28 (0.97, 1.67)	1.31 (0.99, 1.72)
Missing	7			
Whether there are any places where children can play safely				
Yes	4267 (38)	1	1	1
No	2508 (43)	1.24 (1.09, 1.40)	1.16 (1.02, 1.31)	1.16 (1.02, 1.31)
Missing	99			
Access to a garden				
Yes	6112 (39)	1	1	1
No	758 (42)	1.12 (0.91, 1.37)	0.99 (0.80, 1.22)	1.01 (0.82, 1.24)
Missing	4			
Objective measures of the neighbourhood environment				
Ward - Indices of Multiple Deprivation				
(Least deprived) 1	901 (33)	1	1	1
2	656 (37)	1.18 (0.93, 1.51)	1.10 (0.86, 1.41)	1.10 (0.86, 1.41)
3	937 (35)	1.18 (0.93, 1.49)	1.08 (0.85, 1.37)	1.08 (0.86, 1.37)
4	1496 (43)	1.53 (1.25, 1.88)	1.36 (1.09, 1.68)	1.36 (1.10, 1.69)
(Most deprived) 5	2884 (44)	1.68 (1.41, 2.02)	1.39 (1.13, 1.72)	1.40 (1.13, 1.72)
Test for trend		p<.001	p=.001	p<.001
Area level variance (SE)		0.06 (0.02)	0.06 (0.02)	0.06 (0.02)
Super Output Area – Indices of Multiple Deprivation				
(Least deprived) 1	1008 (33)	1	1	1
2	1040 (35)	1.06 (0.86, 1.30)	1.03 (0.84, 1.27)	1.03 (0.84, 1.28)
3	1267 (38)	1.25 (1.03, 1.52)	1.12 (0.91, 1.38)	1.13 (0.92, 1.38)
4	1528 (42)	1.47 (1.22, 1.78)	1.32 (1.07, 1.62)	1.32 (1.08, 1.63)
(Most deprived) 5	2031 (47)	1.86 (1.57, 2.22)	1.58 (1.28, 1.95)	1.59 (1.29, 1.96)
Test for trend		p<.001	p<.001	p<.001
Area level variance (SE)		0.15 (0.04)	0.14 (0.04)	0.14 (0.04)

CI=confidence interval; OR=odds ratio; SE=standard error

[1]Adjusted for maternal ethnic group, socioeconomic circumstances, household income, highest academic qualification, lone motherhood status, age at MCS birth

[2]Adjusted for moving residence between contacts