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Abstract: A large body of literature has shown marked differences in the average levels of resources and child well-being across different family structures. Studies have examined cognitive, educational and behavioural outcomes; less is known about differentials in physical health, and about dynamics in early childhood.
Furthermore, up to the present time, less emphasis has been placed on describing the underlying mechanisms relating childhood experience of family structure to health. In this paper, we hypothesize that socio-economic characteristics and family structure trajectories will affect every-day, more proximal processes (material, behavioral and family stress pathways) directly experienced by the child, which will in turn affect child health.
Using the UK Millennium Cohort Study, a nationally representative cohort of over 19,000 children born in 2001 and living in the UK shortly thereafter, we employ Graphical Chain Models to map the processes linking family structure trajectories to three physical health outcomes at age 5: overweight/obesity, respiratory health, and accidental injury. We construct family trajectories to highlight two components: status (distinguishing between married, cohabiting and single parents), and (in)stability.
We show that both status, the (in)stability of that status, and their interplay, are important components of family structure trajectories which correlate to children's early physical health. Analyses highlight the relative importance of distinct pathways across different health outcomes. As well as some outcome-specific paths, we find that "family stress" variables appeared to underscore the relationship between family structure and child physical health, pointing to the importance of such variables in understanding how family structure relates to early child health.

Response to reviewers

Family Structure Trajectories and Early Child Health in the UK: Pathways to Health

17th December 2018

Dear Editor,

Thank you for allowing us to revise our paper, *Family Structure Trajectories and Early Child Health in the UK: Pathways to Health* (Manuscript ID SSM-D-18-02463). We are pleased to be able to submit a revised paper. Below, we set out how we have addressed the comments made by the reviewers. Overall, the revisions clarify our methods to choose model variables; we also run additional analyses to check that some of the variables suggested the reviewer do not correlate with the outcome variables.
Thank you for your time and we look forward to hearing from you.

Sincerely,
Authors

NOTE: Reviewer's comments (verbatim) are in standard font. Authors' responses are in italics. The page numbers refer to pages in the marked up version of the resubmitted text.

Reviewer 2

This paper is a valuable contribution to the literature and the manuscript has been improved by the authors' revisions.

We thank the reviewer for their positive overall assessment of our paper.

My only issue is that I'm still not sure that the strategy of selecting mechanism variables in the models for different outcomes is made sufficiently clear in the text. I'm happy with the way control variables such as grandparents' education have been excluded, but it is still not clear whether links between all the physical, emotional and health behaviour mechanism variables were tested for all three outcomes. I previously raised the question of whether, for example, sedentary behaviour was empirically linked to accidents and respiratory illness as well as obesity, and suggested that exclusions be tested rather than simply assumed. The text on p.20 says simply "we considered variables that are specific to each health outcome" which makes it sound to the reader as if the selection of mechanism variables for each outcome was not tested empirically.

We thank you the reviewer for this comment, which has allowed us to further clarify our process of model selection in the manuscript. Furthermore, we have implemented additional analyses to check that we were not deselecting important mechanism variables.

As previously mentioned, we do not use an automated selection process, but manually selected variables. First, all theoretically important variables were not included in this *selection process and where directly retained in the final models, it is only more exploratory relationships that were manually tested with a forward/backward approach. For example, for the socio-economic variables, parental education was not tested in this selection procedure and directly included in the final models, while we tested the importance of car ownership (retained) and co-residence with a grandparent (not retained in final models). For mechanism variables, we do adapt each model to the outcome; that is, we allow variables to be retained in one health-specific model but not another, for either theoretical or empirical reasons. This allows having models that are meaningful to each health outcome.*

We do recognize that the question of which variables to include in a model is difficult and different disciplines have very different approaches to this issue. Biomedical sciences are more likely to use extensive sets of covariates. Often social scientists prefer choosing a smaller list and attempt to justify (theoretically and empirically) the inclusion of each variable. Because we try to identify potential mechanisms and not just control out for potential confounders, we have decide to only include in our selection procedure variables that were theoretically relevant (according to the literature) for each outcome. This allows ensuring that variables included are both empirically and theoretically linked to the outcome.

However, to answer the reviewer's concern about certain potential mechanisms that we might be excluding, such as sedentary behaviour and respiratory health and injuries, we checked all correlations between all mechanisms variables used in any model and our health outcome variables. The correlations are relatively week (coefficients range from 0.0024 to 0.0472) and none are significant at the 0.005 level. Some are however significant at the 0.010 level: asthma with screen use (correlation coefficient: 0.0423) and with use of a car as a passenger (0.0472); wheezing and with screen use (correlation coefficient: 0.0462) and with use of a car as a passenger (0.0430). When entered in a logistic regression model using Block 1 (Socio-economic antecedents) covariates to check that correlations are not just driven by socio-economic variables, use of a car as a passenger is no longer significant with either asthma or recent wheeze, however, screen time is still associated with wheeze (OR=0.75, p-value 0.008) and less so with asthma (OR=0.85, p-value 0.072). Because of how the variable is coded, these OR can be interpreted as lower daily screen time exposure is correlated with lower risk of asthma or wheeze (i.e. long daily exposure to screens is detrimental to respiratory health).

Exercise conditioning has been endorsed by the medical community as positive for patients with asthma (see for example American College of Sports Medicine and the American Thoracic Society guidelines on the subject[1]*). While the aetiology linking exercise and asthma is not fully understood (Lucas and Platts-Mills, 2005), and usually relates to adults rather than children, there is some evidence linking both physical activity (Lochte et al., 2016) and inactivity in childhood to future onset of asthma (Sheriff et al., 2009). We have therefore added this variable to the respiratory health models. As a result, tables 4 and 3C (in the Supplementary materials) have been modified. As shown in these tables, screen use does not*

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1 American College of Sports Medicine. 2000. ACSM's guidelines for exercise testing and prescription. 6th ed. Lippencott Williams & Wilkins, Philadelphia.

American Thoracic Society. 1999. Pulmonary rehabilitation. American Journal Respiratory Critical Care Medicine; 159: 1666–1682 *remain significant in the final models, and its introduction in the model only changes very marginally the other estimates. We also include text to the conceptual model section (p. 9) to justify the inclusion of sedentary behaviour to the respiratory model. We clarify further our selection strategy for mechanism variables briefly in the methods section (p. 16). We do not further expand in the methods section about model selection because of word limit, but we would be happy to further clarify this section if the reviewer and/or editors feel it would be beneficial.*

In general, the relationship between the four "Level 3" boxes in Figure 1, and what are called blocks 3 to 6 in the supplementary materials, are not clearly explained. Block 5 variables seem to consist of different variables in different tables and the reasoning behind this is not currently well justified. It would be clearer to just show four different tables in the supplementary materials, each of which shows the relationships between the Level 1 and 2 variables and ALL the Level 3 variables in a specific block (in the way currently done for block 3). And then make clear in the reporting of the results in Tables 4 to 6 of the main text that Level 3 variables excluded from the model for a particular outcome variable were not statistically significant predictors. It may be that I am not fully understanding the strategy behind selection of the Level 3 variables included in different models, but this again suggests that the explanation could be strengthened.

We do agree with the reviewer that Graphical Chain models produce a large quantity of tables, and this is multiplied by our outcome-wide approach. Because mechanisms (i.e., Level 3 variables) do vary across our three outcome-specific models, in particular for the behavioural and physical environment blocks, we are not able to consolidate these tables: each regression includes slightly different mechanism variables, depending on the outcome. As a result, although estimates in these tables (Tables 3C, 3D and 3E, i.e. those relating to behaviour and the physical environment) are not very different, they are not exactly the same as each time different covariates will have been included in the regression model. We hope that having further explained above why mechanisms are different for each health outcome model, it is now clearer why there are so many tables in the Supplementary Materials. We again reiterate that we would be happy to further add text to the Methods section to supplement our brief further explanation (p.16) if the reviewer or editors feel this would be useful.

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Cover Page

Family Structure Trajectories and Early Child Health in the UK: Pathways to Health

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Family Structure Trajectories and Early Child Health in the UK: Pathways to Health

Abstract

A large body of literature has shown marked differences in the average levels of resources and child well-being across different family structures. Studies have examined cognitive, educational and behavioural outcomes; less is known about differentials in physical health, and about dynamics in early childhood.

Furthermore, up to the present time, less emphasis has been placed on describing the underlying mechanisms relating childhood experience of family structure to health. In this paper, we hypothesize that socio-economic characteristics and family structure trajectories will affect every-day, more proximal processes (material, behavioral and family stress pathways) directly experienced by the child, which will in turn affect child health.

Using the UK Millennium Cohort Study, a nationally representative cohort of over 19,000 children born in 2001 and living in the UK shortly thereafter, we employ Graphical Chain Models to map the processes linking family structure trajectories to three physical health outcomes at age 5: overweight/obesity, respiratory health, and accidental injury. We construct family trajectories to highlight two components: status (distinguishing between married, cohabiting and single parents), and (in)stability.

We show that both status, the (in)stability of that status, and their interplay, are important components of family structure trajectories which correlate to children's early physical health. Analyses highlight the relative importance of distinct pathways across different health outcomes. As well as some outcome-specific paths, we find that "family stress" variables appeared to underscore the relationship between family structure and child physical health, pointing to the importance of such variables in understanding how family structure relates to early child health.

Family Structure Trajectories and Early Child Health in the UK: Pathways to Health

Submission to Social Science & Medicine

Paper Highlights:

- Family structure trajectories are correlated to early child physical health
- Both status (married, cohabiting, single) and instability were important features
- We know little about the mechanisms relating family structure to early child health
- Family stress appeared to be an important mechanisms across all family trajectories
- Housing quality was important for cohabitors; daily routines for separating parents

Family Structure Trajectories and Early Child Health in the UK: Pathways to Health

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Abstract

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We show that both status, the (in)stability of that status, and their interplay, are important components of family structure trajectories which correlate to children's early physical health. Analyses highlight the relative importance of distinct pathways across different health outcomes. As well as some outcome-specific paths, we find that "family stress" variables appeared to underscore the relationship between family structure and child physical health, pointing to the importance of such variables in understanding how family structure relates to early child health.

Introduction

Families provide a wide range of social, economic and emotional resources that influence child health and development; the average level of these resources varies across different family types. An extensive literature has shown that children growing with two continuously married parents do better on average on several cognitive, emotional and developmental outcomes, in childhood and adulthood [1-5]. We know less about physical health, especially in the early years, a key stage for understanding lifelong health trajectories.

Research on family structure and child outcomes has concentrated on describing differentials, or testing whether associations are causal [6]. Less emphasis has been placed on describing potential underlying proximate processes that might link family structures to child well-being. However, describing plausible mechanisms through which effects could work is important for scholarship, and is useful for public policy purposes. To describe potential underlying processes, considering family structure from a longitudinal and nuanced perspective is important. First, the resources available to different family types and the form and function of the family differ within the broad groups often used: one versus two-parent households, married versus unmarried parents. Furthermore, family structure is not static and children can experience changes, even from early childhood. These trajectories are linked to both available household resources and to markers of child and parental well-being [7, 8]. Thus, detailed and dynamic measures of family structure can help unpack the relationships between family structure and outcomes for children.

This work therefore explores whether family structure trajectories are correlated to three domains of early physical health: respiratory health, overweight/obesity, and accidental injuries, in a nationally representative sample of children residing in the UK. We construct family trajectories to highlight two components of such trajectories: status (distinguishing between married, cohabiting and single parents), and (in)stability (remaining within the same status or moving from one status to another). While remaining descriptive, the focus of our analyses is describing potential proximate processes that could link contextual factors such as family structure trajectories to children's physical health. Different spheres of health are considered to better understand these processes, as we hypothesised that different health outcomes would be associated with different processes. The focus on early childhood allows describing how these relationships develop during a crucial developmental window, and when children spend more time within the family sphere, allowing better capturing family processes.

1.1 How family structure may affect early childhood physical health

While less is known about the link between family structure and child physical health, particularly in the early years, the available studies present results consistent with the wider literature on family structure and– child development. This broader literature has shown that experiences of parental divorce and unmarried parenthood are associated with poorer emotional, psychosocial and educational outcomes, especially for teenagers, while children living in intact two-parent families tend to report the best outcomes [9-11]. For example, work on the Millennium Cohort Study by Kiernan and Mensah (2011) identified differences across a number of family trajectories in children's emotional well-being at 5 years of age [12]. They showed that children who had experienced different family trajectories varied in terms of emotional and behavioral problems, suggesting that family instability and change appears to be important in explaining differences in early childhood behavioural problems. The wider impact of family structure on child well-being has been linked to increasingly polarized experiences of union formation and dissolution across socio-economic groups [13-15].

These negative impacts appears to persist into adulthood, although effects are relatively modest, probably because children who experience parental divorce are not a homogenous group [1, 16]. However, negative effects have persisted over time, even as divorce has become more common and less stigmatized [16]. In particular, the timing of family transitions might be a source of heterogeneity: transitions occurring in early childhood appeared to be especially detrimental to subsequent child development [17].

Turning to studies exploring specifically the association between family structure and child physical health, the few studies available appear to confirm the trends for other child outcomes. They highlight that family instability [18], marital status [19], and their intersection [20], were related to children's physical health outcomes such as asthma, general health status and overweight. However, much of this work employs data from the Fragile Family study, which is representative of particular time periods and sub-groups [21], and relate to a national setting, the USA, with certain socio-demographic characteristics, notably a high proportion of births to single mothers, and high family instability. In fact, the broader evidence for theories around the impact of family structure on child outcomes is primarily from the United States, where economic inequality has been very marked [22]. Different national contexts, such as Australia [23], or Sweden [24], are also reporting similar associations between family structure (and in particular, partnered vs unpartnered households) and child well-being. However, the association between socio-economic background and family structure trajectories events (such divorce or repartnering) appears to differ across countries and over time [25]. Thus, while the relationship between family structure and child well-being seems to be universal, it is not clear whether the mechanisms underlying these correlations can be generalized across countries.

Work specific to the UK is more sparse but expanding. Nationally-representative data from the Millennium Cohort Study has found significant differences according to family structure in well-known predictors of child health such as breastfeeding and parental smoking [8, 26]. These results are reflected in cross-sectional work showing associations between lone parenthood and child general health, long-standing illness, injury, overweight, and asthma [27], and longitudinal analyses showing that living with a lone mother increased the risks of obesity by age 7, compared to continuously living with two biological parents [28]. The emphasis on lone parenthood did not allow distinguishing between married and cohabiting parents, and the focus on causation meant that less attention could be paid to the mechanisms underlying the relationships described.

Hypothesizes that could explain health differentials by family structure can be summarised in two: mechanisms we consider to be largely “upstream” from family structure, notably socio-economic status; and “downstream” or proximate mechanisms, such as parental health behaviours. Starting with “upstream” processes, studies suggest that the relationship between family structure and child well-being may be intricately intertwined and driven by different socio-economic characteristics [1, 27, 29-31]. For example, in the UK, single mothers are more likely to be unemployed and to reside in social housing [32] and to be persistently in poverty [8]. Furthermore, parental separation often entails increases in childhood poverty and deprivation, particularly for more disadvantaged groups [33].

However, socio-economic characteristics and family structure are contextual factors and do not, per se, cause poor health. A number of intertwined pathways have been put forward to explain the “social to biological” transition [34], although this literature has not considered family structure as a key social stratification variable. Classic economic explanations posit that socio-economic differentials produce differences in parents’ abilities to invest in their children’s human capital [35, 36]. For our analyses, this *material pathway* could suggest a role of, for example, housing quality or adequate nutrition. In epidemiology, a *behavioural/lifestyle path* has been extensively tested to explain socio-economic inequalities in health (see Bartley [37] for a review). In the UK, socio-economic position is, for example, linked to smoking, diet, and physical activity [38]. A less explored pathway, from the psychological literature, is *family stress*. Family stress models hypothesize that (financial) stressors affect children through exposure to poor parental mental health, parental conflict and parenting skills [39, 40], which are strongly correlated to child well-being [12, 41, 42]. While Conger’s original model explored adolescent well-being, similar models have since been successfully adapted for young children [12, 31, 43]. While the family stress model has been mostly applied to cognitive and developmental outcomes and less to child health, it is documented that stress is linked to physical health [44], including to child health outcomes such as asthma [45]; and that stress may both mediate between socio-economic difficulties and child health [46] and interact with socio-economic status to impact child health. For example, children from socially or economically disadvantaged households had a greater cardiovascular reactivity to stress than children from higher status households [47]. In fact, recent research has shown how environmental experiences, including poverty and the family environment, affect the underlying neurological, biological and physiological processes governing child development (often referred to how life exposures “get under the skin”). Children have been shown to have a direct impact of stress on their health, similarly to adults, through a physiological health response [48, 49]. In this response, the activation of the hypothalamic-pituitary-adrenal (HPA) axis leads to the secretion of glucocorticoids from the adrenal glands. A chronic secretion of glucocorticoids can damage physical health due to allostatic load processes, i.e. the wear and tear of various physiological systems (metabolic, immune, etc.) related to HPA activation [50].

Disentangling material, behavioural, and stress proximal pathways, is complicated, as these are likely to co-occur and be interdependent (for example, poor parental mental health might impact health behaviours; and low incomes might increase family stress). One way to unpack the role of different pathways is to investigate different health outcomes with different underlying biological mechanisms. In this paper, we look at three different spheres of child health, allowing us to put forward different expected underlying mechanisms. As detailed further in the next section, hypotheses can be made about the relative importance of these three sets of pathways (and their individual components) according to the outcome considered. Further linking these pathways to different family trajectories can highlight whether some mechanisms are specific to different family set-ups, or whether they are universal across non-traditional family structure trajectories.

2 Conceptual model

In this paper, we hypothesize that socio-economic characteristics and family structure trajectories will affect every-day, more proximal processes (material, behavioural and family stress pathways) directly experienced by the child, which will in turn affect child health (Figure 1).

The model focuses on a description of the potential mechanisms underlying the correlation between family structure and child health, although it does not depict causal associations. The model is organized into four "levels" allowing a *conceptual* differentiation between distal and proximal variables [51]. Variables are grouped into conceptual blocks describing common constructs. Variables to be included in these conceptual blocks vary according to the health outcomes considered, and reflect the mechanisms put forward in the literature. *Respiratory illnesses* such as asthma imply chronic inflammation of the airways. Inflammatory processes regulated by immune and neural phenomena provide plausible biological pathways through which psychosocial stress could influence asthma expression [52]. Allergy plays an increasingly important role past the infant stage. We therefore expect exposure to allergens as proxied by housing quality, breastfeeding initiation, and variables relating to family stress to be highlighted for this health outcome. And at all ages, exposure to environmental pollution and passive smoking is known to have a very strong relationship with different aspects of respiratory health such as wheeze and asthma. While we are not able to explore environmental pollution, we include questions on parental smoking in these models. Finally, while evidence on early childhood remains less conclusive, a growing literature has highlighted the importance of sedentary behaviour to at least explain the increase in asthma prevalence in developed societies.

We therefore hypothesise that sedentary activities such as long daily screen use might be relevant for these models.

The development of *overweight and obesity* is linked to growth: the infant stage is largely driven by nutrition, and later life stages by hormones. While quality of diet and sedentary patterns are clearly important, stress may also have a (direct) role as it affects secretions of growth hormones, as well as have an indirect role through parents' behaviours, including their ability to provide nutritious meals and opportunities for physical activity. Prenatal exposures, such as maternal smoking, may also be important through a role on foetal growth.

Finally, *accidental injury* in young children appears to be linked to lower levels of supervision, which could be proxied by markers of structured parenting, and a more dangerous home environment [53, 54]. This may be driven by financial constraints and housing tenure: for example, those living in rentals may be unable to fit safety equipment [55], or afford such equipment [56].

Blocks are primarily ordered in a theoretically and conceptually driven manner, rather than a strictly temporal fashion. A more temporal ordering would have been beneficial, but difficult for several reasons. First, treating health variables in a longitudinal manner in young children would imply that the outcome has the same meaning across the ages considered. However, for example, wheeze at 9 months may be a temporary symptom due to constricted small airways, while by 5 years atopy becomes increasingly important. Therefore, the health variables are measured at the end of the observed period: at 5 years of age. The rest of the model is mostly time-ordered, with "baseline" socio-economic variables in level 1 measured at the first wave of data collection, and pathway variables measured before the health outcomes, except in a few cases (such as diet and exercise) when data was not available until age 5. To be outcome-relevant, the proximal processes (level 3) are adapted for each health outcome, described in the next section. Also included on level 3 are measures of the household's changing economic environment, allowing modelling income gains and losses over the study period.

3 Data and Methods

Millennium Cohort Study

The Millennium Cohort Study (MCS) is a nationally-representative study of 18,818 children living in the UK at 9 months of age and born in 2000-1. Households were identified through the Department of Work and Pensions Child Benefit system and selected on place of residency shortly after birth. Uptake of Child Benefit is almost universal (98%). The sample has a probability design and is clustered at the electoral ward level. The sampled wards over-represent areas with high ethnic density and/or high child poverty, and the three smaller UK countries [57].

The first three data waves are used, collected when cohort members were aged about 9 months, 3 years and 5 years. The overall response rate for wave 1 was 68%. Final sample sizes were 18,818 cohort children at wave 1; 15,808 at wave 2; and 15,459 at wave 3 [58]. The study mainly consisted of face-to-face interviews with the main carer, usually the mother, and some direct measurements with the children. Information about the main respondent's resident partner was collected in a separate interview with them.

Measures

Family structure trajectories

A longitudinal measure was created representing a typology of family structure trajectories from birth to age 5. These trajectories capture two key distinct elements of family structure that may shape child well-being: status (whether the household contains two married, two cohabiting, or a single parent), and (in)stability (whether households remain within their same status throughout the study period or move from one status to another). These trajectories are described in Table 1, and in more detail in Panico et al. (2010).

Child health outcomes

Three groups of health outcomes are examined: respiratory health, overweight, and unintentional injury, measured at 5 years old. Questions on asthma and wheezing were available as part of the interview with the main carer, using the ISAAC (International Study of Asthma and Allergies in Childhood) core questionnaire, a widely used and validated instrument (ISAAC Steering Committee, 2000). Reports of ever asthma and wheeze in the last year are examined. The cohort members' height and weight were measured by the interviewer at age 5. We use international cut-off points for overweight and obesity based on BMI and age [59, 60]. The main carer was asked about any injuries that required contact with medical services since the last interview (between about ages 3 and 5).

Socio-economic antecedents

The first block of variables describes the household's socio-economic baseline characteristics, collected at the first wave. The *income* of the resident partners (including any welfare or child maintenance) was reported by the main respondent. The variable used for modelling purposes is a continuous, log-transformed measure of weekly net income. Questions to the main respondent on the *number of cars and vans* owned by the household measure the household's access to the resources required to own and maintain a vehicle. The highest *educational qualification* held by either resident partner is used as a measure of social position. The variable is classed according to the National Vocational Qualification (NVQ) classification. Categories for analyses are: no qualifications, overseas qualifications only, NVQ1, NVQ2, NVQ3, NVQ4, and NVQ5. Roughly, an NVQ5 is equivalent to a graduate degree; an NVQ3 to two A-levels (secondary qualifications). For simplicity, we present models with education as a linear variable. Alternative specifications using education as a categorical variable did not affect the key relationships of interest.

The emotional environment of the child

Parental mental health is assessed at 9 months through the Malaise Inventory, a self-completion scale assessing psychiatric morbidity. At age 3, psychological distress was assessed using the six-item Kessler Psychological Distress Scale. Both scales have good reliability and validity [61, 62]. Continuous scores were used in analyses.

The Golombok-Rust Inventory of Marital State is a questionnaire designed to assess the *quality of the relationship* within a couple. It produces an overall score of relationship quality [63]. The reduced questionnaire was included at waves 1 and 2; we create a continuous score at each wave. A dummy for partner absence is added to include households with no co-resident partner.

The *parent-child relationship* is assessed through two measures. Attachment is measured at 9 months using the Condon Maternal Attachment Questionnaire, assessing tolerance and acceptance; pleasure in proximity; and parental competence [64]. At 3 years, the Pianta scale [65] assesses the parent's perception of the quality of the relationship with their child. Items were derived from the attachment Q-set [66], generating a total score reflecting an overall positive relationship. For both scales, a continuous score is used in models. To measure "structured parenting", we use questions at age 3 on whether rules were applied consistently, whether the child had regular bedtimes, and regular mealtimes. These questions loaded positively on one factor (factor loadings: 0.48, 0.69, 0.70, respectively), therefore an overall continuous score was created.

The physical environment

Overcrowding was defined as having more than one individual per room, excluding bathrooms and kitchen. Living conditions were assessed by the presence of *damp* in the home, as reported by the main carer. To tap into the *atmosphere in the home*, the main respondent was asked whether they agreed with the statement "you can't hear yourself think" in their home. Answers on a five-point scale ranged from "strongly agree" to "strongly disagree". To describe neighbourhoods, a question asks the main respondent to describe *how safe they feel in their area*. Answers on a five-point scale range from "very safe" to "very unsafe".

Health behaviours

Exposure to tobacco was defined as whether either resident partner smokes. Maternal smoking during pregnancy was also included. *Breastfeeding initiation*, irrespective of duration, was included. All variables are reported by the main carer and coded as binary (yes/no). To describe *dietary habits*, two variables are retained: whether the child eats at regular times, and whether the child has breakfast regularly. *Inactivity* is measured by the number of the daily hours spent watching TV or playing videogames. These variables are measured at age 5, reported by the main respondent.

Methods

Graphical Chain Models were used to model longitudinal associations. These techniques are particularly suited for modelling complex sets of dependencies: they can include variables with different measurement properties; explicitly model cross-sectional and longitudinal associational chains; and lend themselves well to models where theory and temporality suggest an *a priori* ordering of variables and direction of associations [67]. Variables are partitioned into blocks (Figure 1); a directed edge (arrow) signifies that one block is thought to precede or cause another block. Blocks are split into levels; blocks in the first level are potential causes for blocks in the next level, and so on. The use of arrows and boxes gives substantive meaning to models, as they allow specifying explanatory, response or intermediate variables and the direction of the relationship between blocks. Due to the large number of variables tested in the model, we do not graphically depict all tested associations. While allowing a conceptual ordering of variables and the direction of associations, these models remain descriptive and do not produce causal analyses.

All analyses were carried out in Stata 14 [68] and applied appropriate weights to take account of the survey design.

Analyses are carried out in steps:

- A model is set up, based on *a priori* conceptual and temporal ordering.
- Correlations within blocks are estimated to establish convergent validity. This confirmed that variables constituting a block represented a coherent construct.
- Forward and backwards selection is manually applied to reduce the number of covariates in the model. We use backwards elimination of predictors that are conditionally independent of the health outcome. Further, an empirical assessment of which of variables might be removed from the model without loss of power was carried out. All priori theoretically important variables were not included in this selection process (for example, for block 1, parental education, maternal age, income were considered as essential to the conceptual model and were not included in the selection process, while car ownership and grandparents occupational status were: the latter was not retained at this stage but the former was). Mechanisms variables ("Level 3" variables) were initially selected based on theoretical relevance to the health outcome, and then included in the final models if empirically retained.
- Regression models are estimated for each variable in each block with all variables in the previous levels included as independent variables. The type of regression varies according to the measurement property of each dependent variable.

Our analytical sample excludes multiple births and households not present in wave 3 (age 5). Complete case analyses were rejected to avoid substantial sample size drops. A number of strategies have been deployed to ensure that the analyses and the conclusions drawn were valid. First, multiple imputation methods were used to fill-in missing data. The rate of missingness in model variables ranged between 0 to 26%. All model variables are included in the imputation models, as well as auxiliary variables measuring socio-demographic characteristics, and design variables accounting for the clustered nature of the data. We impute on all variables including auxiliary variables, as suggested by the literature, as such variables provide extra information on the outcomes [69]. Multiple imputation techniques allow accounting for uncertainty about missing values by imputing several values for each missing data point, with variability due to both sampling error and model uncertainty [70]. We imputed 25 datasets and consolidated results from all imputations for analyses using Rubin's combination rules [71].

Sensitivity analyses were carried out by comparing complete cases models to models using imputed data. This showed no substantive differences, suggesting that the missing data mechanism could be MAR. In a further test, we used the FIML option in MPlus, which did not provide different substantive results from the multiply imputed models. Further robustness checks included running analyses excluding non-White British children, and running models separately for boys and girls. No substantive differences were found from the models presented here.

4 Results

Descriptive analyses

Table 2 shows that there were significant differences in health outcomes at age 5 across family structure trajectories. In unadjusted analyses, children living with two stably married parents reported the best outcomes, while those always living with a single parent the worst. Considering our key trajectory elements (status, stability and transitions), we can make several observations. Notably, the interplay between status and stability/change was crucial: while stably living with two married parents appeared to produce the best outcomes, stability into single parenthood did not appear to be positive. Whether transitions were positive or negative depended on status before and after the transition. For example, while the transition from coupled to single parent appeared to be negative, nuancing between marriage and cohabitation pre-separation mattered: in fact, children whose *married* parents separated were slightly *less* likely to be overweight or obese at age 5 than children whose married parents did not separate, and there were no differences for recent wheeze. Looking at the opposite transition, single parents who re-partnered appeared to report better outcomes than those who did not re-partner, but these differences were not statistically significant, and they did not catch-up to the always partnered households. Therefore, the positive transition mattered, but did not do enough to counter the effects of instability. Cohabitants who married did not have significantly different outcomes from the always cohabiting group, showing that the stability of these households mattered more than their status.

Graphical Chain Models

The initial part of the graphical chain models is common across the three outcome-specific models. Table 3 shows the Relative Risk Ratios (RRR) from multinomial regression models for family structure trajectories (level 2) regressed on level 1 variables (baseline socio-economic markers). All family structure trajectories were significantly different from the "always married" group for each *socio-economic* marker considered, even as other socio-economic variables are adjusted for. Overall, all groups are younger, poorer and held fewer educational qualifications than the stably married group. An important exception are cohabitees who marry by the time their child was age 5, who do not have significantly lower incomes and had equal access to car ownership than the married group, once their younger ages and fewer educational qualifications were taken in account. Married parents who separated also do not have different baseline incomes than the "always married" group, and had similar ages.

Next, each variable in level 3 (the emotional, physical and health behaviours spheres, and the changing socio-economic environment) was regressed against on levels 1 and 2 (baseline socio-economic markers and family structure trajectory). The coefficients from the linear regression models for these analyses are shown in Tables 3A-3E in the online supplementary materials.

Overall, more advantaged households were able to provide a more positive emotional environment for their children (Table 3A). Given these socio-economic variations, there are no significant differences in *maternal mental well-being* by family structure trajectory, suggesting direct links between socio-economic and maternal well-being mostly by-passing family structure. A number of groups reported higher levels of *parent-child attachment* at 9 months than the always married (the “always cohabiting”, cohabitees who marry, cohabitees who separate, and those who experience more than one transition). In terms of parenting, few differences were significant: single parents who later cohabited were slightly more likely than the always married group to have a warm relationship with their child, while married parents who separated were less likely to report a warm relationship at 3 years of age. Those who were always in a cohabiting relationship were less likely to exhibit *structured parenting*; no further significant difference from the always married group was detected.

The *changing socio-economic environment* models whether families experienced changes in income or educational qualifications from the baseline measurements. Once baseline socio-economic indicators were included, there was no further association between family structure trajectories and educational qualifications at age 3 (Table 3B). Income at age 3 was however significantly associated with family structure trajectories (except for the cohabitees who married, and the single parents who re-partnered), indicating that groups lost income as family structure changed.

Intermediate models

Next, we considered variables that are specific to each health outcome, starting with the respiratory health models. Socio-economic background at 9 months was strongly linked to behavioural variables such as *parental smoking and breastfeeding* initiation (Table 3C). After control for this socio-economic variation, most family structure trajectories were still more likely to report parental smoking at age 3 and maternal smoking during pregnancy, and less likely to have initiated breastfeeding than the continuously married group, although there were exceptions.

For example, the "always single parents" had a similar smoking profile at age 3 to the married group. Cohabitees who married, married parents who separated, and single parents who married, were similar in terms of smoking during pregnancy and breastfeeding initiation to the always married group. For the physical environment, after socio-economic markers were included, only the "always cohabiting" group was more likely to be living in a *damp home* than the married group, no other significant differences were detected.

In addition to a number of variables considered above, for overweight and obesity (Table 3D), we also consider *regular eating* patterns and child inactivity. Once strong variations in socio-economic profiles were accounted for, few additional differences across family structure trajectories were noted. The "always single parent" group was less likely to report regular meal times than the always married group. The coupled parents who separated were less likely to report regularly having breakfast than the always married group. No differences across family trajectories were noted for screen time.

Finally, for the accidental injury models (Table 3E), the association between being a *car passenger* with family structure trajectories, after socio-economic antecedents were adjusted for, was mixed. Compared to the always married group, children living with always cohabiting parents and cohabiting parents who married were slightly more likely to use a car as passengers, while those living with always single parents and cohabitees who separated were less likely to use a car. Furthermore, once socio-economic antecedents are included, all family trajectories were less likely to include other *siblings* in their household than the always married group (except for married parents who separated and single parents who married, where there was no significant difference). Compared to the always married group, *overcrowding* was less common in three groups (always single parent, married and cohabiting parents who separate) but slightly more common for the always cohabiting and cohabiting parents who married. There were few differences across family trajectories for *neighbourhood safety*, except for the always cohabiting and always single groups who were more likely to report not living in a safe neighbourhood than the always married group. All trajectories reported more *chaotic homes* than the always married group, except for the singles who married, where there is no significant difference.

Final models

Tables 4 presents parameter estimates for all the blocks regressed against ever asthma and recent wheeze at age 5. Most of the initial differences in *asthma* by family structure trajectories and by socio-economic baseline markers are attenuated by model variables (with the exception of the always single group, who are still more likely to report asthma). This indicates that we describe most of the potential mechanisms that might mediate the relationship between these variables and asthma: breastfeeding initiation, damp housing, and maternal malaise and attachment at 9 months of age. Similarly, after all variables are entered in the *recent wheeze* model, all family structure trajectories are no longer significantly different from the "always married" group, except again for the "always single parent" (slightly higher risk of wheeze) and the single to married group (slightly lower risk of wheeze). Malaise, maternal mental health at 3 years of age, and damp housing emerge as potential pathways.

Turning to *overweight and obesity* (Table 5), once all blocks are taken in account, family change trajectories are not associated with an increased risk of overweight or obesity at age 5, except for living with a cohabiting parent who separated, which increased the risk compared to those living with continuously married parents. Smoking during pregnancy, regular breakfast, screen time, and parental attachment appeared to be important underlying mechanisms.

For *accidental injury*, the socio-economic antecedents were no longer associated with injury in the final models (Table 6). However, a number of family structure trajectories remained significantly associated to an increased risk of accidents, suggesting that for this outcome our models were probably not capturing all underlying mechanisms. The number of siblings in the home, agreeing with the statement "you can't hear yourself think", and maternal malaise at 9 months were associated with an increased risk of injury at age 5, suggesting that these variables as potential mediators.

5 Discussion

Both cross sectional [1, 31] and longitudinal studies [8, 12, 33] have shown that family structures are strongly intertwined with socio-economic background. Most previous work has focused on differentials in child well-being across family structures, in this paper we attempt to describe potential proximate pathways underscoring the interplay between family structure and its socio-economic context on the one hand, and three different measures of early child physical health on the other. While remaining descriptive, this type of evidence allows better understanding of the relationship between the family context and child well-being, and can inform effective policies. We focus on early physical health as a neglected yet critical component of child well-being, and replicate models for three different types of health outcomes (respiratory health, excess weight, and accidental injuries), taking a holistic approach to "health" as well as providing robustness to our findings.

We showed that, first, when thinking about family structure and child well-being, we cannot consider marital status, trajectory stability and transitions separately: these components are distinctively important and appear to interplay to shape child health. Second, some of the pathways we highlight (particularly the outcome-specific ones, for example, not having regular eating patterns and long screen times for overweight; living in a damp house for respiratory health; or variables identifying the chaotic nature of the home for accidental injuries) show how the disadvantaged environments that children living in different family structure trajectories might impact their health. These risks are not evenly distributed: as shown in the intermediate models, they correlate with socio-economic background (rather than the family trajectory per se, with some exceptions).

Third, the intermediate models also suggest that certain pathways might matter more for different family trajectories. For example, the always cohabiting group appears to be particularly marked by poor housing: they are more likely to live in overcrowded, damp homes in neighbourhoods they do not feel safe in. This could be partly due to their more precarious housing tenure (40% of this group does not own their home at wave 2, versus 15% in the always married group). Indeed, qualitative research [72, 73] has shown that for young cohabitators, high marital expectations (including in terms of housing stability) may be precluding them from marrying. Another example of a trajectory-specific pathway is for the regularly eating breakfast: this variable predicted the risk of overweight in the final models, and the intermediate models suggest that it is in particular partnered households who experience a separation who are less likely to provide a regular breakfast to the cohort child. Parenting and especially routines such as regular meals have been shown to be affected by "shocks" such as parental separation and divorce [74], and our results suggest that, for this trajectory, parents' ability to maintain children's routine might potentially explain part of their increased risk of poor child health.

Finally, "family stress" variables emerged as an important potential pathway to understand differentials across all domains of early health and for most family structure trajectories. These variables are not often considered when dealing with childhood *physical* health, yet it is plausible that young children's main source of stress might come from their home environment, as measured, for example, by low levels of parental well-being. This result highlights the need to consider family well-being holistically when studying child well-being, including their physical health.

As in any secondary analyses of large datasets, there are some considerations to keep in mind when interpreting results. First, while we propose a conceptual model in which the direction of the association between variables, and the ordering of variables, is explicitated, our analyses are not causal and can only describe associations between variables, and suggest potential mechanisms through which these associations run.

Second, even though the Millennium Cohort Study is representative of children living in the UK, initial response rates and subsequent attrition result in a wealthier sample made up of less mobile households when compared to the general population. The results may therefore underestimate the gap between different family structures, as “lost” households are more likely to be unmarried and to experience family structure transitions, especially as changes in family structures often result in changes in residence. Survey weights, applied to all analyses, take account of sample attrition. Third, not all households answered all questions posed to them, resulting in cases with incomplete data. As incomplete data tends to relate to poorer, more disadvantaged households, we may be underestimating the true relationship between socio-economic variables and the proximate mechanisms studied. As detailed in the methodology section, we take a number of strategies to take account of this. Finally, parental report of child outcomes may introduce some bias. In particular, asthma and wheeze are difficult concepts to fully understand, and diagnosis of asthma among very young children is complicated. Parental reports of asthma and wheeze are therefore unlikely to be always accurate. Furthermore, certain pathway variables are difficult to operationalise in a survey setting, and may therefore not accurately measure the concept they were intended to approximate in the model. For example, in the Millennium Cohort Study, questions on children's diets were designed to tap into several dimensions of diet. However, only questions on eating regularly predicted BMI, while questions on the types of food eaten were not. Potentially, asking questions on whether children eat "mostly sugary foods in-between meals" may lead parents to give more socially acceptable answers. Similarly, questions on exercise attempted to captures both active and inactive behaviour. While questions on inactive behaviour (hours watching TV or playing videogames) did predict excess weight, questions on active behaviour (how often the child plays sports, whether the child walks to school, etc.) are harder to formulate and did not predict BMI. Reverse causation may also be an issue: parents of overweight or obese children may over-report physical activity, and under-report unhealthy dietary habits. Parents of overweight or obese children may also attempt to increase their child's activity levels, and improve their dietary habits. And potentially important pathways variables, such as parental supervision for the injury model, are difficult to operationalize without observational fieldwork.

Nonetheless, this study is one of few to explore the association between family structure trajectories and early physical health, as opposed to more commonly reported outcomes such as cognitive development or behaviour in older children. The early pre-school years, a critical developmental age, is often missing from the family structure and child well-being literature. Using a large, prospective, nationally representative study, we were able to distinguish between detailed longitudinal measures of family structure, showing that the use of simple or cross-sectional variables to describe family structure disguises important differences between groups, even in early life. Our interdisciplinary conceptual model allowed us to include a number of spheres of a child's life, including psychosocial variables such as parental mental health; environmental variables such as housing quality; and health behaviours such as eating patterns and inactivity.

6 Conclusion

This study explored associations between family structure trajectories and three sets of child health outcomes, and described pathways through which family trajectories and their socio-economic context could operate to influence child health. Proximal variables through which the more distal variables of socio-economic background and family structure varied as expected by health outcome; "family stress" came across as a potentially important pathway across all health outcomes. With few exceptions, once all model variables were accounted for, there were no significant differences between different family structure trajectories in early child physical health.

Figures

Figure 1: Conceptual model

Tables

(see separate files for figures and tables)

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Family Structure Trajectories and Early Child Health in the UK: Pathways to Health

Keywords: Family structure; Family instability; Early child health; Asthma; Obesity; Accidents; Millennium Cohort Study

Abstract

A large body of literature has shown marked differences in the average levels of resources and child well-being across different family structures. Studies have examined cognitive, educational and behavioural outcomes; less is known about differentials in physical health, and about dynamics in early childhood.

Furthermore, up to the present time, less emphasis has been placed on describing the underlying mechanisms relating childhood experience of family structure to health. In this paper, we hypothesize that socio-economic characteristics and family structure trajectories will affect every-day, more proximal processes (material, behavioral and family stress pathways) directly experienced by the child, which will in turn affect child health.

Using the UK Millennium Cohort Study, a nationally representative cohort of over 19,000 children born in 2001 and living in the UK shortly thereafter, we employ Graphical Chain Models to map the processes linking family structure trajectories to three physical health outcomes at age 5: overweight/obesity, respiratory health, and accidental injury. We construct family trajectories to highlight two components: status (distinguishing between married, cohabiting and single parents), and (in)stability.

We show that both status, the (in)stability of that status, and their interplay, are important components of family structure trajectories which correlate to children's early physical health. Analyses highlight the relative importance of distinct pathways across different health outcomes. As well as some outcome-specific paths, we find that "family stress" variables appeared to underscore the relationship between family structure and child physical health, pointing to the importance of such variables in understanding how family structure relates to early child health.

Introduction

Families provide a wide range of social, economic and emotional resources that influence child health and development; the average level of these resources varies across different family types. An extensive literature has shown that children growing with two continuously married parents do better on average on several cognitive, emotional and developmental outcomes, in childhood and adulthood [1-5]. We know less about physical health, especially in the early years, a key stage for understanding lifelong health trajectories.

Research on family structure and child outcomes has concentrated on describing differentials, or testing whether associations are causal [6]. Less emphasis has been placed on describing potential underlying proximate processes that might link family structures to child well-being. However, describing plausible mechanisms through which effects could work is important for scholarship, and is useful for public policy purposes. To describe potential underlying processes, considering family structure from a longitudinal and nuanced perspective is important. First, the resources available to different family types and the form and function of the family differ within the broad groups often used: one versus two-parent households, married versus unmarried parents. Furthermore, family structure is not static and children can experience changes, even from early childhood. These trajectories are linked to both available household resources and to markers of child and parental well-being [7, 8]. Thus, detailed and dynamic measures of family structure can help unpack the relationships between family structure and outcomes for children.

This work therefore explores whether family structure trajectories are correlated to three domains of early physical health: respiratory health, overweight/obesity, and accidental injuries, in a nationally representative sample of children residing in the UK. We construct family trajectories to highlight two components of such trajectories: status (distinguishing between married, cohabiting and single parents), and (in)stability (remaining within the same status or moving from one status to another). While remaining descriptive, the focus of our analyses is describing potential proximate processes that could link contextual factors such as family structure trajectories to children's physical health. Different spheres of health are considered to better understand these processes, as we hypothesised that different health outcomes would be associated with different processes. The focus on early childhood allows describing how these relationships develop during a crucial developmental window, and when children spend more time within the family sphere, allowing better capturing family processes.

1.1 How family structure may affect early childhood physical health

While less is known about the link between family structure and child physical health, particularly in the early years, the available studies present results consistent with the wider literature on family structure and child development. This broader literature has shown that experiences of parental divorce and unmarried parenthood are associated with poorer emotional, psychosocial and educational outcomes, especially for teenagers, while children living in intact two-parent families tend to report the best outcomes [9-11]. For example, work on the Millennium Cohort Study by Kiernan and Mensah (2011) identified differences across a number of family trajectories in children's emotional well-being at 5 years of age [12]. They showed that children who had experienced different family trajectories varied in terms of emotional and behavioral problems, suggesting that family instability and change appears to be important in explaining differences in early childhood behavioural problems. The wider impact of family structure on child well-being has been linked to increasingly polarized experiences of union formation and dissolution across socio-economic groups [13-15].

These negative impacts appears to persist into adulthood, although effects are relatively modest, probably because children who experience parental divorce are not a homogenous group [1, 16]. However, negative effects have persisted over time, even as divorce has become more common and less stigmatized [16]. In particular, the timing of family transitions might be a source of heterogeneity: transitions occurring in early childhood appeared to be especially detrimental to subsequent child development [17].

Turning to studies exploring specifically the association between family structure and child physical health, the few studies available appear to confirm the trends for other child outcomes. They highlight that family instability [18], marital status [19], and their intersection [20], were related to children's physical health outcomes such as asthma, general health status and overweight. However, much of this work employs data from the Fragile Family study, which is representative of particular time periods and sub-groups [21], and relate to a national setting, the USA, with certain socio-demographic characteristics, notably a high proportion of births to single mothers, and high family instability. In fact, the broader evidence for theories around the impact of family structure on child outcomes is primarily from the United States, where economic inequality has been very marked [22]. Different national contexts, such as Australia [23], or Sweden [24], are also reporting similar associations between family structure (and in particular, partnered vs unpartnered households) and child well-being. However, the association between socio-economic background and family structure trajectories events (such divorce or repartnering) appears to differ across countries and over time [25]. Thus, while the relationship between family structure and child well-being seems to be universal, it is not clear whether the mechanisms underlying these correlations can be generalized across countries.

Work specific to the UK is more sparse but expanding. Nationally-representative data from the Millennium Cohort Study has found significant differences according to family structure in well-known predictors of child health such as breastfeeding and parental smoking [8, 26]. These results are reflected in cross-sectional work showing associations between lone parenthood and child general health, long-standing illness, injury, overweight, and asthma [27], and longitudinal analyses showing that living with a lone mother increased the risks of obesity by age 7, compared to continuously living with two biological parents [28]. The emphasis on lone parenthood did not allow distinguishing between married and cohabiting parents, and the focus on causation meant that less attention could be paid to the mechanisms underlying the relationships described.

Hypothesizes that could explain health differentials by family structure can be summarised in two: mechanisms we consider to be largely "upstream" from family structure, notably socio-economic status; and "downstream" or proximate mechanisms, such as parental health behaviours. Starting with "upstream" processes, studies suggest that the relationship between family structure and child well-being may be intricately intertwined and driven by different socio-economic characteristics [1, 27, 29-31]. For example, in the UK, single mothers are more likely to be unemployed and to reside in social housing [32] and to be persistently in poverty [8]. Furthermore, parental separation often entails increases in childhood poverty and deprivation, particularly for more disadvantaged groups [33].

However, socio-economic characteristics and family structure are contextual factors and do not, per se, cause poor health. A number of intertwined pathways have been put forward to explain the "social to biological" transition [34], although this literature has not considered family structure as a key social stratification variable. Classic economic explanations posit that socio-economic differentials produce differences in parents' abilities to invest in their children's human capital [35, 36]. For our analyses, this *material pathway* could suggest a role of, for example, housing quality or adequate nutrition. In epidemiology, a *behavioural/lifestyle path* has been extensively tested to explain socio-economic inequalities in health (see Bartley [37] for a review). In the UK, socio-economic position is, for example, linked to smoking, diet, and physical activity [38]. A less explored pathway, from the psychological literature, is *family stress*. Family stress models hypothesize that (financial) stressors affect children through exposure to poor parental mental health, parental conflict and parenting skills [39, 40], which are strongly correlated to child well-being [12, 41, 42]. While Conger's original model explored adolescent well-being, similar models have since been successfully adapted for young children [12, 31, 43]. While the family stress model has been mostly applied to cognitive and developmental outcomes and less to child health, it is documented that stress is linked to physical health [44], including to child health outcomes such as asthma [45]; and that stress may both mediate between socio-economic difficulties and child health [46] and interact with socio-economic status to impact child health. For example, children from socially or economically disadvantaged households had a greater cardiovascular reactivity to stress than children from higher status households [47]. In fact, recent research has shown how environmental experiences, including poverty and the family environment, affect the underlying neurological, biological and physiological processes governing child development (often referred to how life exposures "get under the skin"). Children have been shown to have a direct impact of stress on their health, similarly to adults, through a physiological health response [48, 49]. In this response, the activation of the hypothalamic-pituitary-adrenal (HPA) axis leads to the secretion of glucocorticoids from the adrenal glands. A chronic secretion of glucocorticoids can damage physical health due to allostatic load processes, i.e. the wear and tear of various physiological systems (metabolic, immune, etc.) related to HPA activation [50].

Disentangling material, behavioural, and stress proximal pathways, is complicated, as these are likely to co-occur and be interdependent (for example, poor parental mental health might impact health behaviours; and low incomes might increase family stress). One way to unpack the role of different pathways is to investigate different health outcomes with different underlying biological mechanisms. In this paper, we look at three different spheres of child health, allowing us to put forward different expected underlying mechanisms. As detailed further in the next section, hypotheses can be made about the relative importance of these three sets of pathways (and their individual components) according to the outcome considered. Further linking these pathways to different family trajectories can highlight whether some mechanisms are specific to different family set-ups, or whether they are universal across non-traditional family structure trajectories.

2 Conceptual model

In this paper, we hypothesize that socio-economic characteristics and family structure trajectories will affect every-day, more proximal processes (material, behavioural and family stress pathways) directly experienced by the child, which will in turn affect child health (Figure 1).

The model focuses on a description of the potential mechanisms underlying the correlation between family structure and child health, although it does not depict causal associations. The model is organized into four "levels" allowing a *conceptual* differentiation between distal and proximal variables [51]. Variables are grouped into conceptual blocks describing common constructs. Variables to be included in these conceptual blocks vary according to the health outcomes considered, and reflect the mechanisms put forward in the literature. *Respiratory illnesses* such as asthma imply chronic inflammation of the airways. Inflammatory processes regulated by immune and neural phenomena provide plausible biological pathways through which psychosocial stress could influence asthma expression [52]. Allergy plays an increasingly important role past the infant stage. We therefore expect exposure to allergens as proxied by housing quality, breastfeeding initiation, and variables relating to family stress to be highlighted for this health outcome. And at all ages, exposure to environmental pollution and passive smoking is known to have a very strong relationship with different aspects of respiratory health such as wheeze and asthma. While we are not able to explore environmental pollution, we include questions on parental smoking in these models. Finally, while evidence on early childhood remains less conclusive, a growing literature has highlighted the importance of sedentary behaviour to at least explain the increase in asthma prevalence in developed societies.

We therefore hypothesise that sedentary activities such as long daily screen use might be relevant for these models.

The development of *overweight and obesity* is linked to growth: the infant stage is largely driven by nutrition, and later life stages by hormones. While quality of diet and sedentary patterns are clearly important, stress may also have a (direct) role as it affects secretions of growth hormones, as well as have an indirect role through parents' behaviours, including their ability to provide nutritious meals and opportunities for physical activity. Prenatal exposures, such as maternal smoking, may also be important through a role on foetal growth.

Finally, *accidental injury* in young children appears to be linked to lower levels of supervision, which could be proxied by markers of structured parenting, and a more dangerous home environment [53, 54]. This may be driven by financial constraints and housing tenure: for example, those living in rentals may be unable to fit safety equipment [55], or afford such equipment [56].

Blocks are primarily ordered in a theoretically and conceptually driven manner, rather than a strictly temporal fashion. A more temporal ordering would have been beneficial, but difficult for several reasons. First, treating health variables in a longitudinal manner in young children would imply that the outcome has the same meaning across the ages considered. However, for example, wheeze at 9 months may be a temporary symptom due to constricted small airways, while by 5 years atopy becomes increasingly important. Therefore, the health variables are measured at the end of the observed period: at 5 years of age. The rest of the model is mostly time-ordered, with “baseline” socio-economic variables in level 1 measured at the first wave of data collection, and pathway variables measured before the health outcomes, except in a few cases (such as diet and exercise) when data was not available until age 5. To be outcome-relevant, the proximal processes (level 3) are adapted for each health outcome, described in the next section. Also included on level 3 are measures of the household’s changing economic environment, allowing modelling income gains and losses over the study period.

3 Data and Methods

Millennium Cohort Study

The Millennium Cohort Study (MCS) is a nationally-representative study of 18,818 children living in the UK at 9 months of age and born in 2000-1. Households were identified through the Department of Work and Pensions Child Benefit system and selected on place of residency shortly after birth. Uptake of Child Benefit is almost universal (98%). The sample has a probability design and is clustered at the electoral ward level. The sampled wards over-represent areas with high ethnic density and/or high child poverty, and the three smaller UK countries [57].

The first three data waves are used, collected when cohort members were aged about 9 months, 3 years and 5 years. The overall response rate for wave 1 was 68%. Final sample sizes were 18,818 cohort children at wave 1; 15,808 at wave 2; and 15,459 at wave 3 [58]. The study mainly consisted of face-to-face interviews with the main carer, usually the mother, and some direct measurements with the children. Information about the main respondent’s resident partner was collected in a separate interview with them.

Measures

Family structure trajectories

A longitudinal measure was created representing a typology of family structure trajectories from birth to age 5. These trajectories capture two key distinct elements of family structure that may shape child well-being: status (whether the household contains two married, two cohabiting, or a single parent), and (in)stability (whether households remain within their same status throughout the study period or move from one status to another). These trajectories are described in Table 1, and in more detail in Panico et al. (2010).

Child health outcomes

Three groups of health outcomes are examined: respiratory health, overweight, and unintentional injury, measured at 5 years old. Questions on asthma and wheezing were available as part of the interview with the main carer, using the ISAAC (International Study of Asthma and Allergies in Childhood) core questionnaire, a widely used and validated instrument (ISAAC Steering Committee, 2000). Reports of ever asthma and wheeze in the last year are examined. The cohort members' height and weight were measured by the interviewer at age 5. We use international cut-off points for overweight and obesity based on BMI and age [59, 60]. The main carer was asked about any injuries that required contact with medical services since the last interview (between about ages 3 and 5).

Socio-economic antecedents

The first block of variables describes the household's socio-economic baseline characteristics, collected at the first wave. The *income* of the resident partners (including any welfare or child maintenance) was reported by the main respondent. The variable used for modelling purposes is a continuous, log-transformed measure of weekly net income. Questions to the main respondent on the *number of cars and vans* owned by the household measure the household's access to the resources required to own and maintain a vehicle. The highest *educational qualification* held by either resident partner is used as a measure of social position. The variable is classed according to the National Vocational Qualification (NVQ) classification. Categories for analyses are: no qualifications, overseas qualifications only, NVQ1, NVQ2, NVQ3, NVQ4, and NVQ5. Roughly, an NVQ5 is equivalent to a graduate degree; an NVQ3 to two A-levels (secondary qualifications). For simplicity, we present models with education as a linear variable. Alternative specifications using education as a categorical variable did not affect the key relationships of interest.

The emotional environment of the child

Parental mental health is assessed at 9 months through the Malaise Inventory, a self-completion scale assessing psychiatric morbidity. At age 3, psychological distress was assessed using the six-item Kessler Psychological Distress Scale. Both scales have good reliability and validity [61, 62]. Continuous scores were used in analyses.

The Golombok-Rust Inventory of Marital State is a questionnaire designed to assess the *quality of the relationship* within a couple. It produces an overall score of relationship quality [63]. The reduced questionnaire was included at waves 1 and 2; we create a continuous score at each wave. A dummy for partner absence is added to include households with no co-resident partner.

The *parent-child relationship* is assessed through two measures. Attachment is measured at 9 months using the Condon Maternal Attachment Questionnaire, assessing tolerance and acceptance; pleasure in proximity; and parental competence [64]. At 3 years, the Pianta scale [65] assesses the parent's perception of the quality of the relationship with their child. Items were derived from the attachment Q-set [66], generating a total score reflecting an overall positive relationship. For both scales, a continuous score is used in models. To measure "structured parenting", we use questions at age 3 on whether rules were applied consistently, whether the child had regular bedtimes, and regular mealtimes. These questions loaded positively on one factor (factor loadings: 0.48, 0.69, 0.70, respectively), therefore an overall continuous score was created.

The physical environment

Overcrowding was defined as having more than one individual per room, excluding bathrooms and kitchen. Living conditions were assessed by the presence of *damp* in the home, as reported by the main carer. To tap into the *atmosphere in the home*, the main respondent was asked whether they agreed with the statement "you can't hear yourself think" in their home. Answers on a five-point scale ranged from "strongly agree" to "strongly disagree". To describe neighbourhoods, a question asks the main respondent to describe *how safe they feel in their area*. Answers on a five-point scale range from "very safe" to "very unsafe".

Health behaviours

Exposure to tobacco was defined as whether either resident partner smokes. Maternal smoking during pregnancy was also included. *Breastfeeding initiation*, irrespective of duration, was included. All variables are reported by the main carer and coded as binary (yes/no). To describe *dietary habits*, two variables are retained: whether the child eats at regular times, and whether the child has breakfast regularly. *Inactivity* is measured by the number of the daily hours spent watching TV or playing videogames. These variables are measured at age 5, reported by the main respondent.

Methods

Graphical Chain Models were used to model longitudinal associations. These techniques are particularly suited for modelling complex sets of dependencies: they can include variables with different measurement properties; explicitly model cross-sectional and longitudinal associational chains; and lend themselves well to models where theory and temporality suggest an *a priori* ordering of variables and direction of associations [67]. Variables are partitioned into blocks (Figure 1); a directed edge (arrow) signifies that one block is thought to precede or cause another block. Blocks are split into levels; blocks in the first level are potential causes for blocks in the next level, and so on. The use of arrows and boxes gives substantive meaning to models, as they allow specifying explanatory, response or intermediate variables and the direction of the relationship between blocks. Due to the large number of variables tested in the model, we do not graphically depict all tested associations. While allowing a conceptual ordering of variables and the direction of associations, these models remain descriptive and do not produce causal analyses.

All analyses were carried out in Stata 14 [68] and applied appropriate weights to take account of the survey design.

Analyses are carried out in steps:

- A model is set up, based on *a priori* conceptual and temporal ordering.
- Correlations within blocks are estimated to establish convergent validity. This confirmed that variables constituting a block represented a coherent construct.
- Forward and backwards selection is manually applied to reduce the number of covariates in the model. We use backwards elimination of predictors that are conditionally independent of the health outcome. Further, an empirical assessment of which of variables might be removed from the model without loss of power was carried out. All priori theoretically important variables were not included in this selection process (for example, for block 1, parental education, maternal age, income were considered as essential to the conceptual model and were not included in the selection process, while car ownership and grandparents occupational status were: the latter was not retained at this stage but the former was). Mechanisms variables ("Level 3" variables) were initially selected based on theoretical relevance to the health outcome, and then included in the final models if empirically retained.
- Regression models are estimated for each variable in each block with all variables in the previous levels included as independent variables. The type of regression varies according to the measurement property of each dependent variable.

Our analytical sample excludes multiple births and households not present in wave 3 (age 5). Complete case analyses were rejected to avoid substantial sample size drops. A number of strategies have been deployed to ensure that the analyses and the conclusions drawn were valid. First, multiple imputation methods were used to fill-in missing data. The rate of missingness in model variables ranged between 0 to 26%. All model variables are included in the imputation models, as well as auxiliary variables measuring socio-demographic characteristics, and design variables accounting for the clustered nature of the data. We impute on all variables including auxiliary variables, as suggested by the literature, as such variables provide extra information on the outcomes [69]. Multiple imputation techniques allow accounting for uncertainty about missing values by imputing several values for each missing data point, with variability due to both sampling error and model uncertainty [70]. We imputed 25 datasets and consolidated results from all imputations for analyses using Rubin's combination rules [71].

Sensitivity analyses were carried out by comparing complete cases models to models using imputed data. This showed no substantive differences, suggesting that the missing data mechanism could be MAR. In a further test, we used the FIML option in MPlus, which did not provide different substantive results from the multiply imputed models. Further robustness checks included running analyses excluding non-White British children, and running models separately for boys and girls. No substantive differences were found from the models presented here.

4 Results

Descriptive analyses

Table 2 shows that there were significant differences in health outcomes at age 5 across family structure trajectories. In unadjusted analyses, children living with two stably married parents reported the best outcomes, while those always living with a single parent the worst. Considering our key trajectory elements (status, stability and transitions), we can make several observations. Notably, the interplay between status and stability/change was crucial: while stably living with two married parents appeared to produce the best outcomes, stability into single parenthood did not appear to be positive. Whether transitions were positive or negative depended on status before and after the transition. For example, while the transition from coupled to single parent appeared to be negative, nuancing between marriage and cohabitation pre-separation mattered: in fact, children whose *married* parents separated were slightly *less* likely to be overweight or obese at age 5 than children whose married parents did not separate, and there were no differences for recent wheeze. Looking at the opposite transition, single parents who re-partnered appeared to report better outcomes than those who did not re-partner, but these differences were not statistically significant, and they did not catch-up to the always partnered households. Therefore, the positive transition mattered, but did not do enough to counter the effects of instability. Cohabitants who married did not have significantly different outcomes from the always cohabiting group, showing that the stability of these households mattered more than their status.

Graphical Chain Models

The initial part of the graphical chain models is common across the three outcome-specific models. Table 3 shows the Relative Risk Ratios (RRR) from multinomial regression models for family structure trajectories (level 2) regressed on level 1 variables (baseline socio-economic markers). All family structure trajectories were significantly different from the "always married" group for each *socio-economic* marker considered, even as other socio-economic variables are adjusted for. Overall, all groups are younger, poorer and held fewer educational qualifications than the stably married group. An important exception are cohabitees who marry by the time their child was age 5, who do not have significantly lower incomes and had equal access to car ownership than the married group, once their younger ages and fewer educational qualifications were taken in account. Married parents who separated also do not have different baseline incomes than the "always married" group, and had similar ages.

Next, each variable in level 3 (the emotional, physical and health behaviours spheres, and the changing socio-economic environment) was regressed against on levels 1 and 2 (baseline socio-economic markers and family structure trajectory). The coefficients from the linear regression models for these analyses are shown in Tables 3A-3E in the online supplementary materials.

Overall, more advantaged households were able to provide a more positive emotional environment for their children (Table 3A). Given these socio-economic variations, there are no significant differences in *maternal mental well-being* by family structure trajectory, suggesting direct links between socio-economic and maternal well-being mostly by-passing family structure. A number of groups reported higher levels of *parent-child attachment* at 9 months than the always married (the “always cohabiting”, cohabitees who marry, cohabitees who separate, and those who experience more than one transition). In terms of parenting, few differences were significant: single parents who later cohabited were slightly more likely than the always married group to have a warm relationship with their child, while married parents who separated were less likely to report a warm relationship at 3 years of age. Those who were always in a cohabiting relationship were less likely to exhibit *structured parenting*; no further significant difference from the always married group was detected.

The *changing socio-economic environment* models whether families experienced changes in income or educational qualifications from the baseline measurements. Once baseline socio-economic indicators were included, there was no further association between family structure trajectories and educational qualifications at age 3 (Table 3B). Income at age 3 was however significantly associated with family structure trajectories (except for the cohabitees who married, and the single parents who re-partnered), indicating that groups lost income as family structure changed.

Intermediate models

Next, we considered variables that are specific to each health outcome, starting with the respiratory health models. Socio-economic background at 9 months was strongly linked to behavioural variables such as *parental smoking and breastfeeding* initiation (Table 3C). After control for this socio-economic variation, most family structure trajectories were still more likely to report parental smoking at age 3 and maternal smoking during pregnancy, and less likely to have initiated breastfeeding than the continuously married group, although there were exceptions.

For example, the “always single parents” had a similar smoking profile at age 3 to the married group. Cohabitees who married, married parents who separated, and single parents who married, were similar in terms of smoking during pregnancy and breastfeeding initiation to the always married group. For the physical environment, after socio-economic markers were included, only the “always cohabiting” group was more likely to be living in a *damp home* than the married group, no other significant differences were detected.

In addition to a number of variables considered above, for overweight and obesity (Table 3D), we also consider *regular eating* patterns and child inactivity. Once strong variations in socio-economic profiles were accounted for, few additional differences across family structure trajectories were noted. The “always single parent” group was less likely to report regular meal times than the always married group. The coupled parents who separated were less likely to report regularly having breakfast than the always married group. No differences across family trajectories were noted for screen time.

Finally, for the accidental injury models (Table 3E), the association between being a *car passenger* with family structure trajectories, after socio-economic antecedents were adjusted for, was mixed. Compared to the always married group, children living with always cohabiting parents and cohabiting parents who married were slightly more likely to use a car as passengers, while those living with always single parents and cohabitees who separated were less likely to use a car. Furthermore, once socio-economic antecedents are included, all family trajectories were less likely to include other *siblings* in their household than the always married group (except for married parents who separated and single parents who married, where there was no significant difference). Compared to the always married group, *overcrowding* was less common in three groups (always single parent, married and cohabiting parents who separate) but slightly more common for the always cohabiting and cohabiting parents who married. There were few differences across family trajectories for *neighbourhood safety*, except for the always cohabiting and always single groups who were more likely to report not living in a safe neighbourhood than the always married group. All trajectories reported more *chaotic homes* than the always married group, except for the singles who married, where there is no significant difference.

Final models

Tables 4 presents parameter estimates for all the blocks regressed against ever asthma and recent wheeze at age 5. Most of the initial differences in *asthma* by family structure trajectories and by socio-economic baseline markers are attenuated by model variables (with the exception of the always single group, who are still more likely to report asthma). This indicates that we describe most of the potential mechanisms that might mediate the relationship between these variables and asthma: breastfeeding initiation, damp housing, and maternal malaise and attachment at 9 months of age. Similarly, after all variables are entered in the *recent wheeze* model, all family structure trajectories are no longer significantly different from the “always married” group, except again for the “always single parent” (slightly higher risk of wheeze) and the single to married group (slightly lower risk of wheeze). Malaise, maternal mental health at 3 years of age, and damp housing emerge as potential pathways.

Turning to *overweight and obesity* (Table 5), once all blocks are taken in account, family change trajectories are not associated with an increased risk of overweight or obesity at age 5, except for living with a cohabiting parent who separated, which increased the risk compared to those living with continuously married parents. Smoking during pregnancy, regular breakfast, screen time, and parental attachment appeared to be important underlying mechanisms.

For *accidental injury*, the socio-economic antecedents were no longer associated with injury in the final models (Table 6). However, a number of family structure trajectories remained significantly associated to an increased risk of accidents, suggesting that for this outcome our models were probably not capturing all underlying mechanisms. The number of siblings in the home, agreeing with the statement "you can't hear yourself think", and maternal malaise at 9 months were associated with an increased risk of injury at age 5, suggesting that these variables as potential mediators.

5 Discussion

Both cross sectional [1, 31] and longitudinal studies [8, 12, 33] have shown that family structures are strongly intertwined with socio-economic background. Most previous work has focused on differentials in child well-being across family structures, in this paper we attempt to describe potential proximate pathways underscoring the interplay between family structure and its socio-economic context on the one hand, and three different measures of early child physical health on the other. While remaining descriptive, this type of evidence allows better understanding of the relationship between the family context and child well-being, and can inform effective policies. We focus on early physical health as a neglected yet critical component of child well-being, and replicate models for three different types of health outcomes (respiratory health, excess weight, and accidental injuries), taking a holistic approach to "health" as well as providing robustness to our findings.

We showed that, first, when thinking about family structure and child well-being, we cannot consider marital status, trajectory stability and transitions separately: these components are distinctively important and appear to interplay to shape child health. Second, some of the pathways we highlight (particularly the outcome-specific ones, for example, not having regular eating patterns and long screen times for overweight; living in a damp house for respiratory health; or variables identifying the chaotic nature of the home for accidental injuries) show how the disadvantaged environments that children living in different family structure trajectories might impact their health. These risks are not evenly distributed: as shown in the intermediate models, they correlate with socio-economic background (rather than the family trajectory per se, with some exceptions).

Third, the intermediate models also suggest that certain pathways might matter more for different family trajectories. For example, the always cohabiting group appears to be particularly marked by poor housing: they are more likely to live in overcrowded, damp homes in neighbourhoods they do not feel safe in. This could be partly due to their more precarious housing tenure (40% of this group does not own their home at wave 2, versus 15% in the always married group). Indeed, qualitative research [72, 73] has shown that for young cohabitators, high marital expectations (including in terms of housing stability) may be precluding them from marrying. Another example of a trajectory-specific pathway is for the regularly eating breakfast: this variable predicted the risk of overweight in the final models, and the intermediate models suggest that it is in particular partnered households who experience a separation who are less likely to provide a regular breakfast to the cohort child. Parenting and especially routines such as regular meals have been shown to be affected by "shocks" such as parental separation and divorce [74], and our results suggest that, for this trajectory, parents' ability to maintain children's routine might potentially explain part of their increased risk of poor child health.

Finally, "family stress" variables emerged as an important potential pathway to understand differentials across all domains of early health and for most family structure trajectories. These variables are not often considered when dealing with childhood *physical* health, yet it is plausible that young children's main source of stress might come from their home environment, as measured, for example, by low levels of parental well-being. This result highlights the need to consider family well-being holistically when studying child well-being, including their physical health.

As in any secondary analyses of large datasets, there are some considerations to keep in mind when interpreting results. First, while we propose a conceptual model in which the direction of the association between variables, and the ordering of variables, is explicitated, our analyses are not causal and can only describe associations between variables, and suggest potential mechanisms through which these associations run.

Second, even though the Millennium Cohort Study is representative of children living in the UK, initial response rates and subsequent attrition result in a wealthier sample made up of less mobile households when compared to the general population. The results may therefore underestimate the gap between different family structures, as "lost" households are more likely to be unmarried and to experience family structure transitions, especially as changes in family structures often result in changes in residence. Survey weights, applied to all analyses, take account of sample attrition. Third, not all households answered all questions posed to them, resulting in cases with incomplete data. As incomplete data tends to relate to poorer, more disadvantaged households, we may be underestimating the true relationship between socio-economic variables and the proximate mechanisms studied. As detailed in the methodology section, we take a number of strategies to take account of this. Finally, parental report of child outcomes may introduce some bias. In particular, asthma and wheeze are difficult concepts to fully understand, and diagnosis of asthma among very young children is complicated. Parental reports of asthma and wheeze are therefore unlikely to be always accurate. Furthermore, certain pathway variables are difficult to operationalise in a survey setting, and may therefore not accurately measure the concept they were intended to approximate in the model. For example, in the Millennium Cohort Study, questions on children's diets were designed to tap into several dimensions of diet. However, only questions on eating regularly predicted BMI, while questions on the types of food eaten were not. Potentially, asking questions on whether children eat "mostly sugary foods in-between meals" may lead parents to give more socially acceptable answers. Similarly, questions on exercise attempted to captures both active and inactive behaviour. While questions on inactive behaviour (hours watching TV or playing videogames) did predict excess weight, questions on active behaviour (how often the child plays sports, whether the child walks to school, etc.) are harder to formulate and did not predict BMI. Reverse causation may also be an issue: parents of overweight or obese children may over-report physical activity, and under-report unhealthy dietary habits. Parents of overweight or obese children may also attempt to increase their child's activity levels, and improve their dietary habits. And potentially important pathways variables, such as parental supervision for the injury model, are difficult to operationalize without observational fieldwork.

Nonetheless, this study is one of few to explore the association between family structure trajectories and early physical health, as opposed to more commonly reported outcomes such as cognitive development or behaviour in older children. The early pre-school years, a critical developmental age, is often missing from the family structure and child well-being literature. Using a large, prospective, nationally representative study, we were able to distinguish between detailed longitudinal measures of family structure, showing that the use of simple or cross-sectional variables to describe family structure disguises important differences between groups, even in early life. Our interdisciplinary conceptual model allowed us to include a number of spheres of a child's life, including psychosocial variables such as parental mental health; environmental variables such as housing quality; and health behaviours such as eating patterns and inactivity.

6 Conclusion

This study explored associations between family structure trajectories and three sets of child health outcomes, and described pathways through which family trajectories and their socio-economic context could operate to influence child health. Proximal variables through which the more distal variables of socio-economic background and family structure varied as expected by health outcome; "family stress" came across as a potentially important pathway across all health outcomes. With few exceptions, once all model variables were accounted for, there were no significant differences between different family structure trajectories in early child physical health.

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(see separate files for figures and tables)

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Figures

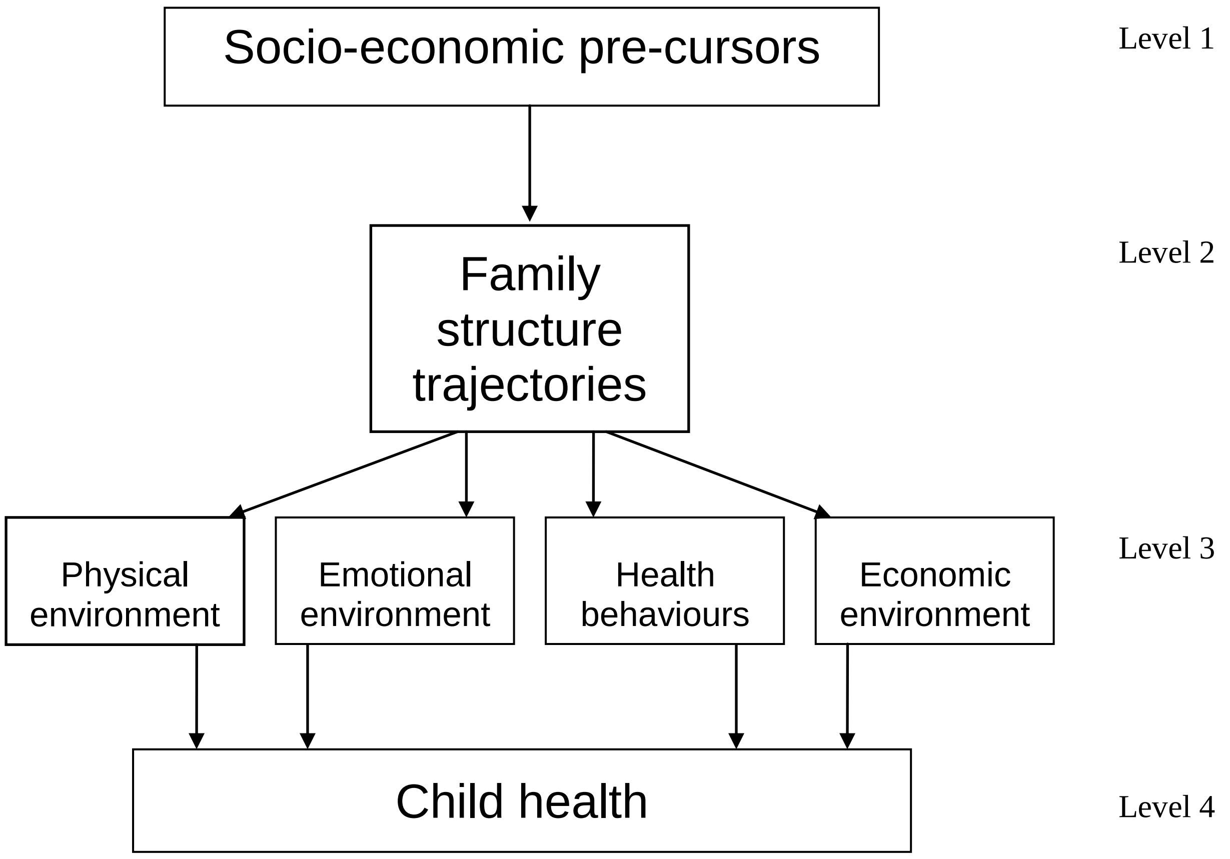

Figure 1: Conceptual model

Tables

Table 1: Typologies of family structure trajectories, birth to age 5

	% (imputed and weighted)	*Unweighted sample size, before imputations*
No changes		
Always married	56.0	*7 148*
Always cohabiting	11.1	*1 398*
Always single parent	5.9	*908*
Total	***73.0***	***9 454***
One transition		
Cohabiting to married	6.5	*788*
Married to single parent	4.4	*556*
Cohabiting to single parent	3.8	*474*
Single parent to cohabiting	3.4	*506*
Single parent to married	1.3	*240*
Total	***19.4***	***2 564***
More than one transition	7.6	*990*
Total imputed sample size		14 678
Total not imputed sample		*13 008*

Table 2: % children reporting health outcome at age 5, by family structure trajectory

	Recent wheeze	**Ever asthma**	**Overweight or obese**	**At least 1 accident**
Always married	14.2	11.9	21.5	25.4
Always cohabiting	15.4	14.6	23.2	29.5
Always single parent	25.3	22.7	28.5	34.0
Cohabiting to married	14.5	15.4	23.2	27.8
Married to single parent	14.2	17.7	18.5	26.7
Cohabiting to single parent	21.4	20.0	29.3	29.2
Single parent to cohabiting	19.8	20.6	25.6	33.9
Single parent to married	11.7	12.9	23.1	28.3
More than 1 transition	19.1	17.2	22.2	34.6
Total sample size (N)	14 678	14 678	14 678	14 678
p-value	<0.0001	<0.0001	0.002	<0.0001

Table 3: Relative Risk Ratios for multinomial regression model of family structure trajectories on block 1 variables.
Comparison category is the “always married” group

	Always cohabiting	Always single	Cohabitees who marry	Married to single	Cohabiting to single	Single to cohabiting	Single to married	More transitions
Maternal age at birth	0.54**	0.51**	0.64**	0.91	0.52**	0.42**	0.59**	0.52**
Age squared	1.01**	1.01**	1.01**	1.00	1.01**	1.01**	1.01**	1.01*
Highest educational qualification in hh	0.89**	0.75**	0.93*	0.92*	0.89*	0.77**	0.74**	0.84**
Car ownership	0.81**	0.27**	0.94	0.40**	0.28**	0.58**	0.64*	0.44**
Income, wave 1	0.99*	0.87**	0.99	0.99	0.98*	0.90**	0.93**	0.97*
Sample size	14 678							

*p-value <0.05, ** p-value <0.001

Table 4: Odds Ratios from a logistic regression, all blocks on ever asthma and wheeze at 5 years of age.
Comparison category is "always married"

		Asthma	Wheeze
Block 6	Damp, wave 1	1.09	0.996
	Damp, wave 2	1.13*	1.15**
	Number of siblings in household	0.947	0.900**
Block 5	Parental smoking, wave 1	1.067	0.992
	Parental smoking, wave 2	1.09	0.919
	Breastfeeding initiation	0.854*	0.94433
	Smoke during pregnancy	1.36*	1.11
	Less than 3 hours screen time	0.86	0.81
Block 4	Income, wave 2	0.999	0.999
	Education, wave 2	1.02	1.05
Block 3	Maternal malaise, wave 1	0.944*	0.933**
	Maternal mental wellbeing, wave 2	1.012	1.04**
	Paternal mental wellbeing, wave 2	0.994	0.993
	Parental relationship, wave 1	0.991	1.001
	Parental relationship, wave 2	0.982	0.986
	Attachment, wave 1	1.02*	1.012
	Structured parenting, wave 2	1.001	0.970
	Warmth, wave 2	1.001	0.996
Block 2	Always cohabiting	0.99	0.9541
	Always single parent	1.31*	1.54**
	Cohabiting to married	1.16	0.970
	Married to single	1.28	0.830
	Cohabiting to single	1.19	1.24
	Single to cohabiting	1.17	1.17
	Single to married	0.73	0.665*
	More than 1 transition	1.02	1.11
Block 1	Maternal age at birth	0.997	1.01
	Maternal age squared	0.998	0.999
	Highest education qualification in household	0.936	0.952
	Car ownership	0.9876	0.968
	Income, wave 1	0.996	0.999
Sample size	14 678		

*p-value <0.05, ** p-value <0.001

Table 5: Odds Ratios from a logistic regression, all blocks on being overweight/obese at 5 years of age. Comparison category is "always married"

Block 5	Smoking during pregnancy	1.18*
	Parental smoking. wave 1	1.11
	Parental smoking, wave 2	0.901
	Breastfeeding initiation	1.16*
	Eat meals at regular times	0.820
	Regular breakfast	0.707**
	Less than 3 hours screen time	0.870*
Block 4	Income, wave 2	0.999
	Education, wave 2	1.03
Block 3	Maternal malaise, wave 1	0.975
	Maternal mental wellbeing, wave 2	0.989
	Paternal mental wellbeing, wave 2	0.992
	Parental relationship, wave 1	0.977
	Parental relationship, wave 2	0.983
	Attachment, wave 1	1.06*
	Structured parenting, wave 2	0.952
	Warmth, wave 2	1.01
Block 2	Always cohabiting	1.09
	Always single parent	1.43*
	Cohabiting to married	1.27
	Married to single	0.977
	Cohabiting to single	1.61*
	Single to cohabiting	1.27
	Single to married	1.14
	More than 1 transition	0.921
Block 1	Maternal age at birth	0.998
	Maternal age squared	0.938
	Highest education qualification in household	0.938
	Car ownership	1.15
	Income, wave 1	0.995
Sample size	14 678	

*p-value <0.05, ** p-value <0.001

Table 6: Odds Ratios from a logistic regression, all blocks on injury requiring a medical visit. Comparison category is "always married"**0**

Block 6	Number siblings in the household	1.19*
	Overcrowding	0.735
	Safety of neighborhood	0.965
	Atmosphere in home	1.20*
Block 5	Use car as passenger	1.19
Block 4	Income, wave 2	0.999
	Education, wave 2	0.977
Block 3	Maternal malaise, wave 1	0.935*
	Maternal mental wellbeing, wave 2	1.001
	Paternal mental wellbeing, wave 2	0.977
	Parental relationship, wave 1	1004
	Parental relationship, wave 2	1.005
	Attachment, wave 1	1.001
	Structured parenting, wave 2	0.996
	Warmth, wave 2	1.001
Block 2	Always cohabiting	1.13*
	Always single parent	1.39*
	Cohabiting to married	1.06
	Married to single	0.834
	Cohabiting to single	1.22
	Single to cohabiting	1.26*
	Single to married	0.806
	More than 1 transition	1.24*
Block 1	Maternal age at birth	0.969
	Maternal age squared	1.002
	Highest education qualification in household	1.06
	Car ownership	1.14
	Income, wave 1	1.006
Sample size	14 678	

*p<0.05, **p<0.001

***Ethics approval/Statement EA not required**

Ethics Statement

Submission to *Social Science and Medicine*

Family Structure Trajectories and Early Child Health in the UK: Pathways to Health; by Lidia Panico (Institut National d'Etudes Démographiques); Mel Bartley; Yvonne Kelly; Anne McMunn; Amanda Sacker (University College London)

The submitted paper involves secondary analysis of existing data, the Millennium Cohort Study, that are publicly archived. We use the fully anonymised datasets available from the ESRC Data Archive, which are generally available to the research community and have minimal risk of disclosure. All analyses were carried out according to the ethical and legal guidelines specified by the Data Archive, including any special requirements for the Millennium Cohort Study.

Research conducted as part of this project was governed by the each partner ethics policies. Research conducted at UCL is governed by the ethics committee at UCL, whose procedures can be found here: www.grad.ucl.ac.uk/ethics. At Ined, good practice in research is ensured through liaising with the Ined Ethics Committee and its appointed Data Protection Officer.

Lidia Panico, Paris, 7th August 2018