Parental Separation and Children's Physical Health

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Abstract: Over the last decades, most industrialized countries experienced an increase in marital instability. Changes in family structure generated a wealth of research on the parental separation on children's well-being. This literature largely focused on children's educational outcomes and considerably less attention given to the consequences of parental separation on children's physical health. Yet, parental separation, by changing resources available in the family, could also affect children's physical health and development negatively. To test this, we use a rich nationally representative longitudinal data from the U.K. Millennium Cohort Study (MCS), which provides information on children's BMI, overweight and obesity at 3, 5, 7 and 11 years of age. We use a fixed-effects regression model to control for time-invariant family (and child) characteristics and we analyze the process of parental break-up more carefully than previous literature by analyzing the short-term, medium-term and delayed effects of parental separation, as well as pre-separation effects. We pay particular attention to [and provide discussion about] the distributional issues related to our physical health indicators measured longitudinally over the childhood period. We find that parental separation is associated with increases in children's BMI and with the risk of overweight and obesity. The effect of separation on BMI is cumulative over time and more pronounced for families with higher socio-economic status before separation.

I. INTRODUCTION

The family context has been undergoing dramatic changes in many of the post-industrial societies in the last three decades (Mclanahan and Sandefur, 2004, Cancian, Meyer and Cook, 2011, etc). Most notably, the trends in family instability have been on the rise despite some variation in all European countries, but with especially high levels in the UK (Gonzalez and Vitaanen, 2009) and it has been stably high in the US (Wolfers and Stevenson, 2008). As a result, today, a considerable number of children experience parental separation, which may have implications for their physical and emotional development.

A large literature has paid attention to the relationship between the changes in family structure and various outcomes for children, such as cognitive skills, educational outcomes, emotional and psychological wellbeing (see the recent literature reviews by Amato, 2010; Bernardi et al 2014; Mclanahan, Tach and Schneider, 2013). Yet, much fewer studies focus on the relationship between family break-up and physical health of children (e.g. Bzostek and Beck, 2011; Schmeer, 2012; Chen, et al. 2010 Yannakoulia, et al 2008; McConly, et al. 2011; Cavanagh, Smith and Crosnoe, 2014)[1]. This is regrettable as parental separation, by changing the quality and quantity of resources, could affect children's physical health negatively. Parents care first and foremost about their children's physical health and development (Eiser and Morse, 2014). Furthermore, poor health in childhood might have long lasting effects on various health and social outcomes in adulthood (Case, Fertig and Paxon, 2003).

More importantly, most of these studies rely on cross-sectional designs, where selection problems associated with non-random distribution of separations may be severe. In fact, only two of them exploit longitudinal data and use within-child (i.e. fixed effects) models that allow controlling for unobserved time-invariant factors that might affect both children's physical development and their parents' break-up. These are Schmeer (2012)'s study that uses Fragile Families dataset and Cavanagh, Smith and Crosnoe (2014)'s study that uses NICHD Study of Early Child Care and Youth Development of the US. These studies rely on datasets that are not nationally representative and moreover, along with most other cross-sectional studies, they focus on the US context. As a result, to our knowledge, there is no evidence from Europe, but especially one that uses representative longitudinal datasets, on the role of parental separation for children's physical development. However, the findings from the US may not be directly transferrable to other countries.

In this paper, we aim to address this gap and make additional contributions to the literature:

[1] In addition to these studies, Hernandez et al 2014 analyze the effect of childhood family instability on adult obesity and overweight using NLSY data from the US.

First, we provide further evidence on the relationship between parental separation and child health using fixed-effects models, which allow us to control for unobserved time constant variables and address the issues of selection. While doing so, we also tease out the process of separation more carefully than previously done. Unlike earlier studies, our modeling strategy takes into account the pre- and post-separation periods as well as, short, medium and longer-term effects of separation on children's physical health. Second, we use data from the Millennium Cohort Study (MCS), a nationally representative longitudinal dataset of children born around the year 2000 from the UK and it contains rich information on family characteristics, and family routines, etc. This allows us to take into account some of the time-varying factors that may mediate the relationship between parental separations and children's physical health. The data also contain precise information about the month of parental separation, which is useful to precisely model the timing of the change in family structure[2]. Third, we further explore the heterogeneity in the effects of separation by parental socioeconomic status, an analysis not previously done in the literature.

As measure of children's physical health, we focus on children's body mass index[3] (BMI), which is a commonly used stock variable of long term health (Komlos, 2009) and the risk of being overweight and obese. Our data covers most of childhood years (from birth until age 11) and modeling changes in BMI and family structure may not be straightforward during these ages when children's physical. Our last contribution is that we provide discussion and insights about potential modeling and measurement issues

II. HOW MAY FAMILY INSTABILITY AFFECT CHILDREN'S PHYSICAL DEVELOPMENT?

There are multiple mechanisms through which parental break-up may affect children's net nutrition intake (i.e. nutrition intake minus energy spent), which ultimately determines their BMI. These may be grouped into two, as direct mechanisms versus indirect mechanisms. In this paper, we do not aim to test *all* of these mechanisms although we are able to introduce various variables into our model specifications that may allow us to rule out or represent some of them.

Direct mechanisms are those that link parental break-up directly to the changes in the amount and type of nutrition that children receive and the amount of energy that they spend. *Resource theories* are mainly concerned about the resources available in the household for children to develop physically. Both food intake and energy spent may be directly related to resources available in the home environment. The resources are assumed to be provided mainly by parents and are defined broadly. For example, they

[2] Unfortunately, due to time constraints, in this version of the paper, we do not exploit this information. Yet, it is our aim to take into account exact timing of separations in the next version.
[3] Computed as: weight (kg)/(height^2 (mt))

do not only include economic resources but also non-economic resources such as parental time and attention available to the children. It is important to distinguish these two types of resources since their relative importance may vary over the childhood period and also across the stages of the separation/ divorce process, although there may be considerable interplay between them (e.g. Case and Paxon, 2001; Bzostek and Beck, 2011; Schmeer, 2012 and Cavanagh, Smith and Crosnoe, 2014).

For example, economic resources are often reduced *after the separation* for the mother and the children staying with the mother (e.g. see McLanahan and Sandefur 1994, Amato 2010). The implications may be on the nutrition intake, such as having less means to buy fresh vegetables, healthy food, and reduced time for the mother to prepare healthy food at home due to her increased market work. Additionally, there may also be fewer resources available for many of the (often) paid extracurricular activities that children might be attending prior to family break-up (e.g. sports activities such as, swimming, tennis, football or other activities such as dancing lesson, summer camps, etc.). Thus, declining time and economic resources may affect the energy spent by children, too. Overall, potentially, single parents might have less time after separation to establish and observe routines and eating schedules, they may be more likely to dine outside, and to provide ready and processed food.

One may argue that a reduction in parental resources and changes in parent's attention to their children's health and physical development may well happen before the separation, especially during the conflict period. A small but growing literature in economics argue that many married women with children increase their labor supply, when marital conflict and their divorce/separation risk increases (Papps 2007; Genadek, Stock and Stoddard, 2007; Bargain et al, 2011). Consequently, time and monetary resources available to children may have already been changing before the actual separation occurs. Thus, it is important to take into account the pre-separation period as a part of the "separation effect" in the model specification (see also Pronzato and Aassve 2013)[4], a strategy we follow in this paper.

There are other mechanisms through which parental separation may affect children's physical health, even if resources available to children remained largely unaffected by separation process. We call them indirect effects since they may affect children's physical health through their influence on children's emotional wellbeing. For example, stress and emotional problems related to parental separation may manifest themselves as changes in the eating behavior. If children respond to the environmental changes by modifying their eating behavior or disrupting their routines, then, weight losses and gains may be read as signs of emotional difficulties associated with parental separation.

[4] A similar strategy is also employed in Pronzato and Aassve (2013) study, which uses the same dataset to look at children's social and behavior outcomes until age 7. In addition to focusing on a very different outcome variable, our study differs from their study because we observe children until age 11, and take into account exact timing of separation to measure delayed effects of separation.

Alternatively, mother's emotional response to separation may also affect changes in the children's eating patterns, even if the available economic or time resources remained constant (e.g. Wynn and Bowering, 1990). There is some evidence in the early literature that single mothers are more likely to overfeed their children compared to married mothers (e.g. Bowering and Wynn, 1986). More recent studies find that parenting styles may be associated with adolescent dietary behavior, such as eating vegetables, having proper breakfast (e.g. Pearson et al 2010). To the extend, that changes in parenting styles are associated with changes in family structure in the UK[5], one may expect parental separation to have a negative effect on children's eating behavior through changes in parenting styles.

Although the majority of these mechanisms imply an overall a negative effect of separation on children's physical development, a negative effect may mean children moving towards both tails of the BMI distribution due to separation. Put differently, both weight losses and weight gains can be thought as negative health consequences of parental separation in children. Yet, as opposed to the height stunting and malnutrition, two issues that are more commonly experienced by children in developing countries due to food insecurity (see Desai, S. 1992 and Bronte-Tinkew, DeJong, G. 2004 in the context of family structure), we expect that any negative effect of separation would more likely be associated with weight gains in the UK context. Recent evidence from the US suggest that child food insecurity and family structure association disappear once a set of factors such as household income, ethnicity, education and family size are controlled for (Miller et al 2014). Thus, we expect that family instability is more likely to move children towards the right end tail of the BMI distribution, and result in increased risk of overweight and obesity in the UK.

It is important to note here that these potential mechanisms do not distinguish whether the parents were cohabiting or married before separation. In line with this, we focus on all separations (of either cohabiting or married partners) in the following analyses. This is less problematic in the UK context as it is well documented that cohabitations are more committed and marriage-like in the UK compared to the US (e.g. Kiernan et al 2011). Finally, the extend to which these mechanisms, especially the ones that are suggested by the family resources theory, play a role in explaining the variation in child health may depend on the initial socio-economic status of the family. Thus, we provide further analyses where we estimate our models separately by SES.

[5] Recent studies in the US suggest that parenting styles cut across all family structures, and not patterned by family types (e.g. Pearson et al 2014), although these studies do not explicitly focus on changes.

III. DATA and METHOD

The Millennium Cohort Study

We use data from the Millennium Cohort Study (MCS), a UK representative longitudinal cohort study, which follows the lives of approximately 18,000 children, who were born around the year 2000. The MCS is an appropriate dataset for this this study as it provides information on indicators of child health (i.e. BMI, overweight and obesity) when these children were 3 (Sweep 2), 5 (Sweep 3), 7 (Sweep 4) and 11 (Sweep 5) years of age. In addition, it provides extensive information on a wide range of fixed and time-varying family characteristics, such as family structure, family socio-economic status, family and children's routines around diet, physical activity etc. The MCS has a complex survey design. Throughout the analyses, in order to account for it, we use individuals' design weight and we cluster the standard errors at the electoral ward level.[6]

We select children whose parents are married or cohabiting at birth (as discussed in the previous section, in the analyses we do not distinguish separations from divorces) and Sweep 1 (i.e. when the children are 9 months old) as we want to focus on children who are at risk of experiencing parental separation. In addition, we consider children whose natural parent is the main interviewee (at every Sweep of data collection) and for whom we have complete data on all variables used in the analyses. In other words, we use a balanced panel of these children. From this sample, we exclude children who experienced the death of at least one parent. The final analytical sample of this study includes 7252 children and a total of 1553 separations which took place between Sweep 2 and Sweep 5. Table 1 shows the percentage of separations which took place between each Sweep of data collection and shows that the highest percentage of separations takes place between Sweep 4 and 5.

[Table 1 about here]

Method

We exploit the longitudinal nature of the MCS data and we use a fixed-effects regression model to control for time-invariant child (and family) characteristics (Amato & Anthony, 2014) that might influence both the likelihood of a parental separation and child health. In order to carefully analyze the process of separation, we make use of the longitudinal nature of the MCS and similarly to Pronzato & Aassve (2013), we consider both the immediate and delayed effects of parental separation on child health (i.e. the outcome variable). We also consider the pre-separation period as a part of the separation process. We do this by including in the fixed-effect regression model, one dummy variable

[6] The MCS has a complex survey design, which normally would be taken care of by employing the survey command 'svy' in Stata, which accounts for both clustering and stratification. Since svy does not support the command 'xtreg' (which is used to run the fixed effects regression), we use design weights (at Sweep 5) and cluster the standard errors at the ward level. At the moment, stratification is not accounted for which results in more conservative estimates.

capturing the pre-separation period, one dummy variable capturing the immediate effect and three dummy variables capturing the delayed effect (short-term, medium-term and longer-term) of parental separation on child health.

In other words, we estimate various versions of the following baseline specification

$$Child\ Health_{si} = \alpha + \beta_1 PreSep_{(s-1)i} + \beta_2 Immediate_{si} + \beta_3 Short_{(s+1)i} + \beta_4 Medium_{(s+2)i}$$

$$+\beta_5 Long_{(s+3)i} + X_{si}\gamma + u_i + \varepsilon_{si} \qquad (1)$$

where, the dependent variable is the measure of child health (i.e. BMI or risk of being overweight or obesity) of child *i* at sweep s, s= 2, 3, 4, 5. β_2 indicates the effect of parental separation (event itself, measured by our separation indicator as explained in the Table 2 below) which we call the immediate effects; β_1 is the pre-separation effect; β_3, β_4, β_2 represent the delayed effects of separation in the short, medium and longer term, respectively, which are defined by the number of sweeps since the timing of separation. ϒ is the effect of other control variables that might vary over time. These may include a set of risk factors through which separation may influence children's physical health, such as whether the cohort child has a regular bedtime routine, or does enough physical exercise, etc. *u* are unobservable characteristics of the child *i* which are constant over time, and *ε* is the error term. We estimate this specification using OLS or LPM depending on the outcome measure. Thus, our coefficients are directly interpretable as marginal effects.

Table 2 describes the dummy variables included in the fixed effect regression model and which groups of children – based on the age at which they experienced parental separation – contribute to identify the pre, immediate and delayed effects of separation on child health.

[Table 2 about here]

Children experienced separations between different pairs of sweeps, but at this stage we assume that, within each group, parental separation occurs at the same time for all children. This might be a strong assumption to make, especially considering the three-year gap between the last two sweeps where most of the separations take place (as shown in Table 1). However, it is our aim to exploit the information on the month and year of separation (and, if relevant to the estimation strategy, include it in an updated version of the paper).

We adopt the following analytical strategy. First, to assess whether parental separation is negatively associated with child health (the outcome variable), we run a set of fixed effect regression models as specified in equation 1, but excluding time-varying covariates (i.e. ΥX_{is}) thereby controlling for only time-invariant child and family characteristics. Second, to assess whether and to what extent the (potentially) negative effects of parental separation and child health are mediated by changes in family resources and family routines following separation, we include in the fixed effects regression model a set of covariates and observe how the association between parental separation and child health varies with their inclusion in the models. In order to get a better sense of variation in family resources and routines in the pre and post separation periods, we also run fixed effect models using these control variables as dependent variables. Third, to explore whether there is heterogeneity in the way in which parental separation is associated with child health – we stratify the fixed effects models by parental socio-economic background, defined by the level of education in the household at baseline (Sweep 1) and before separation took place. The aim here is to assess whether the potentially negative effects of separation are more marked amongst more or less advantaged families. The dependent, control and stratification variables are described next.

Outcome Measures

We use two outcome measures of child health. First, we rely on children's body mass index (BMI), a continuous measure which combines height and weight (kg/m^2) and is commonly used as a stock indicator of long-term health (e.g. Komlos 2009). One of the clear advantages of using this measure of child health is that it is an objective measure., It is measured by a trained interviewer (i.e. BMI was not reported by the parent, which could be subject to error and bias) in the MCS. At each sweep, children were weighed without shoes or outdoor clothing using Tanita HD-305 scales (Tanita UK Ltd, Middlesex, UK) and weights were recorded in kilograms to one decimal place. Heights were obtained using the Leicester Height Measure Stadiometer (Seca Ltd, Birmingham, UK) and recorded to the nearest millimeter. Throughout the analyses, we use BMI percentile ranks. We obtain percentile ranks by regressing - using a standard linear regression model (OLS) - raw BMI scores on age (i.e. age of the child measured in days at each Sweep of data collection) and sex of the child. The residuals we obtain from the linear regression model are used to compute percentile ranks[7]. Thus, we ensure that our outcome measure is comparable over time. Although changes in BMI percentile ranks are easily interpretable they may mask changes happening at the extreme tails of the distribution. Since BMI is not normally distributed, absolute values corresponding to changes in the upper percentile may be more relevant for policy-makers than rank changes (Cole et al 2005).

As a result, we also adopt an additional measure of child health, namely a categorical variable indicating whether the child is overweight or obese. Overweight and obesity are defined using the International Obesity Taskforce (IOTF) body mass index cut-points which are age and gender specific.

Mediators

By taking advantage of the richness of the MCS, we gradually adjust the baseline specifications, using a set of control variables which capture potential changes in

[7] Results not shown, but available on request

family's resources and routines. It is important to highlight that these variables were reported by the main respondent. These control variables are logged household income (OECD adjusted), whether the main respondent declares to suffer from depression at the time of interview, whether the child has a regular bedtime, whether the child watches TV more than 3 hours per day during a weekday, whether there is a step-parent living in the household. These variables are included in the regression models as potential *mediators* of the association between parental separation and children's BMI. This is because, as discussed in the theoretical section of this study, we expect that family resources and routines might vary as a consequence of separation and previous studies have identified these variables as relevant risk factors for children's BMI or risk of being overweight/obese (e.g. Hancox, Milne Pourton, 2004; Goisis, Kelly and Sacker, 2014; Schmeer 2011). As discussed in the analytical strategy section, in order to get a better sense of variation in family resources and routines in the pre and post separation periods, we also run fixed effect models using these variables as outcomes.

Information on these family routines and resources were collected from Sweep 2 to Sweep 5, which is the temporal window we focus on when looking at the association between parental separation and child health. A larger set of information on child routines and behaviours (reported by the main respondent at interview) which previous literature has identified as relevant risk factors for child obesity/overweight were collected from Sweep 3 onwards. For example, we know whether the child had breakfast every day, whether the child has daily fruit consumption, whether the child plays sport at least weekly and whether at least one parent does active playing with the child at least weekly. We could not consider the potential mediating role of these variables on the association between child health and parental separation (since they were collected from Sweep 3 onwards and BMI was collected from Sweep 2 onwards). Nonetheless, in order to get a better sense of whether and how these additional routines and behaviours changed following separation - we ran fixed effects models using these variables as outcomes.

Stratification variable

In order to assess whether the association between parental separation and child health vary by parents' socio-economic status, we group children based on the highest level of education in the household at Sweep 1 (9 months) i.e. before separation. In particular, the models are estimated separately based on whether in the household there is/isn't at least one parent with degree level education.

IV. RESULTS

Descriptive findings

Table 2 provides descriptive statistics about the sample, outcome measures and control variables. The results present average estimates for children who do not experience a parental separation between Sweep 1 and Sweep 5 and children who experience a parental separation at any point between Sweep 1 and Sweep 5. The results reveal that, consistent with what the existing literature suggests, children of separated parents belong to a particularly disadvantaged group. In fact, children of separated parents belong to households with lower average levels of household income and a lower percentage of parents with degree level education at Sweep 1 compared to children of non-separated parents. In so far as the two outcomes measures are concerned, the descriptive results show that children of parents who do not experience a parental separation tend to have higher BMI levels at Sweep 2 but lower BMI levels later on. Children of separated parents show higher average levels of overweight/obesity at any Sweep compared to children of non-separated parents.

[Table 3 about here]

Model results

Tables 4 and 5 report results from the fixed effects regression models. Table 4 shows a linear specification using child fixed effects with dummies capturing the pre, post and delayed effects of separation and, progressively, including a set of potential mediators. The dependent variable in these specification is BMI percentile ranks – which are obtained by regressing – using an OLS model - BMI raw scores on gender and age of child at each Sweep of data collection (i.e. age of children is measured in days). Table 5 reports the same specification for the binary outcome measure, namely whether the child is overweight or obese.

The first model specification in Table 4 shows that experiencing parental separation is positively and significantly associated with BMI percentile ranks. The magnitude of the 'immediate' effect of separation is small (0.042*** i.e. 4 percentiles) but the effects get stronger as time since separation increases. Indeed, the negative effects of parental separation on children's BMI increase monotonically as time since separation increases (6, 7, and 9 percentiles in the short, medium and longer-term respectively, coefficients significant at the 1% level). The pre-separation effect is positive, albeit small and significant at the 10% level (0.015*). The interpretation of the results is that parental separation is positively associated with children's BMI percentile ranks. The evidence suggests that children who experience a parental separation tend to gain more weight than children who live with continuously married/cohabiting parents; moreover, the effect is cumulative as time since separation increases, as the former do not tend to revert back to the levels observed for the latter.

[Table 4 about here]

The first model specification (linear probability model) in Table 5 shows that experiencing parental separation is positively associated with the risk of being overweight or obese, although the results are only significant for the delayed effects of separation (longer term) and the effect sizes are relatively small (0.068***). The fact that the risk of being overweight or obese becomes stronger a few years after separation takes place resonates well with the results on BMI. Indeed, continuous and cumulative increases in BMI might result in (increased risk of becoming) overweight or obesity.

[Table 5 about here]

In both Table 4 and 5, specifications 2-7 adjust for markers of family resources and routines. The aim of these specifications is to assess whether these variables might mediate the association between parental separation and BMI and the risk of being overweight/obese. However, adjusting for potential mediators produced very small changes in the coefficients' size and magnitudes. The left part of Table 6 presents the fixed effects model results for the mediating variables included in Table 4 and 5. The results show that changes in the considered family resources and routines were quite limited and short-lived. For example, consistent with existing evidence, the results show that following separation there is a reduction in the level of family income – but this is only observed immediately following separation, whilst there seems to be a recuperation and even an increase in the longer term. The resident parent is more likely to report being depressed, but again the effect seems to be present only immediately after separation and not in the longer term. The results for the frequency of whether the child watches TV and whether he/she has a regular bedtime are somewhat counterintuitive. In fact, they show that children of separated parents following separation tended to be less likely to watch TV and have an irregular bedtime. However, we should highlight that the effects sizes are considerably small (with the exception of household income) which might explain why adjusting for these family characteristics and routines produces small changes in the association between parental separation and child health.

The right side of Table 6 shows fixed effects models for children's behaviors and routines which were not included in the model specifications in Table 4 and 5, since these variables were collected from Sweep 3 onwards. The results show that before and just after separation, children of separated parents tend to be less likely to eat fruit every day, but similarly to other risk factors, the effects are not strong and appear to fade away as time since separation increases. In contrast, the results show that parental separation is associated with lower probability of at least one parent doing active playing with a child weekly – the results are strong and significant at the 1% level both shortly after separation and in the longer term. This could indicate that some changes in parent-children dynamics take place following separation and suggest that the level of time and attention parents are able to devote to their children potentially declines following separation. This could also imply, for example, that parents have less time to prepare home cooked meals and more often rely on less healthy alternatives. Unfortunately, this is not a hypothesis we can test within this study since the MCS does not provide specific information on children's nutrition (e.g. food diaries) and does not ask specific questions on the culture around food in the household.

[Table 6 about here]

Finally, Tables 7 and 8 replicate the analyses presented in Table 4 stratified by parental education at Sweep 1, namely separately for families where at least one parent had a degree level education or less. The results suggest that the negative effects of separation on children's BMI are stronger in families with higher levels of education than in families with lower levels of education. Similarly, Table 9 and 10 show that parental separation is associated with increased risk of overweight/obesity in the longer-term only for more advantaged children. As before, the results are robust to the inclusion of controls for family resources and routines.

[Table 7-8 about here]

[Table 9-10 about here]

V. PRELIMINARY CONCLUSIONS

The results indicate that the effect of parental separation is positively associated with children's BMI and the risk of being overweight/obese, but the effects become stronger as time since separation increases and more marked for children from advantaged families. The results provide limited explanation of the observed patterns as changes in family resources and routines following separation don't mediate the association between parental separation and child health. However, they provide some evidence that resources and the mental well-being of parents (at least temporarily) decline and strong evidence that the parents tend to spend less time doing active playing with their child following separation. Further analyses intend to inspect these patterns more closely and consider the specific timing of separation (i.e. month and year). Overall, the results underscore the importance of conceptualizing separation and its consequences as a *process* rather than a single event.

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RESULTS

Table 1: Distribution of separations across Sweeps

	% of separations
Sweep 1- Sweep 2	25.8
Sweep 2- Sweep 3	21.8
Sweep 3- Sweep 4	19.3
Sweep 4- Sweep 5	33.1
N	1,553

Table 2: description of dummy variables included in the fixed effects regression

Separation effects	Definition	When child experiences parental separation			
		Sweep 1 - Sweep 2	Sweep 2 - Sweep 3	Sweep 3 - Sweep 4	Sweep 4-Sweep 5
Pre-separation	S-1: will experience parental separation in the next sweep		√	√	√
Immediate Effect	S: experiences parental separation between s-1 and s		√	√	√
Delayed effect short term	S+1: living with separated parents in s and s+1	√	√	√	
Delayed effect medium term	S+2: living with separated parents in s, s+1 and s+2	√	√		
Delayed effect longer term	S+3: living with separated parents in s, s+1, s+2 and s+3	√			

Note: S=separation

Table 3: characteristics of children of separated and non-separated parents

	Children of continuously partnered parents	Children who experience a parental separation between Sweep 1 and Sweep 5
BMI Percentiles (mean)		
Sweep 2	0.52	0.49
Sweep 3	0.48	0.49
Sweep 4	0.48	0.50
Sweep 5	0.47	0.51
Overweight & Obesity (%)		
Sweep 2	4.77	6.70
Sweep 3	4.70	4.70
Sweep 4	4.69	5.80
Sweep 5	5.02	7.66
Mean household weekly income (Sweep 1)	422.12	296.76
% At least one parent has degree level education (Sweep 1)	55.85	36.62
% CM is a girl	50.33	49.91
N	5999	1553

Table 4: Fixed effects regression on BMI percentile ranks

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
	β/s.e.	**β/s.e.**	**β/s.e.**	**β/s.e.**	**β/s.e.**	**β/s.e.**	**β/s.e.**
Pre-separation: S-1	0.015*	0.015*	0.015*	0.015*	0.015*	0.015*	0.015*
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Immediate effect of separation: S	0.042***	0.043***	0.042***	0.042***	0.042***	0.043***	0.044***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)
Delayed effect of separation (short-term): S+1	0.061***	0.063***	0.061***	0.061***	0.061***	0.061***	0.062***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Delayed effect of separation (medium-term): S+2	0.066***	0.068***	0.065***	0.066***	0.066***	0.064***	0.067***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Delayed effect of separation (longer-term): S+3	0.093***	0.095***	0.093***	0.093***	0.093***	0.091***	0.093***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.017)	(0.017)	(0.018)
Sweep 3 (*reference Sweep 2*)	-0.038***	-0.038***	-0.038***	-0.038***	-0.038***	-0.039***	-0.039***
	(0.007)	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)	(0.006)
Sweep 4	-0.040***	-0.040***	-0.040***	-0.040***	-0.040***	-0.041***	-0.041***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Sweep 5	-0.050***	-0.050***	-0.050***	-0.050***	-0.051***	-0.079***	-0.079***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.025)	(0.025)
Main respondent lives with step parent		-0.012					-0.012
		(0.014)					(0.013)
Child watches TV more than 3 hours on weekday			-0.004				-0.004
			(0.005)				(0.005)
Child doesn't have a regular bedtime				0.002			0.002
				(0.006)			(0.006)
Main respondent is depressed					0.007		0.007
					(0.004)		(0.004)
HH income (ln)						0.006	0.006
						(0.005)	(0.005)
Constant	0.513***	0.514***	0.514***	0.513***	0.511***	0.477***	0.475***
	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.029)	(0.029)
Number of observations				7,252			

note: *** p<0.01, ** p<0.05, * p<0.1. Estimates are weighted and standard errors clustered (at the ward level)

Table 5: Fixed effect on being overweight/obese vs. normal weight (linear probability model)

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
	β/s.e.	**β/s.e.**	**β/s.e.**	**β/s.e.**	**β/s.e.**	**β/s.e.**	**β/s.e.**
Pre-separation: S-1	-0.019	-0.019	-0.019	-0.020	-0.019	-0.019	-0.020
	(0.015)	(0.015)	(0.016)	(0.015)	(0.016)	(0.015)	(0.016)
Immediate effect of separation: S	0.005	0.007	0.005	0.004	0.004	0.006	0.008
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.016)	(0.015)
Delayed effect of separation (short-term): S+1	0.024	0.029*	0.024	0.023	0.024	0.024	0.028
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Delayed effect of separation (medium-term): S+2	0.030	0.036*	0.030	0.029	0.030	0.028	0.034*
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Delayed effect of separation (longer-term): S+3	0.068***	0.073***	0.068***	0.067***	0.068***	0.065**	0.070***
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.026)	(0.025)
Sweep 3 (*reference Sweep 2*)	-0.026***	-0.026***	-0.026***	-0.028***	-0.026***	-0.027***	-0.029***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Sweep 4	-0.041***	-0.042***	-0.041***	-0.043***	-0.041***	-0.042***	-0.045***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Sweep 5	0.028***	0.028***	0.028***	0.026***	0.028***	-0.009	-0.013
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.030)	(0.030)
Main respondent lives with step parent		-0.026					-0.027
		(0.023)					(0.023)
Child watches TV more than 3 hours on weekday			0.006				0.007
			(0.008)				(0.008)
Child doesn't have a regular bedtime				-0.024***			-0.024***
				(0.008)			(0.008)
Main respondent is depressed					0.007		0.007
					(0.007)		(0.007)
HH income (ln)						0.008	0.009
						(0.007)	(0.007)
Constant	0.220***	0.221***	0.220***	0.225***	0.218***	0.172***	0.172***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.038)	(0.038)
Number of observations				7,252			

note: *** p<0.01, ** p<0.05, * p<0.1. Estimates are weighted and standard errors clustered (at the ward level)

Table 6: Fixed effect regression using the risk factors as dependent variables

	Available from Sweep 2- Sweep 5				Available from Sweep 3 - Sweep 5 (models run excluding separations that occur between Sweep 1 and Sweep 2)			
	CM watches TV more than 3 hours per day (linear probability model)	CM doesn't have a regular bedtime (linear probability model)	Main respondent is depressed (linear probability model)	HH income (logged)	Child has breakfast everyday (linear probability model)	Child has daily fruit consumption (linear probability model)	Child does sport at least weekly (linear probability model)	Parent does active playing with child at least weekly (linear probability model)
	β/s.e.	β/s.e.	β/s.e.	β/s.e.	β/s.e.	β/s.e.	β/s.e.	β/s.e.
Pre-separation: S-1	-0.035**	-0.024*	0.022	0.033*	0.019	-0.099***	0.005	-0.045*
	(0.017)	(0.014)	(0.021)	(0.018)	(0.018)	(0.020)	(0.030)	(0.025)
Immediate effect of separation: S	-0.022	-0.017	0.057***	-0.143***	-0.021	-0.046**	0.016	-0.259***
	(0.017)	(0.016)	(0.019)	(0.017)	(0.024)	(0.019)	(0.031)	(0.028)
Delayed effect of separation (short-term): S+1	-0.056***	-0.039**	0.001	0.054**	-0.009	-0.006	-0.003	-0.262***
	(0.016)	(0.018)	(0.020)	(0.023)	(0.028)	(0.025)	(0.035)	(0.036)
Delayed effect of separation (medium-term): S+2	-0.058***	-0.029	-0.013	0.199***	-0.030	0.123***	0.050	-0.253***
	(0.022)	(0.021)	(0.027)	(0.025)	(0.032)	(0.041)	(0.045)	(0.048)
Delayed effect of separation (longer-term): S+3	-0.063**	-0.039	-0.019	0.385***				
	(0.028)	(0.026)	(0.034)	(0.032)				
Sweep 3	-0.017**	-0.091***	-0.041***	0.082***				
	(0.008)	(0.006)	(0.008)	(0.008)				

Sweep 4	-0.009	-0.089***	-0.018**	0.155***	0.013***	-0.075***	0.133***	-0.054***
	(0.007)	(0.007)	(0.008)	(0.009)	(0.004)	(0.006)	(0.009)	(0.007)
Sweep 5	0.010	-0.084***	0.078***	4.473***	-0.043***	-0.372***	0.160***	-0.234***
	(0.010)	(0.007)	(0.008)	(0.011)	(0.005)	(0.014)	(0.011)	(0.009)
Constant	0.151***	0.175***	0.318***	5.781***	0.943***	0.904***	0.623***	0.861***
	(0.005)	(0.005)	(0.005)	(0.006)	(0.004)	(0.003)	(0.006)	(0.005)
Number of observations		7,252					6,852	

note: *** p<0.01, ** p<0.05, * p<0.1.Estimates are weighted and standard errors clustered (at the ward level)

Table 7: Fixed effects regression on BMI percentile ranks - higher education group

	Model (1) β/s.e.	Model (2) β/s.e.	Model (3) β/s.e.	Model (4) β/s.e.	Model (5) β/s.e.	Model (6) β/s.e.	Model (7) β/s.e.
Pre-separation: S-1	0.035**	0.034**	0.034**	0.035**	0.034**	0.035**	0.034**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Immediate effect of separation: S	0.048***	0.049***	0.048***	0.048***	0.048***	0.048***	0.048***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Delayed effect of separation (short-term): S+1	0.065***	0.067***	0.065***	0.066***	0.065***	0.066***	0.067***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Delayed effect of separation (medium-term): S+2	0.088***	0.091***	0.088***	0.088***	0.088***	0.089***	0.092***
	(0.024)	(0.025)	(0.024)	(0.024)	(0.024)	(0.023)	(0.025)
Delayed effect of separation (longer-term): S+3	0.097***	0.099***	0.097***	0.097***	0.097***	0.099***	0.101***
	(0.028)	(0.029)	(0.028)	(0.028)	(0.028)	(0.028)	(0.029)
Sweep 3 (*reference Sweep 2*)	-0.047***	-0.047***	-0.047***	-0.046***	-0.046***	-0.046***	-0.046***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
sweep 4	-0.051***	-0.051***	-0.051***	-0.050***	-0.051***	-0.050***	-0.050***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
sweep 5	-0.064***	-0.064***	-0.064***	-0.064***	-0.065***	-0.048	-0.049
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.035)	(0.035)
Main respondent lives with step parent		-0.010					-0.009
		(0.020)					(0.020)
Child watches TV more than 3 hours on weekday			-0.003				-0.003
			(0.008)				(0.008)
Child doesn't have a regular bedtime				0.009			0.010
				(0.009)			(0.009)
Main respondent is depressed					0.005		0.005
					(0.005)		(0.005)
HH income (ln)						-0.004	-0.004
						(0.007)	(0.007)
Constant	0.520***	0.520***	0.520***	0.518***	0.518***	0.542***	0.539***
	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.045)	(0.044)
Number of observations				3,915			

note: *** p<0.01, ** p<0.05, * p<0.1. Estimates are weighted and standard errors clustered (at the ward level)

Table 8: Fixed effects regression on BMI percentile ranks - lower education group

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
	β/s.e.	β/s.e.	β/s.e.	β/s.e.	β/s.e.	β/s.e.	β/s.e.
Pre-separation: S-1	-0.007	-0.007	-0.007	-0.007	-0.006	-0.007	-0.006
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Immediate effect of separation: S	0.033**	0.033**	0.033**	0.033**	0.033**	0.034**	0.035**
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Delayed effect of separation (short-term): S+1	0.058***	0.059***	0.058***	0.058***	0.059***	0.058***	0.059***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Delayed effect of separation (medium-term): S+2	0.044**	0.045**	0.044**	0.044**	0.045**	0.043**	0.045**
	(0.021)	(0.022)	(0.022)	(0.021)	(0.021)	(0.021)	(0.022)
Delayed effect of separation (longer-term): S+3	0.064**	0.065**	0.064**	0.064**	0.064**	0.062**	0.063**
	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.026)	(0.027)
Sweep 3 (*reference Sweep 2*)	-0.026**	-0.026**	-0.026**	-0.026**	-0.025**	-0.027**	-0.027**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
sweep 4	-0.020*	-0.021*	-0.021*	-0.021*	-0.021*	-0.022*	-0.023**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.012)	(0.011)
sweep 5	-0.029**	-0.029**	-0.029**	-0.030**	-0.031**	-0.059	-0.061
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.043)	(0.043)
Main respondent lives with step parent		-0.005					-0.005
		(0.019)					(0.019)
Child watches TV more than 3 hours on weekday			-0.003				-0.004
			(0.008)				(0.008)
Child has regular bedtime				-0.004			-0.004
				(0.010)			(0.010)
Main respondent is depressed					0.016**		0.016**
					(0.007)		(0.007)
HH income (ln)						0.007	0.006
						(0.009)	(0.009)
Constant	0.507***	0.507***	0.507***	0.508***	0.501***	0.471***	0.468***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.047)	(0.046)
Number of observations				2,101			

note: *** p<0.01, ** p<0.05, * p<0.1. Estimates are weighted and standard errors clustered (at the ward level)

Table 9: Fixed effect on being overweight/obese vs. normal weight - higher education group (linear probability model)

	Model (1) β/s.e.	Model (2) β/s.e.	Model (3) β/s.e.	Model (4) β/s.e.	Model (5) β/s.e.	Model (6) β/s.e.	Model (7) β/s.e.
Pre-separation: S-1	-0.001	-0.001	-0.001	-0.002	-0.001	-0.001	-0.002
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Immediate effect of separation: S	-0.001	-0.003	-0.001	-0.002	-0.002	-0.001	-0.004
	(0.021)	(0.022)	(0.021)	(0.021)	(0.021)	(0.021)	(0.022)
Delayed effect of separation (short-term): S+1	0.036	0.032	0.036	0.034	0.036	0.036	0.030
	(0.027)	(0.028)	(0.027)	(0.027)	(0.027)	(0.027)	(0.028)
Delayed effect of separation (medium-term): S+2	0.082***	0.076**	0.082***	0.082***	0.083***	0.083***	0.077**
	(0.029)	(0.032)	(0.029)	(0.029)	(0.029)	(0.030)	(0.032)
Delayed effect of separation (longer-term): S+3	0.119***	0.115***	0.119***	0.120***	0.120***	0.120***	0.116***
	(0.041)	(0.043)	(0.041)	(0.041)	(0.041)	(0.042)	(0.043)
Sweep 3 (*reference Sweep 2*)	-0.034***	-0.034***	-0.034***	-0.036***	-0.033***	-0.034***	-0.035***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
sweep 4	-0.056***	-0.056***	-0.056***	-0.058***	-0.056***	-0.056***	-0.057***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
sweep 5	0.001	0.000	0.001	-0.001	0.000	0.008	0.005
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.042)	(0.042)
Main respondent lives with step parent		0.022					0.021
		(0.040)					(0.040)
Child watches TV more than 3 hours on weekday			-0.006				-0.004
			(0.012)				(0.012)
Child doesn't have a regular bedtime				-0.033**			-0.033**
				(0.014)			(0.014)
Main respondent is depressed					0.008		0.008
					(0.010)		(0.010)
HH income (ln)						-0.002	-0.001
						(0.009)	(0.009)
Constant	0.214***	0.214***	0.214***	0.218***	0.212***	0.223***	0.224***

	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.058)	(0.058)
Number of observations				3,915			

note: *** p<0.01, ** p<0.05, * p<0.1. Estimates are weighted and standard errors clustered (at the ward level)

Table 10: Fixed effect on being overweight/obese vs. normal weight - lower education group (linear probability model)

	Model (1) β/s.e.	Model (2) β/s.e.	Model (3) β/s.e.	Model (4) β/s.e.	Model (5) β/s.e.	Model (6) β/s.e.	Model (7) β/s.e.
Pre-separation: S-1	-0.024	-0.024	-0.024	-0.024	-0.024	-0.025	-0.024
	(0.026)	(0.026)	(0.027)	(0.026)	(0.026)	(0.026)	(0.026)
Immediate effect: S	-0.008	-0.005	-0.008	-0.008	-0.008	-0.004	-0.001
	(0.027)	(0.026)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
Delayed effect (short-term): S+1	0.004	0.008	0.004	0.004	0.004	0.004	0.009
	(0.027)	(0.028)	(0.027)	(0.027)	(0.027)	(0.027)	(0.028)
Delayed effect (medium-term): S+2	-0.007	-0.001	-0.006	-0.007	-0.006	-0.009	-0.002
	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)
Delayed effect longer-term): S+3	0.022	0.027	0.022	0.022	0.022	0.017	0.023
	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)
Sweep 3 (*reference Sweep 2*)	-0.011	-0.011	-0.011	-0.011	-0.011	-0.014	-0.013
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
sweep 4	-0.019*	-0.019*	-0.018*	-0.019*	-0.019*	-0.023**	-0.023**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
sweep 5	0.073***	0.074***	0.073***	0.073***	0.071***	-0.023	-0.025
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.054)	(0.054)
Main respondent lives with step parent		-0.027					-0.028
		(0.039)					(0.039)
Child watches TV more than 3 hours on weekday			0.005				0.005
			(0.015)				(0.015)
Child has regular bedtime				-0.001			-0.001
				(0.013)			(0.013)
Main respondent is depressed					0.016		0.015
					(0.012)		(0.012)
HH income (ln)						0.021*	0.021*
						(0.011)	(0.011)
Constant	0.229***	0.230***	0.228***	0.229***	0.223***	0.116*	0.109*
	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.061)	(0.061)

Number of observations	2,101

note: *** p<0.01, ** p<0.05, * p<0.1. Estimates are weighted and standard errors clustered (at the ward level)