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DISCUSSION PAPER SERIES

IZA DP No. 17239

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ABSTRACT

Parental Health, Adolescents' Mental Distress and Non-cognitive Skills*

Drawing on nationally representative UK data, we explore the association of parental health and disability with mental distress and non-cognitive skills development of adolescents; both self-reported and more objectively measured bio-measures are used to capture parental health. Overall, we demonstrate a systematic association of parental health/disability with the non-cognitive skills development of adolescents living in the same household. However, considerable heterogeneity in these associations is observed between (and within) the mother's and father's health and disability measures. Much less evident is the link between parental health/disability and adolescents' mental distress. Our findings suggest that each parent's health and disability status may be differentially associated with adolescents' non-cognitive skills development.

JEL Classification: I10, J24, C21, J12

Keywords: adolescents, biomarkers, mental distress, non-cognitive skills, parental health

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1. Introduction

The theory of intergenerational mobility assumes that each family maximizes a utility function spanning across generations; the fortune of children is linked to their parents' investments and the endowments acquired from them (Becker and Tomes, 1979). Child outcomes are therefore largely influenced by the investments of their parents, with parental health being a major determinant for their children's health (e.g., Böckerman et al., 2023), educational outcomes (Kristiansen, 2021; Alam, 2015) and future labor market performance (Frimmel et al., 2020), among others.

Central to the literature on intergenerational transmission of health, which also considers genetic and non-shared environmental factors, is the persistence of mental health across generations (Ahlburg, 1998; Johnston et al., 2013). Within this body of literature, most studies investigate the offspring's mental health that is driven by parental divorce, parental bereavement or severe parental health shocks (Auersperg et al., 2019; Rashid et al., 2024; Glaser and Prunckner, 2023). Those studies limit their analysis to severe clinical endpoints and health events rather than examining the role of parental underlying health status (that is not limited to "severe event cases") when raising their offspring.

Parental health also has a crucial role in children's behavioural and social skills development (Le and Nguyen, 2017; Mühlenweg et al., 2016). This is of particular importance for children's later life, given that the presence of behavioural and social difficulties in people's early life may, in turn, lead to learning difficulties, worse labour market prospects and increased social exclusion risks (Becker and Tomes, 1986). Cunha and Heckman (2007) suggest that parental investments are more effective in raising non-cognitive skills; those in turn promote the formation of cognitive skills. Moreover, it has been shown that childhood non-cognitive skills have greater predictive power than cognition on later life socioeconomic and health outcomes (Attanasio et al., 2020).

In this study, we explore the association of parental health and disability measures with mental distress and non-cognitive skills development of adolescents (10-15 years old). We contribute to the literature in a number of ways. To begin with, our work is among the studies that focus on the underlying factors shaping non-cognitive

skills — often disregarded in the policy debates (Kautz et al., 2014); this is even though both cognitive and non-cognitive skills are equally important in explaining people's social and economic life (Heckman, et al., 2006). For the needs of our study, we use nationally representative data from Understanding Society – the UK Household Longitudinal Study (UKHLS) that allows us to link parental physical health/disability measures with adolescents' (10-15 years old) mental distress and non-cognitive outcomes.

Further, unlike the related existing studies which are limited to self-reported parental health measures (Le and Nguyen, 2017), we utilize a wide set of both self-reported and more objectively measured biomarkers to capture parental health. Despite their wide use, mainly due to their simplicity and low collection costs, self-reported health measures are often "coarse" (limited in sensitivity) and "noisy" (subject to measurement error), whereas biomarkers allow for capturing different health dimensions. Moreover, unlike part of the existing relevant literature that focuses on severe immediate health events (Glaser and Prunckner, 2023), biomarkers provide information on pre-disease mechanisms that are below an individual's perception or clinical diagnosis thresholds (Davillas et al., 2019) and, thus, may enhance our understanding of the link between parental health and adolescents' outcomes when parental diseases have not yet become explicit. For example, by employing inflammatory biomarkers, which might be considered "secondary" physiological responses to stress (Davillas et al., 2017), our study may provide potential insights into the role of parental stress in shaping the link between parental ill health and adolescents' adverse developmental outcomes. Moreover, the existing relevant research that solely relies on self-reports of parental health may result in biased econometric estimates because of parental misreporting of their health status; this may be due to micro-social environment during household survey data collection (i.e., "not in front of the children" effect; Conti and Pudney, 2011) and/or due to justification bias, among other sources. Justification bias is relevant to the extent to which parents may view their health as a socially acceptable rationalization for adverse outcomes experienced by their children and, thus, modify their reporting behaviour at self-reported health measures accordingly; biomarkers are not subject to these measurement errors.

The rest of the study is organised as follows. Section 2 describes our data and empirical analysis, and Section 3 presents the results of our analysis. Section 4 concludes and summarises our findings.

2. Data and Methods

The UKHLS is a large nationally representative UK panel study. At UKHLS wave 2 (2010/2011), the participants of the British Household Panel Survey (BHPS) were absorbed into the UKHLS. Physical health measurements and non-fasted blood samples are collected by trained nurses after the UKHLS wave 2 (UKHLS sample) and wave 3 (BHPS sample) main survey interviews. For the needs of our study, we pool data with valid nurse-collected and blood-based information from wave 2 (UKHLS sample) and wave 3 (BHPS sample); this pooled wave 2/3 sample is restricted to those adults who were in a cohabitating or marital relationship at the time of interview (i.e., the wave 2 and 3 for the UKHLS and BHPS samples, respectively). These data on cohabitating or married couples are then linked to information on their parented adolescents, aged 10-15, living in the same household (collected as part of the UKHLS "youth questionnaire").

2.1 Parental health and disability measures

We capture parental health using self-reported measures of health as well as nurse-administered and blood-based biomarkers. Separate measures are collected for each parent, irrespective of whether they are biological, step or adoptive parents.

The self-assessed health (SAH) question collects responses on a five-point scale, ranging from 1 = "excellent" to 5 = "poor health". In order to create our parental SAH measure, we group the lowest two SAH categories (due to their small sample size), giving a four-point scale from 1 = "excellent" to 4 = "fair" or "poor" health; the "excellent" SAH category is the reference group in our analysis. Although SAH is a widely used self-reported general health measure that predicts future mortality risks (Jylhä, 2009), it has been criticised as subject to reporting heterogeneity; that is, SAH may not accurately and unbiasedly reflect an individual's actual health status, and the way biological risks are translated into responses to SAH categories

can vary depending on respondents' characteristics (Bound, 1991; Dowd and Zajacova, 2010).

Our set of nursed-collected and blood-based biomarkers include Body Mass Index (BMI), systolic blood pressure (SBP), diastolic blood pressure (DBP), fat in the blood biomarker (total cholesterol: TC), a biomarker for diabetes (HbA1c), and two inflammatory biomarkers (c-reactive protein: CRP; Fibrinogen).[1] Those biomarkers are directly relevant to diagnosis and clinical management of specific chronic health conditions such as obesity, hypertension, inflammation, diabetes, and high cholesterol. CRP rises as part of the immune response to infection and is associated with chronic or systemic inflammation; higher CRP levels often reflect stress-related and psychosocial processes involving the hypothalamic axis and the sympathetic and parasympathetic nervous system (Davillas et al., 2017). Fibrinogen is a glycoprotein that promotes blood clotting, but it is also regarded as an inflammatory biomarker (Jain et al., 2011) and is directly related to coronary artery thrombosis. HbA1c is a measure of the level of sugar in the blood and is validated as a diagnostic test for diabetes (WHO, 2011). Higher TC concentrations in the blood are associated with elevated cardiovascular risks (e.g., Peters et al., 2016). Our biomarker data for both partners are used as continuous variables in our analysis; biomarkers are expressed into z-scores (mean of zero and a standard deviation of one) to enhance the comparability of biomarker coefficients in our regression models.

Moreover, we use self-reported disability measures; a dichotomous variable for each parent, capturing whether they experience any long-standing impairment or any functional difficulty. Even though disability measures are —by definition— subject to measurement errors as self-reports, existing literature argued that they are still practical, informative and the best available methods of disability measurement in social science surveys (e.g., Meyer and Mok, 2019).

[1] The nurse-collected and blood-based biomarkers are obtained from the nurse visits that are parts of waves 2/3 for the UKHLS and BHPS samples, respectively.

2.2 Adolescents' outcomes

Following McNamee et al. (2021), our measure of mental distress for adolescents is based on eight relevant questions[2]; although these questions are tailored to adolescents, they are broadly close to those used for the General Health Questionnaire, a widely used measure of non-psychotic distress in adults (Goldberg et al., 1997). For the needs of our study, we create a dichotomous mental distress measure that takes the value of one if the adolescents place themselves in the most distressed category at least in one of the eight mental distress questions (as described above), and zero otherwise.

Adolescents' non-cognitive skills are captured using the Strengths and Difficulties Questionnaire (SDQ), in line with existing studies (e.g., Attanasio et al., 2020; De Coulon et al., 2011; Le and Nguyen, 2017). Specifically, in our study we follow the relevant economics literature suggesting the SDQ as a key measure of non-cognitive skills development (e.g., Attanasio et al., 2020; Le and Nguyen, 2017). The SDQ contains five sub-scales measuring emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems and prosocial behaviour; the total difficulties score is a cumulative score that sums the first four SDQ sub-scales. Higher scores on the first four sub-scales and lower scores on the pro-social sub-scale indicate worse adolescent development. Each of the five sub-scales and the total difficulties score are used as separate adolescents' outcomes in our regression analysis. Overall, the SDQ measures are tailored for evaluating the non-cognitive skills development of the adolescent, while our distress outcome aims to capture mental distress problems that may concern further psychiatric evaluation.

Given the UKHLS survey design, adolescents' mental distress and SDQ outcomes are measured at the "youth self-completed questionnaire" administered as part of the UKHLS wave 4 and 5, respectively. It should be mentioned, therefore, that the collection of parental health measures (waves 2/3 as discussed above) precedes the

[2] Specifically, adolescents in UKHLS responded to the following eight questions: "I feel I have a number of good qualities"; "I feel that I do not have much to be proud of"; "I certainly feel useless at times"; "I am able to do things as well as most other people"; "I am a likeable person"; "I can usually solve my own problems"; "All in all, I am inclined to feel I am a failure"; "At times, I feel I am no good at all". Adolescent's response to each question ranges from "Strongly agree" to "Strongly disagree". Responses from these questions used to create our measure of mental distress.

measurement of our adolescents' outcomes, which may alleviate concerns of simultaneity.

2.3 Control variables

In line with existing literature modelling children's and adolescents' outcomes (e.g., Bratti and Mendola, 2014; Le and Nguyen, 2017), we include a set of control variables to account for confounding effects. Specifically, we include adolescents' age and sex as well as parental- and household-level covariates. Parental covariates include the age of each parent and the highest parental educational qualification. Household size, number of kids in the household, home ownership, the natural logarithm of equivalized household income, regional and urbanization dummies are the household-level covariates that included in all model specifications.

After excluding missing data on all control variables, our working sample, linking married/cohabitating adults with adolescents living in the same household, has a maximum of 1,605 observations; our estimation samples vary depending on the parental health/disability measures used, with the maximum sample obtained when the self-reported parental disability measure is employed (1,605 observations); lower estimation samples are available in the case of parental biomarkers. Table A1 (appendix) shows the mean values for all variables employed in our analysis.

2.4 Empirical analysis

Separate regression models are estimated for each of our parental health and disability measures (self-reported and the bio-measures). Specifically, each of the father's and mother's health/disability measures are jointly included in regression models to explore whether they have independent associations with our adolescents' outcomes; this allows us to focus on the association between mother's health/disability and adolescent's outcomes conditioning on father's health/disability and vice versa. Specifically, for each adolescent's outcome Y_i (i.e, the SDQ scores and the mental distress measure), a general model specification can be written as:

$$Y_i = \alpha + FH_i\beta_1 + MH_i\beta_2 + \boldsymbol{X_i\gamma} + \varepsilon_i \quad (1)$$

where, FH and MH are the measures of paternal and maternal health/disability, $\boldsymbol{X}$ is a vector of the covariates accounted for in our analysis, and ε_i is the error term; β_1, β_2 are the coefficients for parental health/disability measures to be estimated, and $\boldsymbol{\gamma}$ stands for the coefficients vector for the control variables in our analysis.

Our continuous adolescents' non-cognitive skills development outcomes (SDQ measures) are modelled by linear regression estimated using ordinary least squares (OLS); for our dichotomous adolescents' mental distress outcome, linear probability models are used. Standard errors are clustered at the household level.

3. Results

The association between parental self-reported health/disability measures and adolescents' mental distress and non-cognitive ability outcomes are presented in Table 1. Overall, Table 1 shows the presence of systematic associations of the self-reported parental health and disability measures with the development of non-cognitive skills in adolescents living in the same household; however, considerable variations in these associations are observed between the mothers' and fathers' health/disability measures. On the other hand, much less pronounced are the associations between adolescents' mental distress outcomes and our parental health/disability measures.

Specifically, we observe the presence of systematic paternal SAH gradient with all non-cognitive outcomes, apart from the pro-social behavior (statistical tests, as shown by "+, ++, +++" in Table 1, reveal the joint significance of the paternal SAH categories across all these non-cognitive outcomes at least in the 10% significance level; p-values range between 0.001 and 0.078). For instance, adolescents whose fathers report the worse SAH categories (fair/poor SAH) exhibit higher emotional symptoms, conduct problems, hyperactivity/inattention levels and more peer relationship problems compared to those with fathers in excellent SAH (reference category). Moreover, there is a clear gradient in the total difficulties score across all paternal SAH categories. It should be explicitly noted that these associations of paternal health measures are obtained in models that simultaneously account for the corresponding maternal health/disability measures too; however, mother's SAH

seems to exert a much less pronounced role in the adolescent's non-cognitive skills development.

Table 1 also shows that adolescents with mothers who experience disabilities tend to show poorer non-cognitive outcomes compared to those with mothers without disabilities. Specifically, maternal disability is systematically associated with adolescents' higher emotional symptoms, increased conduct problems, more pronounced peer relationship problems, and a higher total difficulties score that suggests worse non-cognitive skills development. On the other hand, having a father experiencing disabilities is non-systematically associated with adolescents' non-cognitive outcomes.

Table 1: Estimated coefficients from models jointly accounting for mother's and father's self-assessed health and disability.

	Adolescent's outcomes						
	Distressed	Emotional Symptoms	Conduct Problems	Hyperactivity / Inattention	Peer Relationship Problems	Prosocial behaviour	Total Difficulties Score
Panel A: Self-assessed health							
Mother: Very good	-0.026	-0.126	0.075	0.231	0.064	-0.213	0.244
	(0.021)	(0.208)	(0.142)	(0.206)	(0.148)	(0.142)	(0.516)
Mother: Good	0.012	-0.019	0.082	0.275	-0.053	-0.206	0.285
	(0.024)	(0.220)	(0.153)	(0.220)	(0.159)	(0.154)	(0.551)
Mother: Fair or Poor	0.017	0.297	0.369*	0.528*	0.084	-0.327*	1.278*
	(0.032)	(0.301)	(0.219)	(0.293)	(0.203)	(0.198)	(0.742)
Father: Very good	0.017	0.303	0.345**	0.319	0.114	-0.185	1.080**
	(0.020)	(0.192)	(0.143)	(0.196)	(0.138)	(0.142)	(0.465)
Father: Good	0.027	0.358*	0.498***	0.350*	0.459***	-0.135	1.665***
	(0.022)	(0.210)	(0.161)	(0.212)	(0.159)	(0.161)	(0.505)
Father: Fair or Poor	0.068*	0.732**	0.582**	0.835***	0.614***	0.097	2.763***
	(0.037)	(0.288)+	(0.240)++	(0.303)+	(0.229)+++	(0.220)	(0.784)+++
N	1479			1037			
Panel B: Disability							
Mother: Any disability	0.018	0.410**	0.315**	0.262	0.423***	-0.199	1.410***
	(0.023)	(0.209)	(0.143)	(0.192)	(0.152)	(0.158)	(0.501)
Father: Any disability	0.024	-0.063	-0.019	-0.137	0.293*	-0.004	0.074
	(0.026)	(0.231)	(0.168)	(0.214)	(0.172)	(0.160)	(0.555)
N	1605			1128			

Notes: Standard errors are clustered at household level. All models account for adolescent's age and gender, mother's and father's age, highest parental educational qualification, household size, number of kids in the household, home ownership, log of household income, regional and urbanization dummies.
* p<0. 10 ** p<0.05 *** p<0.01.
+++ p<0.01, ++ p<0.05, and + p<0.10; Tests for the joint significance of the SAH coefficients, separately for mother's and father's SAH categories.

Table 2 presents the corresponding results when nurse-collected and blood-based biomarkers are used to measure parental health. Overall, these results show that the mother's bio-measures (as opposed to the father's) have a more pronounced

association with the adolescents' non-cognitive outcomes. Specifically, mothers with higher BMI are more likely to raise adolescents with more emotional symptoms, peer relationship problems, and a higher total difficulties score, suggesting more impaired overall non-cognitive skills development. Moreover, mothers with higher fat in blood concentrations (TC) are more likely to have more hyperactive/inattention adolescents. Turning to mothers with higher sugar blood levels (HbA1c), they are more likely to have adolescents with higher emotional symptoms, peer relationship problems and higher total difficulties scores. Finally, increased inflammation levels of the mother (as indicated by CRP and Fibrinogen) are systematically associated with adolescents' non-cognitive skills development. Specifically, statistically significant associations are observed between higher maternal CRP levels and adolescents' hyperactivity/inattention, peer relationship problems and a worse (higher) total difficulties score; moreover, higher maternal fibrinogen is associated with more adolescent conduct problems, peer relationship problems and a higher total difficulties score.

Comparisons across models show that one standard deviation increase in mothers' BMI, blood sugar concentrations (HbA1c), or fibrinogen levels (all expressed in z-scores) is associated with a 0.635, 0.600, and 0.518 increase in the total difficulties score (suggesting worse non-cognitive skills development), respectively; one standard deviation increase in maternal CRP levels (inflammatory biomarker) is associated with a more pronounced increase in total difficulties score of about 0.762.

Much less pronounced are the corresponding results for the father's biomarkers (Table 2), with most of the cases showing non-statistically significant associations (or marginally statistically significant at the 10% level in a few cases); the only notable exception is the presence of a strong association between higher paternal systolic blood pressure and adolescent's hyperactivity/inattention problems. Interestingly, there are marginally statistically significant associations of paternal systolic blood pressure, paternal cholesterol levels and maternal diastolic blood pressure with lower adolescent's prosocial behaviour levels (suggesting worse social skills development as the prosocial SDQ sub-scale is increasing with better skills development, unlike all other non-cognitive ability measures).

Table 2: Estimated coefficients from models jointly accounting for mother's and father's nurse-collected and blood-based biomarkers.

	Adolescent's outcomes						
	Distressed	Emotional Symptoms	Conduct Problems	Hyperactivity / Inattention	Peer Relationship Problems	Prosocial behaviour	Total Difficulties Score
Biomarkers (z-scores)							
Mother: Body mass index	-0.001	0.236**	0.070	0.131	0.198***	-0.022	0.635***
	(0.010)	(0.092)	(0.072)	(0.089)	(0.063)	(0.074)	(0.230)
Father: Body mass index	-0.005	0.044	0.071	0.028	-0.059	-0.070	0.085
	(0.011)	(0.093)	(0.078)	(0.093)	(0.064)	(0.073)	(0.238)
N	784			588			
Mother: Systolic blood pressure	-0.007	-0.076	-0.025	-0.133	0.141	0.005	-0.093
	(0.015)	(0.120)	(0.090)	(0.113)	(0.087)	(0.089)	(0.301)
Father: Systolic blood pressure	-0.019	-0.075	0.063	0.308***	-0.084	-0.176*	0.212
	(0.015)	(0.125)	(0.092)	(0.113)	(0.098)	(0.093)	(0.294)
N	535			400			
Mother: Diastolic blood pressure	0.010	0.052	0.102	0.031	0.112	-0.140*	0.298
	(0.014)	(0.111)	(0.080)	(0.105)	(0.084)	(0.082)	(0.273)
Father: Diastolic blood pressure	-0.019	-0.048	0.051	0.225*	-0.030	-0.089	0.198
	(0.014)	(0.114)	(0.091)	(0.125)	(0.102)	(0.092)	(0.306)
N	553			414			
Mother: Total cholesterol	0.032*	0.049	0.073	0.248**	0.021	0.056	0.391
	(0.017)	(0.115)	(0.096)	(0.126)	(0.100)	(0.107)	(0.310)
Father: Total cholesterol	-0.011	0.051	0.085	0.108	0.197*	-0.203*	0.441
	(0.017)	(0.139)	(0.102)	(0.137)	(0.108)	(0.109)	(0.328)
N	422			318			
Mother: HbA1c	-0.007	0.274***	0.187	-0.058	0.197**	0.075	0.600***
	(0.007)	(0.098)	(0.135)	(0.104)	(0.089)	(0.071)	(0.214)
Father: HbA1c	-0.015	-0.086	0.209*	-0.004	0.018	-0.113	0.136
	(0.010)	(0.127)	(0.115)	(0.159)	(0.124)	(0.134)	(0.417)
N	397			298			
Mother: CRP	0.001	0.104	0.148	0.333**	0.177**	-0.017	0.762**
	(0.013)	(0.149)	(0.100)	(0.161)	(0.089)	(0.106)	(0.368)
Father: CRP	0.009	0.162	0.019	0.047	-0.050	0.079	0.178
	(0.018)	(0.121)	(0.101)	(0.123)	(0.091)	(0.099)	(0.287)
N	391			297			
Mother: Fibrinogen	0.005	0.146	0.150*	0.047	0.176**	-0.131	0.518*
	(0.018)	(0.120)	(0.086)	(0.111)	(0.081)	(0.088)	(0.272)
Father: Fibrinogen	0.017	0.077	0.130	0.227*	-0.033	0.024	0.402
	(0.016)	(0.125)	(0.088)	(0.137)	(0.092)	(0.108)	(0.327)
N	420			315			

Notes: Standard errors are clustered at household level. All models account for adolescent's age and gender, mother's and father's age, highest parental educational qualification, household size, number of kids in the household, home ownership, log of household income, regional and urbanization dummies.
* p<0. 10 ** p<0.05 *** p<0.01.

Sensitivity analysis

Our base-case analysis simultaneously accounts for both mother's and father's health and disability measures. Tables A2-A5 (Appendix) present results from our sensitivity analysis estimating adolescent outcome models that *separately* consider mother's and father's health/disability measures. These results corroborate our base-case analysis that simultaneously accounts for both mother's and father's health/disability measures.[3] The fact that our main conclusions do not change between models that jointly account for both parents' health/disability measures and those consider the mother's and father's health/disability measures separately may suggest that mother's and father's health/disability measures exert a mainly independent (from each other) role on adolescent developmental outcomes.

In line with existing literature (Le and Nguyen, 2017), our results so far are based on a sample of adolescents who lived with both parents; this allows us to explore the role of parental health/disability itself rather than potential contaminations from parental separation/bereavement. Tables A6-A9 (Appendix) provide evidence on augmenting our sample to also include single mothers or single fathers when *separately* considering the mother's and father's health/disability measures in our models. These results follow similar patterns to those obtained without including single mothers/fathers (Tables A2-A5) and do not change the conclusions of our study.

[3] Overall, we observe systematic SAH gradients in the same adolescents' non-cognitive measures, as in our base case results, when only accounting for paternal SAH (Tables A2 versus Table 1); as in our base-case analysis that simultaneously accounts for both parents SAH, we found much less pronounced associations between mother's SAH and adolescent's outcomes when independently considering the role of mother's SAH (Table A4). Sensitivity analysis further confirms our base-case results on the presence of stronger associations between maternal, rather than paternal, disability and adolescents' non-cognitive skills development, when separately considering mother's and father's disability measures in regression models (Tables A2 and A3 versus Table 1). Finally, the results from sensitivity analysis estimating separate models for maternal and paternal biomarkers show limited differences to our base-case results that jointly account for both parents' biomarkers confirming that mother's, rather than father's, biomarkers are more strongly associated with adolescent's non-cognitive skills (Tables A3 and A5 versus Table 2).

4. Conclusion

Using nationally representative UK data we explore the associations of parental health and disability measures with adolescents' mental distress and non-cognitive outcomes development. Overall, we find strong evidence of systematic associations of poor parental health and disability with lower non-cognitive skills development of adolescents; however, there is heterogeneity concerning whether maternal or paternal health/disability measures are considered, as well as across the different health and disability measures employed. Overall, the observed associations with poor non-cognitive skills development are more evident for maternal than paternal ill health. Specifically, rather than paternal, maternal self-reported disability measures as well as elevated levels of the more objectively measured maternal biomarkers for adiposity, diabetes and inflammation are systematically associated with worse non-cognitive skills development for the adolescents. An exception is the case of SAH with the father's, but not the mother's, SAH showing stronger associations with adolescents' non-cognitive skills.

The observed heterogeneity across the health measures in our study highlights the nuanced role of the different health dimensions, which would have been missed if we had not explored a wide set of parental health and disability measures that cover the multidimensional aspect of people's health. The fact that the mother's rather than the father's disability appears more strongly associated with their adolescent's non-cognitive skills development may reflect parental gender differences in physical functioning demands for raising offspring according to the traditional parental roles and notions.[4] Moreover, our evidence that maternal biomarkers of adiposity, diabetes and inflammation are associated with adolescents' non-cognitive skills highlights those mother's health dimensions that are more relevant to adolescents' non-cognitive skills development. Of particular importance, among these biomarkers, higher maternal CRP concentrations in the blood, a key stress-related inflammatory biomarker, are associated with the most pronounced impairment in

[4] Traditional roles often place greater physical and emotional caregiving responsibilities on mothers (Bianchi et al., 2006), whilst fathers may have fewer (physical) demands related to child-rearing. Although the economic model of specialized marital roles where mothers focus primarily on domestic tasks and fathers on market work has been long challenged (Doherty et al.,1998), and even though married fathers are spending significantly more time in developmental childcare activities today than in the past, their childcare time remains lower than mothers' (Sayer et al., 2004; Bianchi et al. 2006).

adolescent's total non-cognitive skills score. This is broadly in line with existing studies showing that maternal, but not paternal, parenting stress during childhood predicts adolescent's externalizing problems (de Maat et al., 2021).

On the other hand, the stronger associations we find between fathers', rather than mothers', SAH and adolescents' non-cognitive skills may indicate the role of paternal perceptions of their own health status; these perceptions may not necessarily reflect the respondent's underlying health. Typically, one of the main sources of reporting heterogeneity in SAH reflects respondents' knowledge (for example, via visits to health practitioners and the potential of consequent diagnosis) of their underlying ill health conditions and their perceptions of the severity of these conditions (Jylhä, 2009); to the extent that the documented gender differences in health care utilization, often after conditioning on health care need (Davillas and Pudney, 2020), may reflect gender differences in people's understanding of their true health condition (for example, via increasing the probability of early diagnosis), our results based on SAH measures may be subject to this reporting heterogeneity.

Turning to adolescents' mental distress outcomes, much less pronounced associations are observed between parental health/disability measures and adolescents' mental distress. This aligns with the notion that ongoing physical health issues might be less immediately impactful on a child's mental health as opposed to acute family disruptions like divorce or bereavement, which likely have a more immediate psychological effect (Le and Nguyen, 2017).

We should explicitly highlight here that our study does not aim at causal interpretations. Nonetheless, our results may be useful for understanding the broader context of how various parental health dimensions and disability are associated with adolescent development. The assumption that mothers and fathers might promote children's well-being in different ways receives some support here, however, the key challenge for future research is to establish causal links that distinguish the potential role of the shared family environment in shaping adolescent's skills development.

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Appendix: additional tables

Table A1: Descriptive statistics for the variables used in our analysis: maximum working sample after excluding missing data on all control variables.

	Mean	N
Adolescent's outcomes		
Distressed†	0.144	1,605
Emotional symptoms	2.829	1,074
Conduct problems	1.915	1,074
Hyperactivity/inattention	3.750	1,074
Peer relationship problems	1.775	1,074
Prosocial behaviour	7.770	1,074
Total Difficulties Score	10.269	1,074
Mother's health measures		
Self-assessed health		
Excellent†	0.194	1,518
Very good†	0.393	1,518
Good†	0.283	1,518
Fair or Poor†	0.129	1,518
Any disability†	0.154	1,605
Body mass index (kg/m^2)	28.002	909
Systolic blood pressure (mmHg)	113.984	740
Diastolic blood pressure (mmHg)	72.099	760
Total cholesterol (mmol/L)	5.169	604
HbA1c (mmol/mol)	34.614	590
CRP (mg/L)	1.914	576
Fibrinogen (g/L)	2.705	612
Father's health measures		
Self-assessed health		
Excellent†	0.179	1,505
Very good†	0.427	1,505
Good†	0.295	1,505
Fair or Poor†	0.100	1,505
Any disability†	0.123	1,605
Body mass index (kg/m^2)	28.259	840
Systolic blood pressure (mmHg)	127.756	665
Diastolic blood pressure (mmHg)	76.408	665
Total cholesterol (mmol/L)	5.727	576
HbA1c (mmol/mol)	35.655	545
CRP (mg/L)	1.737	562
Fibrinogen (g/L)	2.621	568
Covariates		
Girl-adolescent†	0.495	1,605
Boy-adolescent†	0.505	1605
Adolescent's age	12.536	1,605
Highest parental education		
Degree†	0.568	1,605
A-level†	0.195	1,605
GCSE†	0.223	1,605
No qualification†	0.014	1,605
Household size	4.553	1,605
Number of kids	2.253	1,605
Own house†	0.799	1,605
Not own house†	0.201	1,605
Log of household income	7.329	1,605
Urban residency†	0.753	1,605
Rural residency†	0.247	1,605
England†	0.802	1,605
Wales†	0.074	1,605
Scotland†	0.124	1,605

† Dichotomous variables

Notes: Our estimations sample vary depending on the parental health measures used, with the maximum sample obtained when the self-reported parental disability measure is used (1,605 observations); lower estimation samples are available when biomarkers are used as parental health measures.

Table A2: Estimated coefficients of father's self-assessed health and disability.

	Adolescent's outcomes						
	Distressed	Emotional Symptoms	Conduct Problems	Hyperactivity/ Inattention	Peer Relationship Problems	Prosocial behaviour	Total Difficulties Score
Panel A: Self-assessed health							
Very good	0.021	0.317*	0.363**	0.354*	0.109	-0.200	1.142**
	(0.020)	(0.192)	(0.1420)	(0.196)	(0.136)	(0.142)	(0.463)
Good	0.034	0.368*	0.512***	0.389*	0.446***	-0.153	1.715***
	(0.022)	(0.2093)	(0.160)	(0.214)	(0.156)	(0.159)	(0.505)
Fair or Poor	0.078**	0.791***	0.644***	0.928***	0.616***	0.061	2.979***
	(0.036)	(0.290)$^{+}$	(0.232)$^{+++}$	(0.299)$^{++}$	(0.225)$^{+++}$	(0.221)	(0.767)$^{+++}$
N	1479				1037		
Panel B: Disability							
Any disability	0.029	-0.007	0.030	-0.088	0.353**	-0.031	0.288
	(0.025)	(0.230)	(0.1667)	(0.211)	(0.178)	(0.159)	(0.554)
N	1605				1128		

Notes: Standard errors are clustered at the household level. All models account for adolescent's age and gender, father's age, highest parental educational qualification, household size, number of kids in the household, home ownership, log of household income, regional and urbanization dummies.
* p<0. 10 ** p<0.05 *** p<0.01.
+++ p<0.01, ++ p<0.05, and + p<0.10; Tests for the joint significance of the coefficients for father's SAH categories.

Table A3: Estimated coefficients of father's nurse-collected and blood-based biomarkers.

	Adolescent's outcomes						
	Distressed	Emotional Symptoms	Conduct Problems	Hyperactivity /Inattention	Peer Relationship Problems	Prosocial behaviour	Total Difficulties Score
Biomarkers (z-scores)							
Body mass index	0.002	0.015	0.087	0.053	-0.052	-0.083	0.103
	(0.012)	(0.089)	(0.073)	(0.085)	(0.058)	(0.066)	(0.220)
N	858				640		
Systolic blood pressure	-0.008	-0.130	0.039	0.215**	-0.093	-0.198**	0.031
	(0.018)	(0.111)	(0.085)	(0.096)	(0.081)	(0.081)	(0.276)
N	679				515		
Diastolic blood pressure	-0.003	-0.057	0.068	0.226**	-0.020	-0.111	0.218
	(0.015)	(0.104)	(0.084)	(0.106)	(0.084)	(0.081)	(0.277)
N	679				515		
Total cholesterol	-0.011	-0.049	0.057	0.072	0.018	-0.072	0.098
	(0.011)	(0.100)	(0.076)	(0.111)	(0.077)	(0.086)	(0.253)
N	591				448		
HbA1c	-0.007	-0.067	0.143	-0.019	0.011	-0.069	0.068
	(0.009)	(0.112)	(0.102)	(0.134)	(0.096)	(0.110)	(0.353)
N	560				425		
CRP	0.012	0.102	-0.015	0.052	-0.056	0.037	0.083
	(0.014)	(0.096)	(0.081)	(0.091)	(0.072)	(0.082)	(0.236)
N	575				439		
Fibrinogen	0.017	0.065	0.142*	0.164	-0.029	-0.060	0.342
	(0.013)	(0.107)	(0.081)	(0.125)	(0.078)	(0.096)	(0.299)
N	583				442		

Notes: Standard errors are clustered at household level. All models account for adolescent's age and gender, father's age, highest parental educational qualification, household size, number of kids in the household, home ownership, log of household income, regional and urbanization dummies.
* p<0. 10 ** p<0.05 *** p<0.01.

Table A4: Estimated coefficients of mother's self-assessed health and disability.

	Adolescent's outcomes						
	Distressed	Emotional Symptoms	Conduct Problems	Hyperactivity Inattention	Peer Relationship Problems	Prosocial behaviour	Total Difficulties Score
Panel A: Self-assessed health							
Very good	-0.026	-0.115	0.082	0.233	0.073	-0.216	0.273
	(0.021)	(0.207)	(0.144)	(0.208)	(0.150)	(0.143)	(0.521)
Good	0.016	0.020	0.132	0.311	-0.003	-0.218	0.460
	(0.024)	(0.220)	(0.154)	(0.222)	(0.160)	(0.154)	(0.556)
Fair or Poor	0.024	0.377	0.426*	0.615**	0.147	-0.313	1.565**
	(0.031)	(0.302)	(0.218)	(0.293)	(0.204)	(0.198)	(0.740)
N	1479			1037			
Panel B: Disability							
Any disability	0.021	0.412**	0.314**	0.250	0.456***	-0.199	1.433***
	(0.023)	(0.208)	(0.143)	(0.192)	(0.155)	(0.156)	(0.500)
N	1605			1128			

Notes: Standard errors are clustered at household level. All models account for adolescent's age and gender, mother's age, highest parental educational qualification, household size, number of kids in the household, home ownership, log of household income, regional and urbanization dummies.
* p<0. 10 ** p<0.05 *** p<0.01.

Table A5: Estimated coefficients of mother's nurse collected and blood-based biomarkers.

	Adolescent's outcomes						
	Distressed	Emotional Symptoms	Conduct Problems	Hyperactivity / Inattention	Peer Relationship Problems	Prosocial behaviour	Total Difficulties Score
Biomarkers (z-scores)							
Body mass index	0.004	0.198**	0.058	0.102	0.132**	-0.042	0.490**
	(0.009)	(0.078)	(0.065)	(0.081)	(0.057)	(0.063)	(0.208)
N	1018			748			
Systolic blood pressure	-0.003	-0.111	0.024	-0.076	0.070	-0.081	-0.093
	(0.011)	(0.095)	(0.075)	(0.097)	(0.073)	(0.070)	(0.258)
N	834			600			
Diastolic blood pressure	0.005	0.048	0.068	0.026	0.099	-0.154**	0.242
	(0.011)	(0.091)	(0.067)	(0.090)	(0.070)	(0.067)	(0.240)
N	855			617			
Total cholesterol	0.012	0.062	0.098	0.197*	0.070	0.025	0.427
	(0.013)	(0.104)	(0.086)	(0.113)	(0.088)	(0.085)	(0.285)
N	687			503			
HbA1c	0.000	0.272***	0.159	0.050	0.159**	0.079	0.640***
	(0.008)	(0.083)	(0.132)	(0.126)	(0.078)	(0.058)	(0.211)
N	667			490			
CRP	0.008	0.217**	0.238***	0.508***	0.175**	-0.171**	1.138***
	(0.011)	(0.106)	(0.086)	(0.116)	(0.076)	(0.085)	(0.299)
N	655			480			
Fibrinogen	0.009	0.191**	0.118	0.158*	0.112*	-0.104	0.578**
	(0.013)	(0.093)	(0.074)	(0.093)	(0.067)	(0.069)	(0.241)
N	695			510			

Notes: Standard errors are clustered at household level. All models account for adolescent's age and gender, mother's age, highest parental educational qualification, household size, number of kids in the household, home ownership, log of household income, regional and urbanization dummies.
* p<0. 10 ** p<0.05 *** p<0.01.

Table A6. Estimated coefficients of father's (including single fathers) self-assessed health and disability.

	Adolescent's outcomes						
	Distressed	Emotional Symptoms	Conduct Problems	Hyperactivity Inattention	Peer Relationship Problems	Prosocial	Total Difficulties Score
Panel A: Self-assessed health							
Very good	0.019	0.309*	0.314**	0.309	0.094	-0.167	1.026**
	(0.019)	(0.187)	(0.138)	(0.190)	(0.131)	(0.136)	(0.449)
Good	0.040*	0.376*	0.467***	0.302	0.467**	-0.079	1.612***
	(0.022)	(0.203)	(0.154)	(0.206)	(0.151)	(0.151)	(0.488)
Fair or Poor	0.078**	0.716**	0.561**	0.776***	0.579***	0.004	2.632***
	(0.035)+	(0.280)+	(0.223)++	(0.288)+	(0.213)+++	(0.210)	(0.738)+++
N	1580			1097			
Panel B: Disability measures							
Any disability	0.039	0.013	0.007	-0.111	0.312*	-0.026	0.220
	(0.026)	(0.223)	(0.161)	(0.205)	(0.172)	(0.155)	(0.536)
N	1688			1178			

Notes: Standard errors are clustered at household level. All models account for adolescent's age and gender, father's age, highest parental educational qualification, household size, number of kids in the household, home ownership, log of household income, regional and urbanization dummies.
* p<0. 10 ** p<0.05 *** p<0.01.
+++ p<0.01, ++ p<0.05, and + p<0.10; Tests for the joint significance of the coefficients for father's SAH categories.

Table A7: Estimated coefficients of father's (including single fathers) nurse-collected and blood-based biomarkers.

	Adolescent's outcomes						
	Distressed	Emotional Symptoms	Conduct Problems	Hyperactivity / Inattention	Peer Relationship Problems	Prosocial behaviour	Total Difficulties Score
Biomarkers (z-scores)							
Body mass index	0.002	0.014	0.078	0.054	-0.062	-0.063	0.084
	(0.012)	(0.087)	(0.072)	(0.085)	(0.057)	(0.066)	(0.216)
N	887			656			
Systolic blood pressure	-0.007	-0.136	0.041	0.213**	-0.088	-0.196**	0.030
	(0.018)	(0.110)	(0.084)	(0.095)	(0.080)	(0.080)	(0.274)
N	702			527			
Diastolic blood pressure	-0.004	-0.060	0.080	0.217**	-0.012	-0.105	0.224
	(0.014)	(0.102)	(0.081)	(0.102)	(0.082)	(0.079)	(0.267)
N	702			527			
Total cholesterol	-0.011	-0.045	0.063	0.062	0.026	-0.072	0.107
	(0.011)	(0.099)	(0.076)	(0.110)	(0.077)	(0.086)	(0.253)
N	604			455			
HbA1c	-0.005	-0.064	0.147	-0.017	0.014	-0.069	0.080
	(0.009)	(0.112)	(0.102)	(0.135)	(0.096)	(0.111)	(0.353)
N	571			430			
CRP	0.014	0.110	-0.021	0.063	-0.048	0.082	0.105
	(0.014)	(0.093)	(0.079)	(0.091)	(0.071)	(0.083)	(0.230)
N	588			446			
Fibrinogen	0.020	0.072	0.145*	0.134	-0.017	-0.056	0.335
	(0.013)	(0.105)	(0.080)	(0.124)	(0.077)	(0.097)	(0.295)
N	596			449			

Notes: Standard errors are clustered at household level. All models account for adolescent's age and gender, father's age, highest parental educational qualification, household size, number of kids in the household, home ownership, log of household income, regional and urbanization dummies.
* p<0. 10 ** p<0.05 *** p<0.01.

Table A8: Estimated coefficients of mother's (including single mothers) self-assessed health and disability.

	Adolescent's outcomes						
	Distressed	Emotional Symptoms	Conduct Problems	Hyperactivity Inattention	Peer Relationship Problems	Prosocial behaviour	Total Difficulties Score
Panel A: Self-assessed health							
Very good	-0.018	-0.138	0.087	0.194	0.081	-0.176	0.225
	(0.019)	(0.188)	(0.134)	(0.189)	(0.138)	(0.130)	(0.479)
Good	0.015	0.051	0.192	0.320	0.076	-0.204	0.639
	(0.021)	(0.201)	(0.147)	(0.201)	(0.149)	(0.144)	(0.516)
Fair or Poor	0.031	0.228	0.359*	0.454*	0.281	-0.241	1.321*
	(0.029)	(0.274)	(0.199)	(0.267)	(0.200)	(0.184)	(0.680)
N	1760			1233			
Panel B: Disability							
Any disability	0.018	0.261	0.136	0.133	0.408***	-0.094	0.939**
	(0.021)	(0.188)	(0.136)	(0.178)	(0.151)	(0.142)	(0.476)
N	1868			1309			

Notes: Standard errors are clustered at household level. All models account for adolescent's age and gender, mother's age, highest parental educational qualification, household size, number of kids in the household, home ownership, log of household income, regional and urbanization dummies.
* p<0. 10 ** p<0.05 *** p<0.01.
+++ p<0.01, ++ p<0.05, and + p<0.10; Tests for the joint significance of the coefficients for mother's SAH categories.

Table A9: Estimated coefficients of mother's (including single mothers) nurse collected and blood-based biomarkers.

	Adolescent's outcomes						
	Distressed	Emotional Symptoms	Conduct Problems	Hyperactivity / Inattention	Peer Relationship Problems	Prosocial behaviour	Total Difficulties Score
Biomarkers (z-scores)							
Body mass index	-0.001	0.200***	0.052	0.101	0.126**	-0.033	0.480**
	(0.013)	(0.077)	(0.065)	(0.080)	(0.056)	(0.062)	(0.206)
N	1047			764			
Systolic blood pressure	0.000	-0.113	0.031	-0.077	0.074	-0.087	-0.084
	(0.016)	(0.095)	(0.075)	(0.096)	(0.073)	(0.069)	(0.257)
N	857			612			
Diastolic blood pressure	0.004	0.051	0.083	0.023	0.103	-0.158**	0.261
	(0.015)	(0.090)	(0.066)	(0.088)	(0.069)	(0.065)	(0.237)
N	878			629			
Total cholesterol	0.020	0.065	0.106	0.190*	0.077	0.018	0.439
	(0.025)	(0.104)	(0.087)	(0.112)	(0.088)	(0.085)	(0.283)
N	700			510			
HbA1c	-0.005	0.266***	0.189	0.040	0.180***	-0.001	0.675***
	(0.014)	(0.073)	(0.116)	(0.109)	(0.066)	(0.076)	(0.186)
N	679			496			
CRP	0.026	0.218**	0.223***	0.498***	0.175**	-0.124	1.113***
	(0.021)	(0.103)	(0.084)	(0.114)	(0.074)	(0.088)	(0.292)
N	668			487			
Fibrinogen	0.020	0.195**	0.131*	0.147	0.121*	-0.108	0.594**
	(0.024)	(0.092)	(0.074)	(0.092)	(0.066)	(0.071)	(0.239)
N	708			517			

Notes: Standard errors are clustered at household level. All models account for adolescent's age and gender, mother's age, highest parental educational qualification, household size, number of kids in the household, home ownership, log of household income, regional and urbanization dummies.
* p<0. 10 ** p<0.05 *** p<0.01.