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15/9: THE IMPACT OF MATERNAL MENTAL HEALTH SHOCKS ON CHILD HEALTH: ESTIMATES FROM FIXED EFFECTS INSTRUMENTAL VARIABLES MODELS FOR TWO COHORTS OF AUSTRALIAN CHILDREN

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The impact of maternal mental health shocks on child health: Estimates from fixed effects instrumental variables models for two cohorts of Australian children

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This paper contributes to an emerging body of literature on intergenerational transmission in health by presenting the first causal estimates on the impact of maternal mental health shocks on child health. The potential endogeneity of maternal mental health shocks is dealt with by utilising nationally representative panel data from two cohorts and individual fixed effects instrumental variables models. While previous literature has found evidence supporting detrimental effects of poor maternal mental health on child health our results found little evidence to support this. Our results hold irrespective of whether we look at the contemporaneous or intertemporal effects. We also found little differential impact based on the gender or age of the child and the levels of maternal education or household income. These results demonstrate that failing to account for endogeneity of maternal mental health shocks could over-estimate the harmful impact of poor maternal mental health on child health. Our findings are robust to a battery of sensitivity and specification tests.

Key words: Intergenerational transmission, health, instrumental variables, panel data, Australia.

JEL classifications: C23, C26, I14, J13

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1. Introduction

Much is now known that mental health disorders are common throughout the world and the consequences of mental illness for individuals, families and societies can be severe (Patel and Kleinman, 2003; Kessler *et al.*, 2008; Kessler *et al.*, 2009; Wittchen *et al.*, 2011; Frijters *et al.*, 2014). In developed countries, it has been shown that children of mothers experiencing mental illness have worse health outcomes (Propper *et al.*, 2007; Johnston *et al.*, 2013). However, it is still largely unknown whether a negative shock in maternal mental health could casually worsen child health outcomes. Identifying the causal effects of maternal mental health shocks on child health is of interest and may have some policy relevance (Solon, 1999; Black and Devereux, 2011). As such, it is the main purpose of this study.

Establishing a causal impact of maternal mental health shocks on child health is challenging. It is well-documented that this is in part due to problems of unobservable individual heterogeneity correlated with both parental health and child health (such as genetic endowments common to the parent and the child or the parent's discount rate (Ahlburg, 1998; Black and Devereux, 2011)) and reverse causality (whether parental health affects child health or *vice versa*). Measurement error issues are also likely as objective measures of child health are not always available in surveyed data and researchers are constrained to use child health measures reported by parents. Parents' reports of their children' health may be influenced by parental health states (De Reyes and Kazdin, 2005; Le and Nguyen, 2015), thus biased estimates of intergenerational correlation in health may be found by using these child health measures.

This paper employs a fixed effects instrumental variables (FE-IV) model, which is identified by time-variant sources of arguably exogenous variations in maternal mental health to estimate a causal impact of maternal mental health shocks on child health. We apply the FE-IV model to five waves of high- quality Australian panel data of two cohorts of children to simultaneously address the issues of unobserved heterogeneity, reverse causality and measurement errors. In particular, we use the death of a close friend of the mother and a recent serious injury of a close relative (not a parent, partner or child) of the mother as two instruments in maternal mental health equations. These instruments affect a large number of mothers in our sample, vary for the same mother overtime and are shown to strongly determine maternal mental health but not maternal physical health. In addition, results from a battery of sensitivity and specification tests, including an over-identification test, different

combinations of instruments and inclusion of various time-variant variables, suggest that these two instruments are empirically strong.

Using a recent nationally representative data set from the Longitudinal Survey of Australian Children (LSAC), this paper makes two important contributions to research into intergenerational transmission in health. First, and most importantly, this paper is the first to estimate a causal impact of maternal mental health shocks on child health. Second, and also for the first time in this area of literature, our novel empirical model and high quality panel data allow us to document the causal impact of maternal mental health shocks on child health over a long duration during children's key developmental periods (Douglas Almond, 2006; Smith, 2009; Case and Paxson, 2010). In particular, for each cohort of children we observe parents and children up to five times over 10 years, starting from birth or kindergarten ages. Observations over a long duration allow investigation of both contemporaneous and intertemporal impacts of maternal mental health shocks on child health. The rich data set also enables us to explore heterogeneous patterns of the intergenerational transfers in health not only by child ages but also by other various characteristics of the mother and the child.

Employing the LSAC data and an FE-IV approach, we find little evidence supporting that poor maternal mental health worsens child health. While this finding differs significantly from preceding research's findings the results hold irrespective of the gender and age of the child, levels of maternal education or household income, or whether contemporaneous or intertemporal impacts are being considered. Also, our results indicate that failing to account for endogeneity of maternal mental health could result in over-estimates of adverse effect of poor maternal mental health on child health. Our findings are robust to a wide range of robustness checks.

The rest of the paper is structured as follows: Section 2 discusses the related literature, while Section 3 describes our data. Section 4 describes our empirical models, and Section 5 presents the empirical results including that from various robustness checks. Section 6 examines heterogeneous effects and Section 7 concludes the findings of this study.

2. Literature review

This paper examines the impact of maternal mental health on child health, relating to a very large body of literature on intergenerational transmissions in various aspects such as income or education (Solon, 1999; Black and Devereux, 2011). It also relates to a rich body of literature on the impact of parental income on child health (Case *et al.*, 2002; Apouey and

Geoffard, 2013; Fletcher and Wolfe, 2014; Khanam *et al.*, 2014; Kuehnle, 2014), as well as emerging literature on the effects of parental health on child education (Bratti and Mendola, 2014; Alam, 2015; Le and Nguyen, 2015).[1] However, this paper more closely connects to an emerging body of research focusing on the relationship between parental health and child health.

A limited number of studies have investigated correlations between various parental health measures and health outcomes of children at different age groups with data sets from countries with different levels of development. For example, Venkataramani (2011) investigates the correlations of height between Vietnamese parents and their children whose ages are under 6 years old and Bhalotra and Rawlings (2011, 2013) use microdata from 38 developing countries to document the correlations between maternal height and infant survival probability. More recently, Kim *et al.* (2014) document associations in health (as measured by general health status[2] or physical difficulties) between Indonesian parents and their older adult children.

Other studies employ data from developed countries, exclusively from the US and European countries. For example, Classen (2010) documents associations between the weight status of US mothers and their children when both generations are between the ages of 16 and 24. Also employing US data, Bauldry *et al.* (2012) examine the associations between parental health conditions and self-rated health of children from adolescence to young adulthood and Thompson (2014) estimate the correlation of same specific chronic health conditions between parents and their young children. Recently, Darden and Gilleskie (2015) study the effects of parental health shocks on self-rated health of US adult offspring.

Research has also been conducted with data sets from Germany (Coneus and Spiess, 2012) and the UK (Propper *et al.*, 2007; Johnston *et al.*, 2013). Coneus and Spiess (2012) examine correlations in health between German parents and their 0-to-4 year old children using various health measures including anthropometric, health disorders, and self-rated health measures. Propper *et al.* (2007) and Johnston *et al.* (2013) both conduct research into correlations between maternal and child health. While Johnston *et al.* (2013) examine intergenerational correlations in mental health over three generations Propper *et al.* (2007)

[1] This study is also related to a rich literature examining the effects of negative events during maternal pregnancy on child outcomes (Currie and Moretti, 2007; Black *et al.*, 2016).

[2] This self-rate health is often constructed from responses to the question "In general, how would you say your current's health is: 1 Excellent; 2 Very good; 3 Good; 4 Fair; 5 Poor". A higher value of this measure indicates worse subjective general health.

investigate correlations in maternal physical and mental health and health measures of their children (aged less than 7 years) including self-rated health, asthma, and anthropometric measures. The two UK studies are of our particular interests because, like the current study, they both correlate maternal mental health to child health.

Studies in this area have used three main strategies to address the possible endogeneity of parental health in the child health equations. The first, and most common approach in this area, tries to limit the impact of unobservable individual heterogeneity by using a rich set of child and parent characteristics. The second approach controls for time-invariant unobservable characteristics using a child FE estimator. So far only one study, by Darden and Gilleskie (2015), has employed the child FE estimator though this is possibly due to data constraints. The third approach in addressing endogeneity employs an instrumental variables method. The first and only attempt following this path within this area of research is a study by Venkataramani (2011). Venkataramani (2011) uses conditions faced by parents early in life as instruments for their height in a cross-sectional regression framework. However, it is not clear whether the positive correlations between parent and child height found by Venkataramani (2011) should be interpreted as causal given the weakness and possible invalidity of the instruments used.[3]

Regardless of data sets and empirical methods used existing evidence often suggests a strong positive association between parental health and child health. Empirical evidence also indicates that the degree of intergenerational correlations in health may not be homogenous. For example, while the study by Darden and Gilleskie (2015) documents stronger health transmission for daughters than sons some studies do not find any difference in transmission strength by gender of children (Coneus and Spiess, 2012; Thompson, 2014). Studies into both paternal and maternal health have returned mixed results with some finding intergenerational correlation is greater for maternal health than paternal health (Coneus and Spiess, 2012; Thompson, 2014) while another finds little difference based on the gender of the parent (Kim *et al.*, 2014). On the combination of parental and child gender, the study by Classen (2010) is the only one that reports a stronger transmission between mothers-daughters or fathers-sons. In contrast, Venkataramani (2011) finds that maternal height is more strongly associated with

[3] These are two main limitations explicitly noted in the work by Venkataramani (2011). Specifically, all instruments are weak as the largest first stage F statistic is only 2. Furthermore, given that many studies have found that early life shocks have long-run effects on human capital and behaviours in later life of the parent (Almond and Currie, 2011b; Malmendier and Nagel, 2011; Cameron and Shah, 2015; Kesternich *et al.*, 2015) it is unlikely that these instruments satisfy the assumption that they can be reasonably excluded for the child health equation.

the heights of boys than girls, while the associations with paternal height are similar across genders. However, some studies do not find any clear patterns in the transmission strength by any gender concordance between parents and children (Coneus and Spiess, 2012; Thompson, 2014). Some studies also report a larger association for older children (Bauldry *et al.*, 2012; Coneus and Spiess, 2012; Thompson, 2014). Thompson (2014) reports smaller health correlation for adopted children than biological children, suggesting that genetic transmission plays an important role in explaining the intergenerational transmission in health. Some studies also report stronger transmission in lower income/less developed areas (Bhalotra and Rawlings, 2013; Kim *et al.*, 2014).

Overall, our above review of emerging literature in this area indicates that while some serious attempts have been made to identify a causal estimate of parental health on child health the current literature is yet to achieve that aim given limitations of the methods or data used. As such, the heterogeneous analyses presented above may not be interpreted as causal. We build on these studies to employ both child-parent fixed effects and instrumental variables approach in a unified framework to provide more robust estimates on a causal impact of maternal mental health on child health. This study follows recent work by Kuehnle (2014) examining intergenerational transmission in an attempt to disentangle the link between parental income, parental health and child health.[4]

3. Data

3.1. Data

We use data from the first five waves of the biannually nationally representative LSAC survey. The LSAC initiated in 2004 contains comprehensive information about children's health and other socio-economic and demographic background of children and their parents. The LSAC sampling frame consists of all children born between March 2003 and February 2004 (B-Cohort, 5,107 infants aged 0–1 year in 2004), and between March 1999 and February 2000 (K-Cohort, 4,983 children aged 4–5 years in 2004). In this study we utilize data from both cohorts. Our current data thus allow us to study the subject during key developmental years of children, from birth to 13 years old.

[4] It is well understood that parental health is strongly associated with parental income. Methodologically, our paper is closely related to the literature on the effect of parental income on child health which also finds it challenging to deal with the endogeneity of parental income. To date, the study by Kuehnle (2014) is the only one in this literature to successfully control the endogeneity of parental income by using local labour market characteristics to instrument for parental income in an IV framework. Previously, being unable to control for endogeneity of parental income, this literature could not separate the impact of parental income from parental health.

3.2. Maternal mental health measures

Two measures of maternal mental health are used in this study: the first measure is a binary indicator which takes the value of one if the mother was depressed for two weeks or more in the year prior to the survey time, and zero otherwise. [5] The second measure is based on the K6 scale of psychological distress. The K6 was based on self-reported response to 6 items which ask the mother about symptoms of depression or anxiety experienced in the past four weeks. It uses a five level response scale that ranges from "all of the time" (1) to "none of the time" (5). The 6 questions asked are: "In the past 4 weeks, how often did you feel…": 1. Nervous, 2. Hopeless, 3. Restless or fidgety, 4. Everything was an effort, 5. So sad couldn't cheer up, and 6. Worthless. The sum of scored responses to the six questions is used to generate a single score of psychological distress. The summed score ranges from 6 to 30, with higher scores indicating a lower level of psychological distress. K6 validation studies were carried out in a number of countries throughout the world (Kessler *et al.*, 2010), including Australia (Furukawa *et al.*, 2003). These studies uniformly found the K6 to have very good concordance with independent clinical ratings of mental health. For the sake of interpretation and consistency with the first maternal mental health measure used in this study we use a reversed K6 score with a higher score indicates higher levels of psychological distress, which is associated with poorer mental health. While the K6 has been proven to be a high quality measure of mental health, concerns have been raised that as a subjective measure it may be prone to a self-reporting scale bias.[6] We therefore use the dummy maternal mental health indicator in the main analysis and the K6 as an alternative measure of maternal mental health in a robustness check.

Maternal mental health is the focus of our study for two reasons. Firstly, similar to data used in international literature (Propper *et al.*, 2007; Johnston *et al.*, 2013) health indicators are more widely available for mothers than for fathers in our data. Secondly, and specific to our context, we use the IV method and instruments are mainly available for maternal mental

[5] This variable is derived from responses to the question "In the past year, have you had two weeks or more during which you felt sad, blue or depressed or lost pleasure in things that you usually cared about or enjoyed?". This information is only available from wave 2. See Appendix Table A1 for variable description and other summary statistics. Appendix Table A2 represents correlation structure among measures of maternal mental health and child health.

[6] It is understood from the existing literature that individuals may have different scales of reference in answering the same question on the assessment of their health status (Bertrand and Mullainathan, 2001; Crossley and Kennedy, 2002). Note that our empirical models which control for parent-child time invariant unobservable characteristics also help reduce any scale of reference bias.

health. While maternal mental health is our main focus we will test for robustness of the results by including similar paternal health indicators where available.

3.3. Child health measures

Several child health measures are used in this study. The first measure is the number of on-going conditions the child has as reported by parents.[7] We also use a dummy variable to indicate whether the child is diagnosed as having asthma as the second measure of child health. This measure is used as it was specifically asked separately from questions about on-going health conditions described above. In addition, while being reported by parents, the question about asthma tends to suggest that this condition may be more objective because it is more likely to be diagnosed by a professional.[8] Two additional child health measures are dummy variables indicating whether the child currently uses prescribed medicine or whether the child needs extra medical care.[9]

In addition to the above parents' self-reported measures of child health the survey also contains child height and weight indicators which are measured by a professional so less prone to measurement errors and biases than parental self-reports. These two health indicators are therefore used as additional child health measures in this study. We also use them to construct an additional anthropometric indicator: the body mass index (BMI). Given health may be a non-linear function of BMI, indicators for child overweight or obesity as defined in Cole *et al.* (2000) are used as two additional anthropometric indicators.[10]

[7] Specifically, we use responses to the question "Does study child have any of these ongoing conditions? ('Ongoing conditions' exist for some period of time (weeks, months or years) or re-occur regularly. They do not have to be diagnosed by a doctor.)". The list of ongoing conditions include hearing, eyes or seeing properly, developmental delay, eczema, diarrhoea or colitis, anaemia, ear infections, food or digestive allergies, constipation, frequent headaches, tonsillitis, and others. The results presented below largely extend to a wider range of child health measures, including child self-rated health (reported by parents) or whether the child is under a medicated condition for 12 months. For brevity considerations, results using these additional health measures are not reported but will be available from the authors upon request.

[8] This variable is constructed using responses to a question "Has a doctor ever told you that child has asthma?", which is asked in all waves except wave 1 for B cohort. Studies in the psychology field often document a positive association between parental stress and child asthma morbidity (see, for example, Yamamoto and Nagano (2015) for a review of this related literature). However, none of studies in the psychology literature addresses the endogeneity of parental stress like we do in this paper.

[9] These variables are derived from responses to the question "Does child currently need or use medicine prescribed by a doctor, other than vitamins?" and "Does child need or use more medical care than is usual for most children of the same age", respectively.

[10] To account for non-linear effect of maternal mental health on child BMI, we introduce BMI in a log form in regressions. BMI is not available for children of the B cohort at wave 1 because question about height is not asked.

3.4. Sample

We focus on 96 % of initial surveyed sample where the Parent 1 is the biological mother of the child.[11] We further restrict our sample to children without missing information on a list of important explanatory variables (as detailed in Section 4). Finally, since we focus on results estimated using a child FE estimator we necessarily restrict our sample to children observed at least twice in the data. Our above sample restrictions result in final samples which vary by measures of child health and maternal mental health. Specifically, final sample sizes for K cohort range from 13,424 wave-child observations (of 3,922 unique children) to 17,490 wave-child observations (of 4,175 unique children). Final sample sizes for B cohort vary from 14,178 wave-child observations (of 4,008 unique children) to 18,436 wave-child observations (of 4,349 unique children).

3.5. Descriptive analyses

Summary statistics for child health outcomes and other individual level characteristics by maternal depression status for two cohorts of children are presented in Table 1. On average, about 30 % of mothers of Australian children in both cohorts were depressed for two weeks or more in the year prior to the survey time. Mothers experiencing depression are appreciably different from those not experiencing depression; in particular, mothers experiencing depression have much lower K6 scores (indicating higher levels of psychological distress), are older or more likely to have come to Australia from a non-English speaking background country, and are more likely to be less educated or to have experienced negative life events. Similarly, as compared with children of mothers not experiencing depression, those of mothers experiencing depression are older, more likely to be native, Aboriginal, have low birth weight, or are less likely to live with both parents. Table 1 also suggests that children of mothers experiencing depression have worse health outcomes. However, it is important to note that this positive relationship between maternal depression and child health measures could be driven by the effects of unobserved characteristics as well as reverse causality. We will address both issues using fixed effects instrumental variables regressions in the following sections.

[Table 1 around here]

[11] In the LSAC, Parent 1 is defined as the parent knows the study child best and in most of cases is the biological mother of the child (AISF, 2013). Parent 1 completes most of interviews including child health and life events which we use in this study. 99 % of individuals identified as the Parent 1 in the data are biological parents of the study child.

4. Empirical framework

4.1. Theoretical backgrounds

Theoretically, poor parental health could affect child health through a number of possible mechanisms: poor parental health may reduce income, reduce household wealth, or reduce the amount or the quality of time parents spend with their children (Becker, 1965; Grossman, 1972; Becker and Tomes, 1986; Cunha and Heckman, 2007; Heckman, 2012). Poor parental health may also directly worsen health of children as children may take care of parents (Coe and Van Houtven, 2009). The above channels suggest that poor parental health reduces good health outcomes in children, however, there are some suggestions the impact may originate from the opposite direction. For instance, poor health may cause parents to reduce their labour market working time (Becker, 1981; Cai and Kalb, 2006; Frijters *et al.*, 2014) and hence increase their time with their children. The combining effects of those factors thus leave the impact of parental health on child health to be an empirical issue.

4.2. Empirical models

In practice, we lack suitable instruments and data to specifically identify which mechanism prevails. As such, most empirical studies focus on the estimation of the cumulative impact via all pathways using a reduced form model in which parental health is included as an explanatory variable in the child health equation. We therefore follow previous literature to estimate the health outcome Y of child i at time t as follows:

$$Y_{it} = \alpha + \beta_m MH_{it} + X_{it}\gamma + \delta_i + \mu_{it} \quad (1)$$

In equation (1), MH indicates maternal mental health which we measure in different ways; X_{it} is a vector of individual characteristics; and μ_{it} represents an error term. α, β and γ are parameters to be estimated. β_m is our interested parameter.

We include in X_{it} a rich list of factors contributing to the child health such as the child's characteristics (i.e., gender, age, migration status, ethnicity, birth weight, number of siblings, whether the child is living with both parents),[12] maternal characteristics (i.e., age, education, and migration status), and indicators of neighbourhood characteristics.[13] We also control for the differences in the survey time by including dummies for years and quarters of survey time

[12] All time invariant variables such as gender, birth weight and migration status are dropped in the FE estimator.
[13] Local variables include percentages of individuals completed year 12, working, speaking English, being born in Australia, or having an Aboriginal/Torres Strait Islands origin in linked areas, percentages of households with household income less than AU$1,000/week in linked areas, and a metropolitan dummy.

in regressions. We additionally include state dummy variables to control for differences in socio-economic environments by states/territories.

Regression model (1) which controls for time-invariant individual unobservable characteristics (δ_i) would, in principle, produce more accurate estimates than a simple regression which does not control for individual heterogeneity. Yet there may still be a concern that unobserved time-variant, individual-specific factors (μ_{it}) are correlated with both the maternal mental health and child health outcomes, thus biasing the estimates of maternal mental health. We further address the possible endogeneity problem in equation (1) using an instrumental variables approach, introducing an auxiliary equation for the maternal mental health.

$$MH_{it} = \pi + X_{it}\tau + Z_{it}\sigma + \delta_i + \omega_{it} \qquad (2)$$

where Z_{it} is a $1 * H$ vector of instruments ($H \geq 1$), ω_{it} is an idiosyncratic error term, and τ and σ are vectors of parameters. The elements of the vector of instruments Z_{it} must satisfy the following conditions: (1) they must be sufficiently correlated with MH_{it}; (2) they must be uncorrelated with Y_{it} except through MH_{it}; and (3) they cannot be correlated with time-variant, individual specific error terms in the child health outcome equations (Wooldridge, 2010).

4.3. Instrumental variables

We propose to use two instruments: (1) the death of a close friend of the mother and (2) a serious illness or injury of a close relative of the mother.[14] There two instruments are likely to satisfy the three requirements specified above. Specifically, they may deteriorate maternal mental health as evidenced in the psychological literature that stressful life events lead to depression or anxiety (Faravelli and Pallanti, 1989; Kessler, 1997; Kendler *et al.*, 1999). These instruments are also theoretically sound: the (arguably unexpected) recent death of a close friend or serious injury/illness of a close relative should directly affect the mother's mental health, but only indirectly affect her child's health outcomes through the maternal mental health channel.[15] We will empirically test the strengths of the instruments against the

[14] In LSAC data, parents 1 are asked "in the last year, have any of the following happened to you". We use statements about "A close family friend or another relative (aunt, cousin, grandparent) died" and "A serious illness, injury or assault happened to a close relative" to construct the two instruments.

[15] We do not use events such as illness, injury or assault of the mother or the death of the mother's parent, partner or child because they may directly affect the child's health. We also do not use events relating to the mother's work or relationship as they are particularly endogenous in our context (e.g. depression may cause relationship breakdown or work and mental health are inter-related (Salm, 2009; Frijters *et al.*, 2014)). We do

third requirement by (1) employing the Sargan-Hansen test to formally test for exogeneity of instruments and (2) additionally controlling for a rich list of time-variant variables which are potentially associated with our instruments in Section 5.

These two instruments have been previously used but in different contexts. For example, health status (including the death) of close relatives have been used to instrument for the caregiving decision to examine the impact of caregiving on some outcomes of caregivers (Ettner, 1995; Heitmueller, 2007; Van Houtven *et al.*, 2013; Nguyen and Connelly, 2014; Do *et al.*, 2015). Note that we do not use a serious illness or injury of close family members such as parents, spouses and children of the mother as instruments for the maternal mental health because they are the main recipients of informal care as found in the informal care literature (Nguyen and Connelly, 2014). As another example, the death of close friends has been employed to instrument for mental health when analysing the impact of mental health on labour supply (Frijters *et al.*, 2014). This paper improves on previous studies as it is the first to use these instruments to analyse the impact of maternal mental health on child health. In addition, unlike in previous studies where instruments directly affect the individuals being considered our study uses instruments that indirectly influence the individuals being considered (i.e. the child): this setting helps consolidate the second condition of the IV method that the instruments do not directly affect the outcome other than through the endogenous variable.

The IV approach in our research is also strengthened by three other features. First, since these instruments vary over time we are able to apply the IV approach to panel data (IV-FE approach), thus effectively accounting for both time-invariant and time-variant unobserved individual heterogeneity at the same time. Second, we have two instruments and one endogenous variable so our empirical model is over-identified, enabling us to test the external validity of instruments. Third, by using both instruments we are able to broaden the sub-population of interests as each captures a different source of maternal mental health variations and thus each results in an estimate of the local average treatment effect (LATE) for the different subset of the population (i.e. compliers).

4.4. Other empirical issues

We model all outcomes as linear. While this linear specification seems quite appropriate for continuous outcomes such as the number of conditions, weight, height and BMI it is not well-

not use some negative events such as whether the child "lived in drought-affected area" or "home of local area was affected by bushfire, flooding" since these events are weakly correlated with maternal mental health.

suited to other outcomes which are binary. Unfortunately, other models that respect the binary nature of the dependent variable such as fixed-effects probit or logit models do not produce consistent estimates for the endogenous variables. In addition, the linear probability model usually provides a good approximation for the "population average" that is in the interests of policy makers (Angrist, 2001; Fernández-Val, 2009). An Ordinary Least Squares (OLS) method is employed to estimate the equation (1) while a Two-Staged Least-Squares (2SLS) method to estimate the system of equation (1) and (2). In all regressions, standard errors are clustered at the individual level to account for the fact that each child has up to five observations, one for each wave in which he or she was evaluated.

5. Empirical results

5.1. Maternal mental health and child health – K cohort

Within this section, for illustration and brevity purposes, we will focus on estimation results from the sample of K cohort children and use the maternal depression dummy as the main indicator of maternal mental health. Estimates of maternal depression dummy from child health equations are presented in Table 1. In Table 1 we report estimates from three alternative specifications: (1) "Pooled" results estimated from a model similar to model (1) without controlling for individual FEs, (2) "Fixed Effects" results estimated from model (1), and (3) "FE-IV" results estimated from models (1) and (2). Pooled results are reported to enable us to compare them with those presented in most of the prior literature which does not account for individual FEs. For FE-IV regressions we report results from three specifications in which we use the two instruments separately and jointly. By comparing estimates from IV regressions using different instruments, we can be ensured about the validity of instruments, as suggested by Angrist *et al.* (2010).

Pooled results (reported in columns 1, 6 and 11 of Table 2) show that maternal depression is positively and highly statistically significantly (at the 1 % level) associated with five out of nine child health outcomes considered. These results suggest that, as compared to children of mentally healthy mothers, those of depressed mothers have more health conditions, are more likely to have asthma, use prescribed medicines, require extra medical care, or be overweight. Our pooled results are thus in line with that reported in the previous cross-sectional studies for the UK (Propper *et al.*, 2007; Johnston *et al.*, 2013) which consistently show that children of mothers experiencing mental illness have worse health outcomes.

[Table 2 around here]

FE estimates (reported in columns 2, 7 and 12 in Table 2) show that controlling for the individual FE changes the results noticeably. In particular, the FE estimates are much smaller than pooled estimates in terms of the magnitude and statistical significance level. Specifically, controlling for individual heterogeneity at least reduces the size of the maternal depression estimates by two thirds (e.g. the estimate on extra medical care). Accounting for the individual confounders also turns the estimates of maternal depression from highly statistically significant to less statistically significant (such as estimates from the number of conditions or BMI regressions) or statistically insignificant (e.g. estimates from asthma, prescribed medicine, and overweight regressions). After all, FE estimates indicate that children of mothers experiencing depression have only 0.04 more health conditions and are more likely (by 2 percentage point) to require extra medical care.

The above comparisons between pooled and FE estimates suggest that failing to account for the individual unobserved confounders would over-estimate the detrimental impact of poor maternal mental health on child health. One of the unobserved confounders would be maternal discount rates (Fuchs, 1982). Mothers with a lower discount rate have more risky life style and hence worse mental health and also invest less in child health. Another unobserved factor could be maternal gene that is transmitted from the mother to the child (Thompson, 2014). As a result, the simple estimate which fails to account for such unobserved characteristics over-estimates the adverse impacts of poor maternal mental health on child health.

While the FE model helps remove time-invariant individual characteristics (including the mother's discount factor or self-reporting scale of reference or genetic factors common to both the mother and the child), it cannot deal with problems associated with reversed causality and measurement errors. Regarding the measurement errors issue, current literature shows that mothers with worse mental health are more likely to report that their children have health or behavioural problems. This suggests using mother-reported measures of child health would over-estimate the harmful impact of maternal mental health on child health (De Reyes and Kazdin, 2005; Le and Nguyen, 2015). This measurement error issue appears to present in our data as controlling for individual heterogeneity only removes the statistical significance of all estimates for all likely objective measures of child health (i.e. asthma, prescribed medicine and overweight).[16] By contrast, FE estimates are still statistically significant (at

[16] Ideally, one can use two similar measures of child health evaluated by the mother and a professional to detect for this type of measurement error bias. Unfortunately, such information is not available in our data.

least at the 5 % level) for two more subjective measures of child health (i.e. number of conditions and extra medical care). We next turn to results estimated from FE-IV models which address all three issues simultaneously.

FE-IV estimates are reported in the remaining columns in Table 2. Three results from FE-IV regressions suggest that our instruments are empirically strong. First, the lowest first-stage F statistic is 24, which is well above the rule of thumb value of 10 for a strong instrument (Stock and Yogo, 2005). This is the case for all regressions regardless of child health measures or instrument sets used. Second, the Sargan-Hansen statistic for over identification restrictions from the FE-IV3 regressions which use the two instruments collectively (reported in columns 5, 10 and 15) suggests that our instruments are exogenous. Third, all FE-IV estimates suggest that maternal depression has no detrimental impact on child health. The consistency in the finding from the FE-IV results which are estimated from regressions using different combinations of instruments thus provides the third empirical evidence demonstrating the strength of our instruments.

The Appendix Table 3A reports a placebo test that provides further support for the validity of our instruments. This test is motivated by an expectation that the instruments will affect maternal mental health but not maternal physical health. This is shown to be true in the Appendix Table 3A as both instruments, while being strongly correlated with maternal depression (columns 1 to 3), are not associated with maternal physical health (as represented by maternal BMI or a general health index in the remaining columns).

We further test for whether unobserved time varying factors may account for the impact of maternal mental depression on child health. We do so by additionally controlling for some important time-variant variables which are potentially associated with our instruments and child health outcomes at the same time.[17] Particularly, we alleviate concerns that a recent serious injury of a close relative of the mother may cause a shift in maternal time towards provision of care to the injury/ill relative by introducing a variable representing whether the mother provided any care for a relative last year to the IV-FE regressions (results are presented in Panel F of Table 3). We also separately control for two variables describing the working status of the mother for the same reason (Panel D and E). Additionally, we address the concern that the recent death of a friend or relative might lead to windfall income (such as

[17] In this robustness check, we use both instruments (i.e. FE-IV3). Some important statistics from the F test for the strength of the association between instruments and maternal mental health and the Sargan-Hansen test for the externality of instruments are largely similar to those reported in Table 2. They are therefore not reported for brevity but will be available upon request.

bequests) by explicitly controlling for household income (Panel M) and whether the mother reports that she had a major financial crisis in the last year (Panel Q). The inclusion of household income in our model is also to test for whether maternal mental health has a separate impact from that of household income as has been done in the literature on parental income-child health ingredient (Kuehnle, 2014). Furthermore, since maternal health behaviours such as smoking (Panel G) or drinking (Panel H) may be associated with the instruments and child health outcomes we control for maternal smoking and drinking status separately in the regressions. Finally, for a similar reason, we additionally control for other variables representing maternal physical health (as represented by a general health indicator, BMI, or any serious illness, injury or assault – Panel B, C, and O, respectively), paternal health (as described by paternal general health, BMI, K6 and depression – Panels I to L), and health of other household members (as represented by a death of the mother's parent, partner, or child – Panel P) in the regressions.

[Table 3 around here]

Estimation results reported in Table 3 show that additionally controlling for all above mentioned time-variant variables does not change our results in any significant way as estimates of the maternal depression variable are largely the same as those obtained from the baseline regressions (reproduced in Panel A of Table 3). Results from these sensitivity checks when viewed with results of a Sargan-Hansen test about the exogeneity of our instruments reported in Table 2 suggest that our instruments are not correlated with time-variant unobservable characteristics in the child health outcome equations.

Above, we used the depression dummy to represent maternal mental health. In this section, we replicate the above results using maternal K6 as an alternative indicator of maternal mental health. Estimates for maternal K6 from various specifications for nine child health outcomes (results are reported in Table 4) show similar patterns as observed in Table 2. Specifically, while pooled results show some positive and statistically significant association between (reversed) maternal K6 and child health outcomes, FE results show a much smaller association in terms of the magnitude and statistical significance level. In turns, FE-IV results in all cases point to an insignificant impact of maternal K6 on child health. An exception is observed for the FE-IV2 estimate of maternal K6 on the probability that the child needs extra medical care (Panel B – column 4). However, the estimate is only marginally statistically significant at the 10 % level. We note that the first stage F-statistic in specifications which use the death of a close friend as a sole instrument is lower at around 7. However, using the

injury of a close relative as a sole instrument (or in conjunction with the death of a close friend) produces the first stage F-statistic of about 23 (14). Results from a Sargan-Hansen test also suggest that we cannot reject the null hypothesis that the instruments are valid.[18] Again, the similarity in the results using different measures of maternal mental health provides additional evidence for the robustness of our findings.

[Table 4 around here]

5.2. Maternal mental health and child health – B cohort

We next turn to examine the effects of maternal mental health on health outcomes of children of the B cohort. Estimation results for the maternal depression dummy variable from various specifications (reported in Table 5) show similar patterns as previously observed for children of the K cohort. Specifically, while pooled results suggest children of depressed mothers have worse health outcomes (as measured by a greater number of health conditions, a higher probability of using prescribed medicine or requiring extra medical care), FE results point to statistically insignificant impact of maternal depression on all child health outcomes. FE-IV results also suggest that maternal depression does not worsen health outcomes in children. By contrast, results from FE-VI regressions on the child height (Panel B – columns 9 and 10) suggest that children of mothers experiencing depression grow taller than children of mothers without depression by about 3 %. While this effect seems surprising we note that it is only statistically significant at the 10 % level. We also note that in some FE-IV regressions using the death of a close friend as an instrument the first stage F-statistic is lower than 10, indicating this instrument may be weak.[19] Similar to results for the K cohort, using maternal K6 as an alternative measure of maternal mental health for the B cohort leads to similar conclusions as using the maternal depression dummy (See Table 6).

[Table 5 and 6 around here]

5.3. Intertemporal impact of maternal mental health on child health

Our above FE-IV results conclusively indicate no contemporaneous impact of maternal mental health on child health outcomes. It would be possible that for some child health measures it may take time for maternal mental health to have a visible impact. We investigate

[18] We also carried out other sensitivity checks to the maternal K6 as we did for the maternal depression dummy and found similar results. Results of this experiment (and other unreported robustness checks) will be available from the authors upon request.

[19] The FE-IV1 estimate of maternal depression on prescribed medicine (panel A – column 13 – Table 5) while being statistically insignificant is implausibly large. This could be a result of a weak instrument as explained by Yogo (2004).

this possibility by including lags of maternal mental health (and that of the instruments) in the FE-IV regressions of current health outcomes of children from both cohorts. Our data and empirical FE-IV methods allow us to examine the impact of maternal depression that occurred two and four years ago on current child health outcomes. Regression results (reported in Table 7) suggest that poor maternal mental health does not impair subsequent health outcomes of children of both cohorts either.

[Table 7 around here]

6. Heterogeneity

Empirical child development literature has often found differing effects on boys and girls (Almond and Currie, 2011a). We test whether maternal depression affects health outcomes of sons and daughters differently by running the FE-IV regressions for sons and daughters separately. Results presented in Table 8 suggest no differential effects by gender of children.

[Table 8 around here]

The above estimates by cohorts suggest that there is no difference in the impact of maternal mental health on health outcomes of children of different age cohorts. Above, for each cohort, we presented results that pool child health outcomes across all ages. In this sub-section, we investigate the heterogeneity of the impact by ages by estimating the FE-IV regression models separately by waves of survey and cohorts.[20] As explained in Section 3, children in our B (K) cohort sample were 0/1 (4/5) year old at wave 1 of the survey. They were therefore two years older in every subsequent wave of the survey. As such, waves of survey represent the age groups of children in our sample well. Regression results (reported in Table 9) show that, consistent with the pooled estimates, all cohort-wave specific estimates are statistically insignificant, suggesting that poor maternal mental health does not reduce child health across all age groups.

[Table 9 around here]

Literature on intergenerational transmission also suggests that the degree that parental health transmits to child health may vary by the level of household credit constraints (Solon, 2004). As credit constraints are most severe for low income parents we test for the above prediction by running the FE-IV regressions separately for two sub-samples defined relative to the

[20] Note that with the child FE approach which compares outcomes and controls of the same child over time, only regression results for the second earliest wave where a child health outcome and maternal mental health are observed are reported. In addition, with the FE regressions by survey waves, data from two consecutive waves are used for each regression. Using maternal K6 reveals similar patterns.

median of household annual income of all households in the whole sample for each cohort. Results (reported in Table 10) show no differential impact by household income since all estimates of the maternal depression dummy are statistically insignificant.

[Table 10 around here]

Finally, it would be likely that more educated mothers are better at shielding their children from any negative impact of maternal depression. We investigate this possibility in our data by running the FE-IV regressions separately for mothers with low or high qualifications. Estimation results (reported in Table 11) suggest that the statistically insignificant impact of maternal depression does not vary by the level of maternal education.[21]

[Table 11 around here]

7. Conclusion

Drawing on the recent and nationally representative panel of two cohorts of Australian children we have presented the first causal effects of maternal mental health shocks on health outcomes of children from birth to 13 years old. This study improves on most previous research by using an individual fixed effects instrumental variables approach to deal with the endogeneity of maternal mental health.

Our preferred results provide limited evidence to support that poor maternal mental health worsens health outcomes in children. This contrasts to common findings in previous research reporting harmful impacts of poor maternal mental health on child health. We also find no differential effects based on the gender or age of the child, the education level of the mother or household income levels. Our finding holds irrespective of contemporaneous or intertemporal impacts of maternal mental health on child health.

Our results are robust to a battery of sensitivity and specification tests investigating the plausibility of our identifying assumption, including different combinations of instruments and inclusion of various time-variant variables. These results have been proven to be consistent across the two cohorts of children and the use of alternative measures of maternal mental health and various measures of child health. Overall, the results from this work highlight the importance of controlling for individual heterogeneity, reverse causality, and measurement errors when modelling the effects of maternal mental health on child health. Failing to address these issues could result in over-estimates of the harmful effect of poor

[21] We also experimented with running FE-IV regressions separately for children living in metropolitan and non-metropolitan areas and found no differential effects by this characteristic either.

maternal mental health on child health. Future work should take this important methodological implication into account when extending the topic to other countries' data.

The positive conclusion from our analysis is that we find no significant detrimental effects of poor maternal mental health on child health. However, it is important to emphasize that the results we present only apply to maternal mental health; they cannot necessarily be generalized to the effects of other maternal health conditions or paternal health. Neither can they be generalized to the case of mental health of mothers in other countries. It is not clear whether the results still apply for countries with poor systems of social protection (Gertler *et al.*, 2004; Wagstaff, 2007; Bhalotra and Rawlings, 2013). To this end, more studies applying our proposed methods to data from other countries, especially developing countries, are certainly needed. Furthermore, because our data and empirical strategy do not allow us to speak more directly to the impact of maternal physical health and paternal health on child health more research into these parental health measures is also worthwhile.

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Table 1: Sample means of outcomes and key covariates by maternal mental health condition

	K cohort			B cohort		
	Depressed mother (1)	No depressed mother (2)	(1)-(2)	Depressed mother (1)	No depressed mother (2)	(1)-(2)
Maternal K6 (reversed)	12.08	8.16	3.92***	11.75	8.08	3.67***
Number of conditions	0.78	0.50	0.28***	0.75	0.50	0.25***
Asthma	0.35	0.30	0.05***	0.25	0.21	0.04***
Prescribed medicine	0.18	0.13	0.04***	0.15	0.13	0.03***
Extra medical care	0.15	0.08	0.07***	0.15	0.08	0.07***
Height (cm)	141.23	139.96	1.27***	117.26	115.75	1.51***
Weight (kg)	38.95	37.29	1.66***	23.87	23.09	0.78***
BMI	18.89	18.41	0.49***	16.93	16.82	0.11**
Overweight	0.21	0.17	0.04***	0.18	0.16	0.02**
Obesity	0.07	0.07	0.00	0.06	0.05	0.01**
Child age (month)	122.06	119.09	2.97***	74.16	71.50	2.66***
Male	0.52	0.51	0.02	0.52	0.51	0.01
Native	0.97	0.96	0.01***	1.00	1.00	0.00
Aboriginal	0.04	0.02	0.02***	0.06	0.03	0.03***
Low birth weight	0.08	0.07	0.01*	0.07	0.06	0.01**
Maternal age (age)	39.81	40.11	-0.3***	36.01	36.65	-0.65***
Mother is a NESB migrant	0.25	0.22	0.02***	0.22	0.23	-0.01
Mother is an ESB migrant	0.13	0.15	-0.02***	0.16	0.15	0.01
Mother education: Certificate	0.38	0.32	0.06***	0.36	0.31	0.06***
Mother education: Diploma	0.10	0.10	-0.01	0.11	0.11	0.00
Mother education: Bachelor degree	0.12	0.16	-0.04***	0.16	0.19	-0.04***
Mother education: Graduate diploma/certificate	0.07	0.07	-0.01*	0.06	0.07	-0.01**
Mother education: Postgraduate degree	0.06	0.07	-0.01**	0.06	0.08	-0.02***
Number of siblings	1.63	1.63	0.01	1.51	1.49	0.01
Living with both parents	0.67	0.83	-0.16***	0.73	0.87	-0.14***
Illness to close relative	0.21	0.13	0.07***	0.20	0.12	0.08***
Death of close friend	0.27	0.21	0.06***	0.25	0.21	0.04***
Number of observations	4092	9630		4040	10406	

Notes: Figures are sample means. Estimated sample from the regression of the number of conditions as the child health outcome on maternal depression dummy. Tests are performed on the significance of the difference between the sample mean for children of depressed and non-depressed mothers. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Table 2: Maternal depression and child health outcomes - results from various models for K cohort

	Pooled	FE	FE-IV1	FE-IV2	FE-IV3	Pooled	FE	FE-IV1	FE-IV2	FE-IV3	Pooled	FE	FE-IV1	FE-IV2	FE-IV3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Panel A	Number of conditions					Asthma					Prescribed medicine				
Maternal depression	0.24***	0.04**	-0.14	0.19	0.02	0.03***	0.00	0.09	0.02	0.06	0.04***	0.01	0.06	0.21	0.13
	[0.02]	[0.02]	[0.38]	[0.41]	[0.29]	[0.01]	[0.00]	[0.08]	[0.08]	[0.06]	[0.01]	[0.01]	[0.13]	[0.15]	[0.10]
F test			28.39	24.74	24.76			28.61	23.88	24.47			27.81	24.10	24.20
p SH					0.53					0.54					0.41
Observations			13,722					13,703					13,711		
Number of individuals			3,964					3,962					3,961		
Panel B	Extra medical care					Height (log)					Weight (log)				
Maternal depression	0.06***	0.02***	-0.03	0.14	0.06	-0.00	-0.00	0.00	0.00	0.00	0.01	-0.00	0.02	0.02	0.02
	[0.01]	[0.01]	[0.12]	[0.13]	[0.09]	[0.00]	[0.00]	[0.01]	[0.01]	[0.01]	[0.01]	[0.00]	[0.04]	[0.04]	[0.03]
F test			28.09	25.01	24.70			27.83	26.91	25.59			26.50	25.48	24.19
p SH					0.27					0.86					0.98
Observations			13,654					13,471					13,535		
Number of individuals			3,953					3,926					3,935		
Panel C	BMI (log)					Overweight					Obesity				
Maternal depression	0.01*	-0.00	0.02	0.01	0.01	0.03***	0.01	-0.06	-0.04	-0.05	-0.01	-0.00	0.07	0.10	0.08
	[0.00]	[0.00]	[0.04]	[0.04]	[0.03]	[0.01]	[0.01]	[0.15]	[0.14]	[0.11]	[0.01]	[0.00]	[0.08]	[0.07]	[0.06]
F test			27.36	26.11	24.97			27.36	26.11	24.97			27.36	26.11	24.97
p SH					0.89					0.90					0.76
Observations			13,424					13,424					13,424		
Number of individuals			3,922					3,922					3,922		

Notes: Pooled results are from the regression (1) without controlling for individual FEs while FE results are from the regression (1). FE-IV results from models (1) and (2). Instruments: IV1: death of close friend, IV2: illness to close relative, IV3: death of close friend and illness to close relative. F test denotes the F statistic for the excluded instrument in the first stage regression and p SH denotes results from the Sargan-Hansen test for over identification restrictions. Other explanatory variables include the child's characteristics (gender, age, migration status, Aboriginal status, birth weight, number of siblings, and living with both parents), mother' characteristics (age, education, and immigration status), local socio-economic background variables, state/territory dummies, year dummies, and survey quarters. Robust standard errors clustered at the individual level in parentheses. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Table 3: Maternal depression and child health outcomes - K cohort – Inclusion of time-variant observable variables

	Number of conditions	Asthma	Prescribed medicine	Extra medical care	Height (log)	Weight (log)	BMI (log)	Overweight	Obesity
With inclusion of	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Baseline	0.02	0.06	0.13	0.06	0.00	0.02	0.01	-0.05	0.08
	[0.29]	[0.06]	[0.10]	[0.09]	[0.01]	[0.03]	[0.03]	[0.11]	[0.06]
Panel B: Maternal general health	0.01	0.05	0.13	0.05	0.00	0.02	0.01	-0.05	0.08
	[0.30]	[0.06]	[0.10]	[0.09]	[0.01]	[0.03]	[0.03]	[0.11]	[0.06]
Panel C: Maternal BMI	-0.01	0.08	0.12	0.02	0.00	0.00	-0.00	-0.12	0.09
	[0.30]	[0.06]	[0.10]	[0.09]	[0.01]	[0.03]	[0.03]	[0.11]	[0.06]
Panel D: Maternal employment status	0.02	0.06	0.14	0.05	0.00	0.02	0.01	-0.05	0.08
	[0.30]	[0.06]	[0.10]	[0.09]	[0.01]	[0.03]	[0.03]	[0.11]	[0.06]
Panel E: Maternal working hours	0.01	0.06	0.14	0.05	0.00	0.02	0.01	-0.05	0.08
	[0.30]	[0.06]	[0.10]	[0.09]	[0.01]	[0.03]	[0.03]	[0.11]	[0.06]
Panel F: Maternal informal care	0.02	0.05	0.13	0.05	0.00	0.02	0.01	-0.05	0.08
	[0.29]	[0.06]	[0.10]	[0.09]	[0.01]	[0.03]	[0.03]	[0.11]	[0.06]
Panel G: Maternal smoking	0.02	0.05	0.13	0.06	0.00	0.02	0.01	-0.05	0.08
	[0.29]	[0.06]	[0.10]	[0.09]	[0.01]	[0.03]	[0.03]	[0.11]	[0.06]
Panel H: Maternal drinking	0.14	0.06	0.13	0.03	0.00	0.01	0.00	-0.04	0.06
	[0.28]	[0.06]	[0.10]	[0.09]	[0.01]	[0.03]	[0.02]	[0.10]	[0.05]
Panel I: Paternal general health	0.44	-0.02	0.09	0.14	-0.00	0.02	0.02	0.04	0.05
	[0.30]	[0.06]	[0.11]	[0.10]	[0.01]	[0.03]	[0.03]	[0.11]	[0.05]
Panel G: Paternal BMI	0.36	0.04	0.05	0.17	0.00	0.02	0.02	-0.01	0.03
	[0.35]	[0.09]	[0.13]	[0.12]	[0.01]	[0.04]	[0.03]	[0.14]	[0.07]
Panel K: Paternal K6 (reversed)	0.37	-0.02	0.04	0.10	-0.00	0.01	0.01	0.05	0.04
	[0.31]	[0.06]	[0.11]	[0.10]	[0.01]	[0.03]	[0.03]	[0.11]	[0.05]
Panel L: Paternal depression	0.52*	-0.03	0.11	0.16	-0.00	0.02	0.02	0.06	0.05
	[0.31]	[0.06]	[0.11]	[0.10]	[0.01]	[0.03]	[0.03]	[0.11]	[0.05]
Panel M: Household income (log)	-0.09	0.02	0.17	0.04	0.00	0.02	0.01	-0.02	0.07
	[0.31]	[0.06]	[0.11]	[0.10]	[0.01]	[0.03]	[0.03]	[0.12]	[0.06]
Panel O: Maternal illness, injury or assault	-0.02	0.06	0.14	0.05	0.00	0.02	0.01	-0.05	0.09
	[0.31]	[0.06]	[0.11]	[0.10]	[0.01]	[0.03]	[0.03]	[0.12]	[0.06]
Panel P: Mother's parent, partner or child died	0.05	0.09	0.16	0.07	0.00	0.02	0.02	-0.08	0.10
	[0.34]	[0.07]	[0.12]	[0.11]	[0.01]	[0.03]	[0.03]	[0.13]	[0.07]
Panel Q: Mother had a major financial crisis	0.01	0.05	0.14	0.06	0.00	0.02	0.01	-0.05	0.09
	[0.30]	[0.06]	[0.10]	[0.09]	[0.01]	[0.03]	[0.03]	[0.11]	[0.06]

Notes: Separate estimates of maternal depression from FE-IV regressions with death of close friend and illness to close relative as instruments. Other explanatory variables include the child's characteristics (age, number of siblings, and living with both parents), mother' characteristics (age and education), local socio-economic background variables, state/territory dummies, year dummies, and survey quarters. Robust standard errors clustered at the individual level in parentheses. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Table 4: Maternal K6 and child health outcomes - results from various models for K cohort

	Pooled	FE	FE-IV1	FE-IV2	FE-IV3	Pooled	FE	FE-IV1	FE-IV2	FE-IV3	Pooled	FE	FE-IV1	FE-IV2	FE-IV3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Panel A	Number of conditions					Asthma					Prescribed medicine				
Maternal K6 (rev.)	0.03***	0.01***	-0.11	0.01	-0.01	0.00***	-0.00	0.03	-0.01	-0.00	0.01***	0.00	-0.01	0.03	0.02
	[0.00]	[0.00]	[0.12]	[0.07]	[0.06]	[0.00]	[0.00]	[0.03]	[0.02]	[0.02]	[0.00]	[0.00]	[0.04]	[0.02]	[0.02]
F test			7.13	22.98	13.65			7.04	22.92	13.56			6.97	23.30	13.73
p SH					0.31					0.21					0.36
Observations			17,490					17,461					17,479		
Number of individuals			4,175					4,173					4,172		
Panel B	Extra medical care					Height (log)					Weight (log)				
Maternal K6 (rev.)	0.01***	0.00**	-0.02	0.04*	0.03	-0.00	0.00	0.00	0.00	0.00	-0.00	0.00	-0.01	-0.01	-0.01
	[0.00]	[0.00]	[0.03]	[0.02]	[0.02]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.01]	[0.01]	[0.01]
F test			7.49	22.65	13.59			7.33	24.76	14.56			7.25	23.08	13.76
p SH					0.12					0.90					0.81
Observations			17,420					17,236					17,298		
Number of individuals			4,170					4,152					4,154		
Panel C	BMI (log)					Overweight					Obesity				
Maternal K6 (rev.)	0.00	0.00	-0.01	-0.01	-0.01	-0.00	-0.00	0.02	0.02	0.02	0.00	0.00**	-0.01	0.00	0.00
	[0.00]	[0.00]	[0.01]	[0.01]	[0.01]	[0.00]	[0.00]	[0.05]	[0.02]	[0.02]	[0.00]	[0.00]	[0.02]	[0.01]	[0.01]
F test			7.47	24.23	14.34			7.47	24.23	14.34			7.47	24.23	14.34
p SH					0.90					0.88					0.62
Observations			17,185					17,185					17,185		
Number of individuals			4,148					4,148					4,148		

Notes: See Table 2.

Table 5: Maternal depression and child health outcomes - results from various models for B cohort

	Pooled	FE	FE-IV1	FE-IV2	FE-IV3	Pooled	FE	FE-IV1	FE-IV2	FE-IV3	Pooled	FE	FE-IV1	FE-IV2	FE-IV3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Panel A	Number of conditions					Asthma					Prescribed medicine				
Maternal depression	0.20***	0.02	-2.99	0.78	0.69	0.02*	0.00	0.23	0.11	0.12	0.02**	-0.01	1.11	0.15	0.17
	[0.02]	[0.02]	[4.89]	[0.64]	[0.63]	[0.01]	[0.01]	[0.70]	[0.14]	[0.14]	[0.01]	[0.01]	[1.77]	[0.21]	[0.21]
F test			0.57	12.60	6.36			0.64	12.95	6.54			0.56	13.04	6.57
p SH					0.18					0.85					0.33
Observations			14,446					14,360					14,431		
Number of individuals			4,127					4,106					4,126		
Panel B	Extra medical care					Height (log)					Weight (log)				
Maternal depression	0.05***	0.00	0.37	0.20	0.21	-0.00	0.00	-0.06	0.03*	0.03*	0.00	0.00	-0.17	0.03	0.03
	[0.01]	[0.01]	[0.82]	[0.18]	[0.18]	[0.00]	[0.00]	[0.11]	[0.01]	[0.01]	[0.00]	[0.00]	[0.37]	[0.06]	[0.06]
F test			0.77	13.68	6.94			0.46	12.51	6.29			0.57	12.59	6.36
p SH					0.83					0.24					0.47
Observations			14,376					14,279					14,282		
Number of individuals			4,120					4,104					4,102		
Panel C	BMI (log)					Overweight					Obesity				
Maternal depression	0.00	-0.00	-0.11	-0.02	-0.02	0.01	-0.01	-0.37	0.05	0.05	0.01	0.01	0.16	0.08	0.08
	[0.00]	[0.00]	[0.34]	[0.06]	[0.06]	[0.01]	[0.01]	[1.38]	[0.23]	[0.23]	[0.01]	[0.00]	[0.73]	[0.12]	[0.12]
F test			0.43	12.28	6.17			0.43	12.28	6.17			0.43	12.28	6.17
p SH					0.77					0.74					0.91
Observations			14,250					14,250					14,250		
Number of individuals			4,100					4,100					4,100		

Notes: See Table 2.

Table 6: Maternal K6 and child health outcomes - results from various models for B cohort

	Pooled	FE	FE-IV1	FE-IV2	FE-IV3	Pooled	FE	FE-IV1	FE-IV2	FE-IV3	Pooled	FE	FE-IV1	FE-IV2	FE-IV3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Panel A	Number of conditions					Asthma					Prescribed medicine				
Maternal K6 (rev.)	0.03***	0.01***	-0.58	0.02	0.02	0.00**	-0.00	0.02	0.02	0.02	0.00***	0.00*	0.09	0.01	0.01
	[0.00]	[0.00]	[1.23]	[0.06]	[0.06]	[0.00]	[0.00]	[0.07]	[0.02]	[0.02]	[0.00]	[0.00]	[0.27]	[0.02]	[0.02]
F test			0.30	25.74	12.91			1.29	15.85	8.02			0.28	25.64	12.86
p SH					0.28					0.91					0.73
Observations			18,436					14,295					18,421		
Number of individuals			4,349					4,097					4,348		
Panel B	Extra medical care					Height (log)					Weight (log)				
Maternal K6 (rev.)	0.01***	0.00***	0.15	0.03	0.03	-0.00	-0.00	-0.01	0.00**	0.00*	0.00	0.00	-0.10	0.01	0.01
	[0.00]	[0.00]	[0.36]	[0.02]	[0.02]	[0.00]	[0.00]	[0.01]	[0.00]	[0.00]	[0.00]	[0.00]	[0.17]	[0.01]	[0.01]
F test			0.24	25.38	12.75			0.84	15.23	7.65			0.39	25.28	12.67
p SH					0.56					0.21					0.07
Observations			18,349					14,207					17,370		
Number of individuals			4,344					4,092					4,285		
Panel C	BMI (log)					Overweight					Obesity				
Maternal K6 (rev.)	0.00*	0.00	-0.01	-0.00	-0.00	0.00	0.00	-0.03	0.01	0.01	0.00	0.00	0.01	0.01	0.01
	[0.00]	[0.00]	[0.03]	[0.01]	[0.01]	[0.00]	[0.00]	[0.14]	[0.03]	[0.03]	[0.00]	[0.00]	[0.08]	[0.02]	[0.02]
F test			0.83	14.79	7.42			0.83	14.79	7.42			0.83	14.79	7.42
p SH					0.87					0.78					0.96
Observations			14,178					14,178					14,178		
Number of individuals			4,088					4,088					4,088		

Notes: See Table 2.

Table 7: Maternal depression and child health outcomes - Intertemporal impact

	Number of conditions	Asthma	Prescribed medicine	Extra medical care	Height (log)	Weight (log)	BMI (log)	Overweight	Obesity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: K cohort									
Maternal depression 2 years ago	0.63	-0.01	0.08	0.05	-0.00	0.03	0.03	0.10	-0.06
	[0.40]	[0.06]	[0.13]	[0.11]	[0.01]	[0.04]	[0.03]	[0.14]	[0.08]
Observations	9,273	9,264	9,237	9,196	9,019	9,068	8,970	8,970	8,970
Number of individuals	3,413	3,413	3,402	3,396	3,345	3,358	3,334	3,334	3,334
F test	14.55	14.42	14.38	13.48	13.56	13.88	13.89	13.89	13.89
pSH2	0.12	0.52	0.68	0.30	0.40	0.58	0.81	0.36	0.72
Maternal depression 4 years ago	-0.03	-0.06	-0.28	0.16	0.00	-0.01	-0.01	0.07	-0.10
	[0.48]	[0.04]	[0.18]	[0.14]	[0.01]	[0.04]	[0.04]	[0.17]	[0.09]
Observations	4,942	4,926	4,910	4,866	4,704	4,754	4,652	4,652	4,652
Number of individuals	2,471	2,463	2,455	2,433	2,352	2,377	2,326	2,326	2,326
F test	8.87	8.84	8.99	8.67	8.92	9.17	9.04	9.04	9.04
pSH2	0.03	0.93	0.93	0.87	0.67	0.71	0.66	0.05	0.05
Panel B: B cohort									
Maternal depression 2 years ago	1.28	0.01	0.17	0.12	-0.00	0.01	0.02	-0.23	0.09
	[1.02]	[0.14]	[0.26]	[0.24]	[0.01]	[0.08]	[0.08]	[0.32]	[0.16]
Observations	9,808	9,782	9,785	9,756	9,675	9,659	9,653	9,653	9,653
Number of individuals	3,591	3,584	3,589	3,588	3,553	3,551	3,550	3,550	3,550
F test	3.07	3.26	3.35	3.52	3.30	3.12	3.05	3.05	3.05
pSH2	0.59	0.72	0.91	0.01	0.56	0.40	0.48	0.55	0.50
Maternal depression 4 years ago	-6.93	-0.48	-0.28	0.70	-0.08	-0.20	-0.08	-1.17	0.93
	[13.79]	[1.12]	[1.25]	[1.77]	[0.17]	[0.48]	[0.35]	[2.32]	[1.73]
Observations	5,302	5,286	5,262	5,218	5,200	5,184	5,180	5,180	5,180
Number of individuals	2,651	2,643	2,631	2,609	2,600	2,592	2,590	2,590	2,590
F test	0.14	0.12	0.22	0.16	0.12	0.16	0.16	0.16	0.16
pSH2	0.87	0.77	0.21	0.76	0.79	0.67	0.34	0.71	0.93

Notes: See Table 3.

Table 8: Heterogeneity of maternal depression effects on child health by child gender

	Number of conditions	Asthma	Prescribed medicine	Extra medical care	Height (log)	Weight (log)	BMI (log)	Overweight	Obesity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: K cohort									
Panel A1: Female	0.10	0.07	0.02	0.09	0.00	0.03	0.03	0.09	0.04
	[0.36]	[0.07]	[0.12]	[0.10]	[0.01]	[0.04]	[0.03]	[0.14]	[0.07]
Observations	6,744	6,736	6,739	6,710	6,610	6,637	6,580	6,580	6,580
Number of individuals	1,940	1,940	1,938	1,935	1,919	1,921	1,916	1,916	1,916
F test	18.25	17.93	18.23	18.15	17.53	17.46	17.57	17.57	17.57
p SH	0.80	0.65	0.48	0.88	0.85	0.70	0.80	0.99	0.80
Panel A2: Male	-0.06	0.02	0.29	0.00	0.00	0.01	-0.00	-0.25	0.16
	[0.48]	[0.10]	[0.18]	[0.17]	[0.01]	[0.05]	[0.04]	[0.18]	[0.10]
Observations	6,978	6,967	6,972	6,944	6,861	6,898	6,844	6,844	6,844
Number of individuals	2,024	2,022	2,023	2,018	2,007	2,014	2,006	2,006	2,006
F test	8.47	8.43	8.04	8.58	9.66	8.63	9.13	9.13	9.13
p SH	0.31	0.74	0.60	0.21	0.72	0.58	0.58	0.91	0.81
Panel B: B cohort									
Panel B1: Female	-0.21	0.16	0.57*	-0.11	-0.00	-0.04	-0.04	-0.19	0.06
	[0.72]	[0.15]	[0.30]	[0.20]	[0.01]	[0.07]	[0.07]	[0.29]	[0.15]
Observations	7,033	6,992	7,028	7,003	6,957	6,957	6,943	6,943	6,943
Number of individuals	2,013	2,001	2,013	2,010	1,999	1,997	1,996	1,996	1,996
F test	4.33	4.61	4.60	4.87	4.60	4.74	4.46	4.46	4.46
p SH	0.51	0.86	0.74	0.84	0.08	0.29	0.58	0.72	0.88
Panel B2: Male	1.55	0.07	-0.20	0.40	0.04*	0.05	-0.03	0.37	0.07
	[1.00]	[0.20]	[0.29]	[0.30]	[0.02]	[0.08]	[0.07]	[0.35]	[0.16]
Observations	7,411	7,366	7,401	7,371	7,320	7,323	7,305	7,305	7,305
Number of individuals	2,113	2,104	2,112	2,109	2,104	2,104	2,103	2,103	2,103
F test	3.59	3.49	3.70	3.70	3.33	3.25	3.32	3.32	3.32
p SH	0.69	0.95	0.81	0.23	0.45	0.63	0.90	0.98	0.82

Notes: See Table 3.

Table 9: Heterogeneity of maternal depression effects on child health by child age

	Number of conditions	Asthma	Prescribed medicine	Extra medical care	Height (log)	Weight (log)	BMI (log)	Overweight	Obesity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: K cohort									
Panel A1: aged 8/9	0.28	0.05	0.06	-0.06	0.01	0.06	0.04	0.17	0.03
	[0.42]	[0.14]	[0.19]	[0.17]	[0.01]	[0.04]	[0.04]	[0.21]	[0.09]
Observations	5,506	5,494	5,504	5,480	5,462	5,470	5,456	5,456	5,456
Number of individuals	2,753	2,747	2,752	2,740	2,731	2,735	2,728	2,728	2,728
F test	7.17	7.17	7.19	6.82	6.97	6.91	6.91	6.91	6.91
p SH	0.01	0.97	0.00	0.15	0.96	0.39	0.31	0.80	0.55
Panel A2: aged 10/11	0.13	0.00	0.22	0.06	0.00	0.03	0.02	0.11	0.06
	[0.38]	[0.05]	[0.13]	[0.12]	[0.01]	[0.03]	[0.03]	[0.13]	[0.06]
Observations	6,380	6,358	6,374	6,340	6,154	6,300	6,150	6,150	6,150
Number of individuals	3,190	3,179	3,187	3,170	3,077	3,150	3,075	3,075	3,075
F test	15.60	15.05	15.09	15.16	16.35	14.86	16.21	16.21	16.21
p SH	0.28	0.27	0.14	0.82	0.56	0.72	0.96	0.96	0.32
Panel A3: aged 12/13	-0.83	0.04	-0.16	-0.14	0.00	-0.01	-0.01	-0.23	0.10
	[0.63]	[0.06]	[0.20]	[0.17]	[0.01]	[0.05]	[0.05]	[0.20]	[0.10]
Observations	6,912	6,896	6,902	6,830	6,606	6,684	6,538	6,538	6,538
Number of individuals	3,456	3,448	3,451	3,415	3,303	3,342	3,269	3,269	3,269
F test	7.18	7.22	7.05	7.11	7.47	7.85	7.53	7.53	7.53
p SH	0.60	0.80	0.82	0.33	0.46	1.00	0.89	0.76	0.58
Panel B: B cohort									
Panel B1: aged 4/5	-0.48	0.64	-1.44	1.25	0.03	0.22	0.16	-0.48	0.48
	[1.97]	[0.80]	[1.69]	[1.49]	[0.06]	[0.30]	[0.26]	[1.14]	[0.75]
Observations	5,756	5,718	5,756	5,724	5,646	5,678	5,630	5,630	5,630
Number of individuals	2,878	2,859	2,878	2,862	2,823	2,839	2,815	2,815	2,815
F test	0.45	0.54	0.45	0.45	0.36	0.40	0.36	0.36	0.36
p SH	0.41	0.85	0.73	0.75	0.23	0.69	0.30	0.66	0.42
Panel B2: aged 6/7	1.15	0.13	0.43	0.19	0.01	0.01	-0.01	-0.10	0.12
	[1.06]	[0.19]	[0.37]	[0.30]	[0.02]	[0.07]	[0.07]	[0.36]	[0.19]
Observations	6,770	6,734	6,764	6,726	6,692	6,680	6,674	6,674	6,674
Number of individuals	3,385	3,367	3,382	3,363	3,346	3,340	3,337	3,337	3,337
F test	2.25	2.38	2.37	2.26	2.23	2.24	2.23	2.23	2.23
p SH	0.36	0.83	0.48	0.80	0.57	0.30	0.41	0.90	0.50
Panel B3: aged 8/9	-0.35	0.06	0.52	0.09	0.04	-0.01	-0.10	0.55	-0.21
	[1.16]	[0.10]	[0.45]	[0.29]	[0.03]	[0.09]	[0.11]	[0.54]	[0.24]
Observations	7,396	7,338	7,368	7,308	7,270	7,246	7,240	7,240	7,240
Number of individuals	3,698	3,669	3,684	3,654	3,635	3,623	3,620	3,620	3,620
F test	1.84	1.98	1.95	2.17	1.65	1.61	1.43	1.43	1.43
p SH	0.02	0.38	0.66	0.44	0.36	0.51	0.92	0.97	0.92

Notes: See Table 3.

Table 10: Heterogeneity of maternal depression effects on child health by household income

	Number of conditions	Asthma	Prescribed medicine	Extra medical care	Height (log)	Weight (log)	BMI (log)	Overweight	Obesity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: K cohort									
Panel A1: low income	-0.43	0.04	0.08	-0.05	0.01	0.05	0.02	-0.18	0.14
	[0.44]	[0.09]	[0.14]	[0.13]	[0.01]	[0.04]	[0.04]	[0.17]	[0.09]
Observations	5,589	5,582	5,585	5,549	5,491	5,519	5,474	5,474	5,474
Number of individuals	1,644	1,644	1,643	1,639	1,628	1,632	1,628	1,628	1,628
F test	10.99	10.70	10.94	11.51	11.60	10.59	11.21	11.21	11.21
p SH	0.45	0.55	0.83	0.43	0.59	0.89	0.93	0.26	0.44
Panel A2: high income	0.61	0.06	0.09	0.18	-0.01	-0.02	-0.00	0.14	0.02
	[0.44]	[0.08]	[0.16]	[0.14]	[0.01]	[0.04]	[0.04]	[0.15]	[0.07]
Observations	6,809	6,799	6,804	6,786	6,672	6,706	6,649	6,649	6,649
Number of individuals	1,923	1,922	1,922	1,918	1,904	1,908	1,901	1,901	1,901
F test	12.15	12.12	11.67	11.85	12.40	12.01	12.26	12.26	12.26
p SH	0.72	0.07	0.37	0.96	0.56	0.90	0.66	0.42	0.53
Panel B: B cohort									
Panel B1: low income	1.23	0.05	0.45	0.32	0.02	0.10	0.06	0.43	0.11
	[0.85]	[0.15]	[0.30]	[0.26]	[0.02]	[0.08]	[0.07]	[0.32]	[0.17]
Observations	6,012	5,969	6,008	5,977	5,938	5,937	5,924	5,924	5,924
Number of individuals	1,748	1,735	1,748	1,743	1,738	1,735	1,734	1,734	1,734
F test	4.00	4.19	4.12	4.21	3.90	4.00	3.87	3.87	3.87
p SH	0.77	0.96	0.51	0.23	0.60	0.79	0.86	0.60	0.74
Panel B2: high income	-0.00	0.16	-0.16	-0.02	0.03*	0.02	-0.03	-0.09	0.04
	[0.60]	[0.16]	[0.22]	[0.17]	[0.02]	[0.06]	[0.06]	[0.24]	[0.12]
Observations	7,269	7,241	7,261	7,242	7,187	7,190	7,174	7,174	7,174
Number of individuals	2,047	2,044	2,046	2,046	2,034	2,035	2,034	2,034	2,034
F test	5.74	5.94	5.84	6.09	5.61	5.72	5.57	5.57	5.57
p SH	0.13	0.82	0.21	0.67	0.27	0.93	0.50	0.19	0.67

Notes: Low (high) income if household income is below (equal or above) the median of all household income surveyed in wave 1. Other notes: see Table 3.

Table 11: Heterogeneity of maternal depression effects on child health by maternal education

	Number of conditions	Asthma	Prescribed medicine	Extra medical care	Height (log)	Weight (log)	BMI (log)	Overweight	Obesity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: K cohort									
Panel A1: low qualification	0.05	0.05	0.15	0.09	0.00	0.04	0.03	-0.14	0.16*
	[0.41]	[0.08]	[0.14]	[0.13]	[0.01]	[0.04]	[0.04]	[0.16]	[0.09]
Observations	7,575	7,565	7,568	7,530	7,421	7,466	7,398	7,398	7,398
Number of individuals	2,282	2,280	2,280	2,274	2,256	2,264	2,255	2,255	2,255
F test	13.06	12.88	12.70	12.96	13.53	12.31	12.89	12.89	12.89
pSH2	0.45	0.71	0.85	0.19	0.27	0.55	0.75	0.80	0.73
Panel A2: high qualification	0.16	0.09	0.13	0.05	0.01	0.02	0.01	0.11	0.01
	[0.38]	[0.08]	[0.14]	[0.12]	[0.01]	[0.04]	[0.03]	[0.14]	[0.05]
Observations	5,974	5,965	5,970	5,948	5,873	5,897	5,850	5,850	5,850
Number of individuals	1,711	1,710	1,710	1,705	1,694	1,699	1,691	1,691	1,691
F test	13.45	13.20	13.27	13.53	14.44	14.21	14.70	14.70	14.70
pSH2	0.57	0.49	0.10	0.86	0.09	0.53	0.97	0.98	0.49
Panel B: B cohort									
Panel B1: low qualification	0.60	0.00	0.15	0.39	0.00	0.07	0.06	0.13	0.06
	[0.78]	[0.17]	[0.28]	[0.28]	[0.02]	[0.09]	[0.08]	[0.33]	[0.20]
Observations	7,274	7,213	7,264	7,232	7,192	7,185	7,172	7,172	7,172
Number of individuals	2,166	2,150	2,165	2,160	2,151	2,150	2,147	2,147	2,147
F test	3.46	3.74	3.55	3.61	3.14	3.19	3.15	3.15	3.15
pSH2	0.67	0.98	0.78	0.18	0.99	0.75	0.69	0.68	0.39
Panel B2: high qualification	0.34	0.18	0.36	-0.15	0.02	-0.02	-0.06	0.04	-0.04
	[0.70]	[0.17]	[0.27]	[0.19]	[0.01]	[0.06]	[0.06]	[0.27]	[0.13]
Observations	7,028	7,004	7,022	7,002	6,941	6,952	6,932	6,932	6,932
Number of individuals	1,980	1,975	1,979	1,979	1,968	1,968	1,968	1,968	1,968
F test	5.19	5.58	5.30	5.73	5.09	5.23	5.02	5.02	5.02
pSH2	0.15	0.80	0.12	0.88	0.02	0.66	0.58	0.92	0.45

Notes: Low (high) qualification if maternal completed qualification is certificate or no qualification (diploma or higher). Other notes: see Table 3.

Appendix Table 1A: Variable description and summary statistics

Variables	Variable description	K cohort		B cohort	
		Mean	S.D	Mean	S.D
Maternal depression	Dummy variable: = 1 if the mother was depressed for two weeks or more in the year prior to the survey time and zero otherwise	0.30	0.46	0.28	0.45
Maternal K6 (reversed)	(Reversed) maternal K6 score with a higher score indicates a worse mental health level	9.38	3.58	9.10	3.33
Number of conditions	The number of on-going conditions the child has	0.56	0.94	0.51	0.92
Asthma	Dummy variable: = 1 if the child is diagnosed to have asthma last year and zero otherwise	0.28	0.45	0.22	0.41
Prescribed medicine	Dummy variable: = 1 if the child currently uses prescribed medicine and zero otherwise	0.14	0.35	0.13	0.33
Extra medical care	Dummy variable: = 1 if the child needs extra medical care and zero otherwise	0.10	0.30	0.09	0.28
Height (cm)	Child height (in cm)	133.50	18.54	115.88	15.60
Weight (kg)	Child weight (in kg)	33.59	14.05	20.75	8.78
BMI	Child body mass index	17.97	3.38	16.81	2.22
Overweight	Dummy variable: = 1 if the child is defined as overweight and zero otherwise	0.17	0.38	0.16	0.37
Obesity	Dummy variable: = 1 if the child is defined as obesed and zero otherwise	0.06	0.23	0.05	0.22
Child age (month)	Child age (month)	106.36	34.99	58.44	35.07
Male	Dummy variable: = 1 if the child is a male and zero otherwise	0.51	0.50	0.51	0.50
Native	Dummy variable: = 1 if the child is born in Australian and zero otherwise	0.96	0.19	1.00	0.06
Aboriginal	Dummy variable: = 1 if the child has an Aboriginal and Torres Strait Islanders origin and zero otherwise	0.02	0.15	0.03	0.17
Low birth weight	Dummy variable: = 1 if the child birth weight is 2,500g or lower and zero otherwise	0.07	0.25	0.05	0.22
Maternal age (age)	Mother's age (years)	39.10	5.76	35.60	5.85
Mother is a NESB migrant	Dummy: = 1 if mother was born in a Non-English Speaking Background (NESB) country and zero otherwise	0.20	0.40	0.20	0.40
Mother is an ESB migrant	Dummy: = 1 if mother was born in an English Speaking Background (ESB) country and zero otherwise	0.15	0.36	0.15	0.36
Mother education: Certificate	Dummy: = 1 if mother has a certificate and zero otherwise	0.29	0.46	0.28	0.45
Mother education: Diploma	Dummy: = 1 if mother has advanced diploma/diploma and zero otherwise	0.10	0.30	0.11	0.31
Mother education: Bachelor degree	Dummy: = 1 if mother has a bachelor degree and zero otherwise	0.18	0.38	0.22	0.41
Mother education: Graduate diploma/certificate	Dummy: = 1 if mother has graduate diploma/certificate and zero otherwise	0.08	0.27	0.07	0.26
Mother education: Postgraduate degree	Dummy: = 1 if mother has a postgraduate degree and zero otherwise	0.08	0.26	0.08	0.28
Number of siblings	Number of siblings	1.57	1.01	1.37	1.02
Living with both parents	Dummy variable: = 1 if the child is living with both biological parents and zero otherwise	0.81	0.39	0.87	0.33
Illness to close relative	Dummy variable: = 1 if the mother has a close relative other than parent, spouse, or child had a serious illness, injury or assault last year and zero otherwise	0.17	0.38	0.16	0.37
Death of close friend	Dummy variable: = 1 if the mother has a close family friend or another relative (aunt, cousin, grandparent) died last year and zero otherwise	0.23	0.42	0.22	0.42
Number of observations		17490		18436	

Notes: Estimated sample from the regression of the number of conditions as the child health outcome on maternal K6. Longitudinal sampling weights are used.

Appendix Table 2A: Correlation structure

	Maternal depression	Maternal K6 (reversed)	Number of conditions	Asthma	Prescribed medicine	Extra medical care	Height	Weight	BMI	Overweight	Obesity
Panel A: K cohort											
Maternal depression	1***										
Maternal K6 (reversed)	0.48***	1***									
Number of conditions	0.13***	0.13***	1***								
Asthma	0.05***	0.04***	0.14***	1***							
Prescribed medicine	0.06***	0.05***	0.23***	0.32***	1***						
Extra medical care	0.1***	0.11***	0.3***	0.11***	0.28***	1***					
Height	0.04***	-0.06***	0.09***	0.1***	0.02***		1***				
Weight	0.05***	-0.03***	0.1***	0.11***	0.03***		0.88***	1***			
BMI	0.06***		0.09***	0.1***	0.04***	0.01*	0.5***	0.83***	1***		
Overweight	0.05***		0.04***	0.03***	0.04***	0.02**	0.1***	0.26***	0.41***	1***	
Obesity		0.02***	0.04***	0.05***	0.02**	0.02***	0.08***	0.34***	0.58***	-0.11***	1***
Panel B: B cohort											
Maternal depression	1***										
Maternal K6 (reversed)	0.48***	1***									
Number of conditions	0.11***	0.12***	1***								
Asthma	0.04***	0.04***	0.15***	1***							
Prescribed medicine	0.03***	0.05***	0.23***	0.38***	1***						
Extra medical care	0.09***	0.1***	0.32***	0.13***	0.26***	1***					
Height	0.04***		0.1***	0.13***	0.02**	0.05***	1***				
Weight	0.04***	-0.02**	0.14***	0.13***	0.03***	0.07***	0.88***	1***			
BMI	0.02***	0.03***	0.07***	0.07***	0.04***	0.02***	0.18***	0.61***	1***		
Overweight	0.02**	0.02***	0.02***	0.02**				0.19***	0.42***	0.02**	
Obesity	0.03***	0.03***	0.05***	0.06***	0.03***	0.03***	0.07***	0.35***	0.63***	0.03***	***

Notes: Estimated sample from the regression of the number of conditions as the child health outcome on maternal K6. Only correlation with statistical significance level of 10 % or higher is listed. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Appendix Table 3A: First-stage equation and instrumental variable validation models

	Maternal depression			Maternal BMI			Maternal general health		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Death of close friend	0.05***		0.05***	0.01		0.02	0.00		0.01
	(0.01)		(0.01)	(0.05)		(0.05)	(0.02)		(0.02)
Illness to close relative		0.06***	0.06***		-0.07	-0.07		-0.03	-0.03
		(0.01)	(0.01)		(0.06)	(0.06)		(0.02)	(0.02)
Observations	13,722	13,722	13,722	13,061	13,061	13,061	13,717	13,717	13,717
Number of individuals	3,964	3,964	3,964	3,937	3,937	3,937	3,964	3,964	3,964
F-test	28.39	24.74	24.76	0.04	1.29	0.72	0.08	2.31	1.28
Prob > F	0.00	0.00	0.00	0.84	0.26	0.49	0.78	0.13	0.28

Notes: Results are from the regression (2) using the estimated sample of the number of conditions as the child health outcome and K cohort. The F-statistic is from a test of the null hypothesis that the coefficient(s) of instrument(s) equals zero. Other explanatory variables include the child's characteristics (age, number of siblings, and living with both parents), mother' characteristics (age and education), local socio-economic background variables, state/territory dummies, year dummies, and survey quarters. Robust standard errors clustered at the individual level in parentheses. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

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