Parental Migration and Early Childhood Development in Rural China

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Abstract

Nearly one-quarter of all children under age 2 in China are left behind in the countryside as parents migrate to urban areas for work. We use a four-wave longitudinal survey following young children from 6 to 30 months of age to provide first evidence on the effects of parental migration on development, health, and nutritional outcomes in the critical first stages of life. We find that maternal migration has a negative effect on cognitive development: migration before children reach 12 months of age reduces cognitive development by 0.3 standard deviations at age 2. Possible mechanisms include reduced dietary diversity and engagement in stimulating activities, both known to be causally associated with skill development in early life. We find no effects on other dimensions of physical and social-emotional health.

Keywords Early childhood development · Migration · Left-behind children · China

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Introduction

The largest movement of people in modern history has occurred over the last several decades in China, as rural residents migrate to urban areas in search of off-farm work (Chan 2008). When parents migrate, they commonly leave children in the care of family members in their home communities. Several factors contribute to this phenomenon, including restricted access to public services for migrants in urban areas (All China Women's Federation 2013). As of 2010, there were approximately 61 million "left-behind" children in China (UNICEF et al. 2014).

In this study, we examine the effects of maternal migration on early childhood development outcomes. Approximately 11.7 million left-behind children are under age 2, accounting for more than one-quarter of all 0- to 2-year-olds in China (UNICEF et al. 2014). Parental migration during this time could be particularly consequential because early childhood is thought to be a critical period affecting human capital accumulation throughout life (Knudsen et al. 2006). Research on child nutrition emphasizes the importance of the "first 1,000 days," with some studies suggesting that nutritional insults in this period are difficult to reverse (Hoddinott et al. 2008; Maluccio et al. 2009; Martorell et al. 1994; Victora et al. 2008). Long-term follow-ups of experiments increasing investments in the nutrition/health and stimulation of children have shown positive consequences for later-life outcomes, including educational attainment, earnings, and adult health (Campbell et al. 2014; Heckman 2006; Hoddinott et al. 2008; Maluccio et al. 2009; Schweinhart et al. 2005; Victora et al. 2008).

We use a unique panel data set of young Chinese children/caregivers to estimate the causal effects of maternal out-migration during this critical period on development, health, and nutrition outcomes of left-behind children. Outcomes were measured at six-month intervals during the first two years after childbirth, a period during which a large fraction of Chinese mothers migrate to cities in search of work, leaving children in care of family members. We address endogeneity using a difference-in-difference/two-way fixed-effects approach across the four survey rounds. We then attempt to demonstrate the credibility of this identification strategy through a series of robustness checks.

A priori, the effect of parental migration on early childhood outcomes is not clear. Whether parental migration helps or harms the outcomes of children left behind depends on the balance of the (likely positive) effects of increased income against the (likely negative) effects of parental absence (Antman 2012). Although parental migration will presumably lead to an increase in household income and resources available to invest in children, parental absence could adversely affect children depending on how the time, attention, and decision-making of remaining caregivers substitutes for that of the migrating parent. The net effect of parental migration, therefore, depends on how any resulting increase in investments affects child outcomes and the degree to which these effects are counteracted by the effects of the absence of migrating parents.

There are reasons to believe that the influence of parental absence is more likely to outweigh income effects for the very young relative to older children. Meeting the material needs of young children is relatively inexpensive (at least in the Chinese context) compared with older children. Even in poor areas of China, the cost of providing goods necessary for a healthy and stimulating environment are well within the means of most households, particularly given low fertility rates (of around 1.6

births/woman; United Nations 2019). At the same time, parental absence during early childhood may have large negative and long-term effects. Studies from different disciplines have suggested that maternal absence—specifically, during early childhood—can be detrimental to development outcomes. Research in neuroscience has shown that maternal support in early childhood (but not later in childhood) is strongly associated with the development of the hippocampus—the region of the brain thought to be integral to memory, learning, and emotion—into adolescence (Luby et al. 2012, 2016).[1] Social science research in developed countries has also shown early childhood to be a sensitive period for the effect of maternal-child separation. These studies have shown that maternal-child separation due to employment during the first year of a child's life has negative effects on developmental and later schooling outcomes, but maternal employment has more mixed effects thereafter (Baum 2003; Ermisch and Francesconi 2013; Han et al. 2001; James-Burdumy 2005; Waldfogel et al. 2002).

In addition to the likely importance of maternal support during early childhood, examining the effect of the migration of mothers is important for two other reasons. First, in China and internationally, the share of female migrants is increasing, as is the fraction of migrant mothers (Connelly et al. 2012; Cortes 2015; de Brauw et al. 2008; Mu and de Brauw 2015). Second, maternal migration is likely to accompany significant changes in caregiving practices and investments. Given that the mother is often the second parent to migrate, primary caregiving falls to other remaining family members (in China, typically paternal grandmothers) and likely represents a large shift in parenting practice as a result (Wang and Mesman 2015). Caregivers who remain may have different preferences from parents that affect how the household budget is allocated and what material investments are made in children.[2] They may invest less time engaging in stimulating activities with children and be less knowledgeable of or less attentive to the nutritional and health needs of children (Tan et al. 2010). Maternal migration thus is increasingly common and likely represents a large shift in caregiving practices that could have large effects on the cognitive, physical, and emotional development of young children.

We find that maternal out-migration has significant negative effects on cognitive development for young children in rural China. Migration during the earliest period (when children are younger than 15 months) is estimated to reduce cognitive scores at age 2 by 0.3 standard deviations (SD), an effect on par with recent evaluations of intensive parenting interventions in Colombia and China. These effects are mirrored by decreases in caregiver time engaged in stimulating activities as well as reduced dietary quality. We do not find significant effects of maternal migration on psychomotor development, social-emotional development, anemia, or the frequency of illness.

[1] This finding for human children echoes numerous studies using rodents showing that early maternal care has a large effect on hippocampal development in rat pups and that this operates through an epigenetic mechanism (Fish et al. 2004; Liu et al. 1997; Meaney 2001; Szyf et al. 2005).

[2] Divergent preferences, particularly with the older generation, may include increased preference toward male children. Meyerhoefer and Chen (2011) found that parental labor migration in China is associated with a significant lag in the educational progress of girls and argued that this is due to shifting girls' time allocation toward home production. Chang et al. (2011) also showed that migration in China increases work time for girls and not boys.

Our findings are consistent with the influence of parental absence outweighing income effects in this context. For young children in rural China, income effects may be limited given that important material inputs are inexpensive relative to wealth. For instance, few households currently face poverty severe enough to prevent them from meeting children's caloric needs (Luo et al. 2015). Parental absence appears to play a relatively more important role: because mothers are most often the second parent to migrate, maternal migration can represent a large shift in parenting practice as primary caregiving typically falls to grandparents (Tan et al. 2010). Divergent preferences and beliefs of parents and grandparents regarding child-rearing may explain the negative effects we find on caregiver time invested in stimulating activities and dietary diversity, both of which are known to be important for cognitive development in early life (Aboud et al. 2013; Luo et al. 2015, 2017; Martorell 1997).

Our study contributes to the literature on the effects of parental migration on left-behind children in China and elsewhere. In China, this literature has focused on school-aged children, showing mixed effects on schooling/health outcomes (see Chen et al. 2009; de Brauw and Giles 2017; Hu 2012; Meyerhoefer and Chen 2011; Zhang et al. 2014). Notable exceptions to this focus on school-aged children include de Brauw and Mu (2011) and Mu and de Brauw (2015), who studied the effects of parental migration on the nutritional status of young left-behind 2- to 7-year-olds. After addressing the endogeneity of migration decisions, they found no effect on height but an increase in weight-for-age by 0.19 SD. Using data from the same survey, Li et al. (2015) also found that parental migration increases the probability of illness for 0- to 6-year-olds. Finally, although they did not focus explicitly on young children, Meng and Yamauchi (2017) examined the cumulative impact of parental migration on education and health among 0- to 15-year-olds. Using data from the RUMiC survey (a national longitudinal survey of China's rural migration population), they showed that when the entire history of migration is accounted for, leaving children behind has significant negative impacts on a number of different outcome variables.

Outside China, several studies have estimated the effect of parental migration on young children left behind. Macours and Vakis (2010) estimated the effect of seasonal migration on early childhood outcomes in rural Nicaragua. They found that shock-driven migration of mothers has a positive effect on cognitive development for children aged 3 to 7. Hildebrandt and McKenzie (2005) looked at how the migration experience of Mexican nationals to the United States by at least one adult family member affects infant mortality and birthweight. Finally, Schmeer (2009), also looking at the case of Mexico, examined the impact of father's migration on child illness.

Our study adds to this literature in three ways. First, to our knowledge, this is the first study in or outside China to estimate the effects of parental migration on cognitive, psychomotor, and social-emotional development during the first two years of life. Second, our data set includes an unusually rich set of early childhood development, nutritional, and health outcomes, allowing us to estimate effects across multiple domains. Finally, multiple rounds of data collection covering children from 6 to 30 months of age allow us to estimate the effects of migration during different stages of early childhood.

Data, Variables, and Empirical Strategy

Sampling and Data Collection

The data used in this study come from a survey of children and households conducted by the authors in 11 nationally designated poverty counties located in southern Shaanxi Province. Shaanxi is a relatively poor province located in Western China, ranking 19 of 31 provinces nationally in terms of GDP per capita with a per capita income of 6,503 yuan ($1,032 USD) in 2013 (National Bureau of Statistics 2014). In terms of rates of migration and percentage of left-behind children, this region is comparable to other rural areas in northwest China (Duan et al. 2013).

To choose households, we followed a multistage cluster sampling design. From each of the 11 counties, we included all townships (the administrative level between county and village) in the sampling frame. In each of the 174 townships included, we then randomly selected two villages. In these villages, we obtained a list of all registered births over the past 12 months. Our baseline sample consists of 1,834 children and their caregivers.

Following an initial baseline survey wave in 2013, we conducted three follow-up surveys at six-month intervals until 2015. Surveys were conducted when children were 6–12 months old, 12–18 months old, 18–24 months old, and 24–30 months old. In each wave of the survey, trained enumerators collected detailed information on characteristics of the child and household, indicators of child development and health/nutrition status, and information on parenting and feeding practices. In the first round, 1,802 children and their caregivers were successfully interviewed; the numbers for subsequent rounds were 1,592 in the second, 1,585 in the third, and 1,490 in the fourth. Of those not surveyed, 32 refused participation in the first round; 15, in the second; 19, in the third; and 22, in the fourth.

Early Childhood Development, Nutrition, and Health Outcomes

A strength of the data set for the purposes of this study is the extensive information collected on various dimensions of child development, nutrition, and health. In each survey round, we collected information on cognitive, psychomotor, and social-emotional development; anthropometric measurements; and child illnesses. In each survey round, we also asked about outcomes related to parenting and feeding practices.

Cognitive and psychomotor development are assessed using the Bayley Scales of Infant Development (BSID-I), which is considered the gold standard for assessing infant and toddler development and is used extensively in the psychological and health literature (Rubio-Codina et al. 2016). The BSID-I was formally adapted to the Chinese language and environment and was scaled according to an urban Chinese sample (Yi et al. 1993). The BSID-I was administered by trained testers who underwent a formal weeklong course, including 2.5 days of field training. The test yields two indices: (1) a mental development index (MDI), which measures memory, habitation, problem solving, early number concepts, generalization, classification, vocalizations, and language; and (2) a psychomotor development index (PDI), which measures fine and gross motor skills. Both indices are scaled relative to the distribution of scores in the Chinese reference population. Children are considered delayed with scaled index values less than 80.

As a measure of social-emotional development, we use the social-emotional module of the Ages and Stages Questionnaire (ASQ:SE), an instrument administered to caregivers to screen for social-emotional delay. It consists of a series of age-appropriate questions about child behavior and caregiver-child interactions. Based on caregiver responses to these questions, the ASQ:SE indicates children at risk of social-emotional delay. In the analysis, we generate a dummy variable equal to 1 if a child is deemed at risk in a given survey wave, and 0 if not.

Direct measures of nutritional status were also obtained in each survey wave. To assess anemia status, nurses from Xi'an Jiaotong Medical School collected hemoglobin concentrations from all children using a HemoCue Hb 201+ finger prick system (Hemocue, Inc, Ängelholm, Sweden). The World Health Organization (WHO) considers children in our age range to be anemic if their hemoglobin concentration is less than 110 g/L (WHO 2011). Nurses also recorded the length/height and weight of children in each survey round, which we use to construct three standardized indicators using WHO growth charts (WHO 2009): length/height-for-age z scores (HAZ), weight-for-age z scores (WAZ), and weight-for-height z scores (WHZ). HAZ are thought to measure cumulative nutritional investments and illnesses over time and are known to be particularly sensitive to insults when children are under 2 years of age (Schroeder et al. 1995; WHO 1983). WAZ and WHZ, in contrast, are thought to be more sensitive to immediate changes in diet.

As indicators of general health, we use caregiver responses to questions about recent episodes of illness. In each survey round, caregivers were asked whether children had been ill with diarrhea, fever, cold, cough, or indigestion in the past month.

Finally, surveys collected information on intermediate outcomes related to parenting and feeding practices. We asked caregivers about time spent with their children in specific activities over the past 24 hours, including playing, telling stories, reading, and singing. For feeding practices, we construct measures based on breastfeeding; formula feeding; feeding solid foods; and, given the high burden of iron deficiency in the area, feeding iron supplements. For each wave, we construct measures based on the Indicators of Infant and Young Child Feeding (IYCF; WHO 2010).

Maternal Migration in Early Childhood

In each survey round, we asked whether the child's mother was living at home and, if not, when she left. We consider a mother to have migrated if, at the time of each survey round, she had been gone for more than three months since the previous survey round. Note that this definition does not distinguish maternal absence for work from absence for other reasons. Only 2.1% of mothers were absent for nonwork reasons.[3]

Figure 1 illustrates the pattern of maternal migration that we observe in our sample. For each of the four survey waves, we plot the fraction of children whose primary caregiver was the child's mother, the child's grandmother, or someone else. Over this short period, the fraction of children whose primary caregiver was the mother fell by 27% (from 82% to

[3] We are unfortunately unable to examine paternal migration because our survey did not collect data on paternal migration over time. In our survey, we collected data about the first and second caregivers, who were almost always the mother and grandmother. The share of fathers who are primary caregivers is less than 2.89% in our sample. In the first survey round (when children were 6–12 months of age), 54% of fathers were absent.

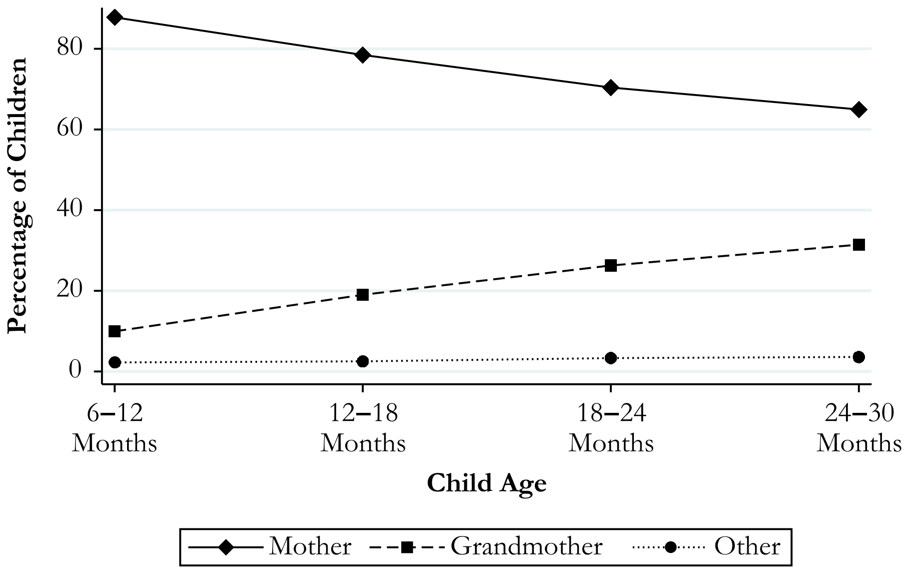

Fig. 1 Primary caregiver by child age. *Source:* Authors' data.

60%). By the time children in our sample reached 24–30 months of age, 26% had been left behind with family members when their mothers migrated for work.

Descriptive Analysis of Maternal Migration and Early Childhood Outcomes

We present descriptive statistics to characterize maternal migration during early childhood. Table 1 compares characteristics of children/households in which mothers did not migrate at any point during the survey and those in which the mothers did (when children were 6–12 months old).

Three results here are particularly informative of the context. First, at baseline, a large fraction of children in our sample are delayed and malnourished. Among 6- to 12-month-olds, 14% are cognitively delayed (MDI < 80), and 24% are delayed in their psychomotor development (PDI < 80). Almost 40% of children are at risk of social-emotional delay. More than one-half of children are anemic. These statistics hold for children in both migrant and nonmigrant households.

Second, we find evidence of positive selection of mothers into migration in terms of child outcomes. Children whose mothers later migrated had higher MDI scores, higher hemoglobin concentrations, and higher HAZ and WAZ initially compared to children whose mothers never migrate. There is also evidence of positive selection in terms of parent and household characteristics: parents in migrant households are more educated and wealthier (more household assets and less likely to receive welfare support).

Finally, Table 1 shows the main correlates of maternal migration during early childhood. First, children of migrants are less likely to have an older sibling. Only 8% of migrant households have an older child, compared with 26% of nonmigrant households. Second, mothers are more likely to migrate if their husbands have already migrated at baseline. Third, paternal grandmothers of left-behind children tend to be healthier and more educated. This likely reflects the fact that mothers may be more

Table 1 Summary statistics of child and household characteristics when children were aged 6–12 months

	Full Sample (1)	Nonmigrant Mother (2)	Migrant Mother (3)	Difference: (2) – (3) *p* Value (4)
A. Development Outcomes				
1. Bayley mental development index (MDI)	96.673 (16.891)	96.295 (16.959)	98.042 (16.597)	.093
2. Cognitively delayed (Bayley MDI < 80)	0.139 (0.346)	0.148 (0.355)	0.110 (0.313)	.077
3. Bayley psychomotor development index (PDI)	89.981 (17.365)	89.923 (17.494)	90.190 (16.914)	.803
4. Psychomotor development (Bayley PDI < 80)	0.240 (0.427)	0.242 (0.428)	0.231 (0.422)	.694
5. Social-emotional delay (1 = yes; 0 = no)	0.392 (0.488)	0.384 (0.487)	0.421 (0.495)	.213
B. Health Outcomes				
6. Hemoglobin concentration (g/L)	108.761 (12.669)	108.479 (12.878)	109.779 (11.849)	.097
7. Anemic (Hb below 110 g/L)	0.505 (0.500)	0.513 (0.500)	0.478 (0.500)	.254
8. Weight-for-age *z* score	0.349 (0.994)	0.323 (1.016)	0.446 (0.905)	.045
9. Height-for-age *z* score	0.103 (1.180)	0.075 (1.182)	0.205 (1.169)	.074
10. Weight-for-height *z* score	0.361 (1.144)	0.346 (1.166)	0.415 (1.062)	.326
11. Times ill in past month	1.078 (0.025)	1.084 (0.029)	1.060 (0.050)	.691
C. Child characteristics				
12. Age of child (months)	8.912 (1.855)	8.856 (1.863)	9.113 (1.816)	.025
13. Female	0.469 (0.499)	0.471 (0.499)	0.463 (0.499)	.785
4. Premature birth	0.111 (0.320)	0.116 (0.327)	0.095 (0.294)	.296
15. Has sibling	0.224 (0.417)	0.263 (0.441)	0.083 (0.276)	.000
D. Household Characteristics				
16. Age of mother above 25	0.520 (0.500)	0.564 (0.496)	0.359 (0.480)	.000
17. Mother completed junior high	0.171 (0.377)	0.157 (0.364)	0.223 (0.417)	.005
18. Father completed junior high	0.058 (0.233)	0.045 (0.208)	0.104 (0.306)	.000
19. Father at home	0.460 (0.499)	0.499 (0.500)	0.318 (0.466)	.000
20. Grandmother healthy	0.409 (0.492)	0.379 (0.485)	0.519 (0.500)	.000

Table 1 (continued)

	Full Sample (1)	Nonmigrant Mother (2)	Migrant Mother (3)	Difference: (2) – (3) *p* Value (4)
21. Grandmother completed primary school	0.160 (0.367)	0.120 (0.326)	0.303 (0.460)	.000
22. Asset index	–0.011 (1.191)	–0.044 (1.175)	0.108 (1.240)	.038
23. Household receives social security support under *dibao*	0.242 (0.429)	0.260 (0.439)	0.178 (0.383)	.002

Notes: Standard deviations are shown in parentheses. Column 1 shows the mean of each characteristic for the full sample; column 2 shows statistics for children and households where the mother did not migrate during the study period; column 3 shows statistics for children and households where the mother migrated at some point before children are 30–36 months of age. Social-emotional delay is determined using the Ages and Stages Questionnaire: Social-Emotional (ASQ:SE). Father at home is equal to 1 if the father has been at home for a majority of the past 6 months at the time of the baseline survey, and 0 otherwise. Whether the grandmother is healthy is based on self-reported general health. The asset index is constructed using polychoric principal components on the following variables: tap water, toilet, water heater, washing machine, computer, Internet, refrigerator, air conditioner, motor or electric bicycle, and car.

Source: Authors' survey.

likely to migrate if they believe grandmothers are better able to provide childcare. In section I of the online appendix, we further analyze the correlates of maternal out-migration in a multivariate framework and find the results mostly consistent, although there is no significant association between baseline child outcomes and later maternal migration once other household characteristics are controlled for.

Empirical Strategy

A concern when estimating the effects of maternal migration on child outcomes is the endogeneity of the migration decision. That is, there may be unobserved factors that are correlated with both the migration of mothers and child outcomes. Reverse causality is another possibility: mothers may be less likely to migrate if they feel that their children are unhealthy or lagging in their development. Although we find no indication that maternal migration is correlated with baseline child outcomes after controlling for other observable characteristics, maternal perceptions may not be fully captured by these outcome measures.

Our main approach to estimate the effects of maternal migration is to take advantage of the longitudinal nature of our data set and use a difference-in-difference/child fixed-effects specification to account for time-invariant observed and unobserved confounding factors. Accordingly, our identification strategy relies on the assumption that trends in the outcomes for children whose mothers do and do not migrate would be the same absent maternal migration. We test this assumption and other threats to credible identification.

To implement this approach, we estimate variants of the following regression:

$$Outcome_{it} = \alpha + \beta_1 MigrantMother_{it} + \beta_2 \mathbf{X}_{it} + \eta_i + w_t + s_{it} + \varepsilon_{it}, \qquad (1)$$

where $Outcome_{it}$ is the outcome for child i in survey wave t; $MigrantMother_{it}$ is a dummy variable equal to 1 if the mother of child i migrated in the period preceding survey wave t; $\mathbf{X}_{it}$ is a vector of control variables; η_i is a fixed effect for child i; w_t are survey wave indicators; s_{it} are enumerator effects designed to capture measurement error; and ε_{it} is an error term. In our primary specification using two-way fixed effects (child and time fixed effects), $\mathbf{X}_{it}$ includes a cubic function of child age meant to capture nonlinearities in development at early ages (in practice, this has little effect on estimates). Although recruitment took place in two rounds, data are constructed so that timing corresponds to child age. Regardless of cohort, children are 6–12 months in the first period, 12–18 months in the second, and so on. Standard errors are clustered at the village level, thus accounting for correlation within villages as well as serial correlation over time (Bertrand et al. 2004). To simplify interpretation, the main analysis excludes 245 children whose mothers were initially absent and returned later in the study period so that the estimated effect is that of out-migration. The main results are not significantly different including return migrants in the analysis sample.

In addition to this main specification, we also estimate other models for comparison that exclude child fixed effects and vary controls included in $\mathbf{X}_{it}$. We estimate one model with no additional controls (i.e., controlling only for survey wave) and another model with controls for the following: observed child, caregiver, and household characteristics at baseline, including a cubic function of child age, child gender, whether the child was premature, whether the child has siblings, maternal age and education, paternal education, whether the father was at home in the initial survey wave, health status of the child's paternal grandmother, the educational attainment of the child's paternal grandmother, a household durable goods asset index, whether the household receives support under *dibao* (China's minimum living standards guarantee program), a dummy variable for recruitment cohort, and BSID-I tester or nurse fixed effects depending on the outcome variable (designed to capture measurement error).

To account for the fact that we estimate the effect of maternal migration on several outcomes, we base inference on p-values adjusted for multiple hypothesis testing using the step-down procedure of Romano and Wolf (2005). We adjust separately across all nine primary outcomes in the main analysis and across the eight intermediate outcomes using 500 bootstrap repetitions.

Results

Primary Results

The primary results for the impact of maternal migration on early childhood outcomes are shown in Table 2. For each outcome, we report the coefficient and standard error on the variable indicating maternal migration estimated using three variants of Eq. (1). Column 1 shows estimates from ordinary least squares (OLS) regressions controlling only for survey wave and cohort fixed effects; column 2 further controls for additional child and household covariates and enumerator fixed effects; and column 3 includes child fixed effects, wave fixed effects, and a cubic function of child age.

In the first column of OLS correlation results, we see evidence of positive selection into migration in terms of child health outcomes. The coefficient on maternal migration is positive and significant for Hb concentration, anemia reduction, WAZ, HAZ, and

Table 2 Effect of maternal migration on early childhood outcomes

Outcome	Pooled OLS (1)	Pooled OLS With Controls (2)	Two-Way Fixed Effects (3)
1. Bayley Mental Development Index (MDI)	–1.023 (1.039)	–2.308* (0.971)	–2.569* (1.100)
N	5,395	5,393	5,393
2. Bayley Mental Development Delay (MDI < 80)	0.015 (0.023)	0.033 (0.022)	0.082** (0.027)
N	5,395	5,393	5,393
3. Bayley Psychomotor Development Index (PDI)	1.117 (0.981)	0.646 (0.985)	1.477 (1.252)
N	5,377	5,374	5,374
4. Bayley Psychomotor Development Delay (MDI < 80)	–0.009 (0.016)	–0.006 (0.018)	–0.025 (0.025)
N	5,377	5,374	5,374
5. Social-Emotional Delay (1 = yes; 0 = no)	–0.002 (0.023)	–0.000 (0.021)	–0.020 (0.032)
N	5,517	5,415	5,415
6. Hemoglobin Concentration (g/L)	1.440* (0.646)	0.567 (0.605)	–0.726 (0.801)
N	5,284	5,283	5,283
7. Anemic (Hb below 110 g/L)	–0.033† (0.018)	–0.012 (0.018)	0.017 (0.030)
N	5,284	5,283	5,283
8. Weight-for-Age *z* Score	0.192*** (0.055)	0.162*** (0.053)	0.020 (0.030)
N	5,349	5,349	5,349
9. Height-for-Age *z* Score	0.162* (0.066)	0.109 (0.066)	–0.095 (0.048)
N	5,352	5,352	5,352
10. Weight-for-Height *z* Score	0.135* (0.054)	0.139** (0.054)	0.106 (0.055)
N	5,369	5,369	5,369
11. Times Ill in Past Month	–0.045 (0.047)	–0.030 (0.046)	–0.031 (0.059)
N	5,406	5,406	5,406
12. Wave Fixed Effects	✓	✓	✓
13. Controls		✓	✓
14. Child Fixed Effects			✓

Notes: The table shows coefficients and standard errors on a variable indicating maternal absence for a majority of the previous six months in regressions with development and health outcomes at left as dependent variables. Column 1 shows the coefficients on maternal migration in an OLS regression pooling data across waves, controlling for survey wave dummy variables. Column 2 shows coefficients from pooled OLS regressions additionally controlling for baseline controls (cubic term for child age, gender, whether the child was premature, whether the child has siblings, maternal age, maternal education level, paternal education level, paternal migration status, health of the child's grandmother, the education level of the child's grandmother, asset index, and whether the household receives social security support under *dibao*). Column 3 controls for child fixed effects, survey wave fixed effects, and child age. All regressions with Bayley MDI and PDI as dependent variables additionally control for tester fixed effects and regressions, with health and nutrition outcomes as dependent variables additionally controlling for nurse fixed effects. Standard errors, shown in parentheses, are clustered at the village level. *N* is the total number of observations in each regression. We calculate significance levels after adjusting for multiple hypotheses using the step-down procedure of Romano and Wolf (2005) to control the familywise error rate (FWER).

Source: Authors' survey.

†$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$

WHZ. Once additional child and household characteristics are controlled, most of these positive correlations survive, although the coefficients on HAZ and the hemoglobin-based outcomes become insignificant. The estimated effect of maternal migration on cognitive development (MDI), on the other hand, becomes significantly negative. These estimates, however, are still potentially biased because they may fail to account for important sources of endogeneity.

Our main estimates using child fixed effects are shown in column 4. Once time-invariant heterogeneity is accounted for, only the effect of maternal migration on cognitive development, as measured by the MDI subindex of the BSID-I, is statistically significant after we adjust for multiple outcomes. We estimate that, on average, maternal migration is associated with a 2.57 point (0.15 SD) reduction in MDI scores. Moreover, we find that maternal migration increases the probability of cognitive delay (defined as MDI scores less than 80) by 8.2 percentage points ($p < .01$).

We find no significant effects on psychomotor development, the probability of social-emotional delay, anemia, WAZ, or the frequency of illness. There is some indication of effects on linear growth and WHZ—small negative effects on HAZ of 0.095 SD and positive effects of about the same magnitude on WHZ (0.101 SD)—but these are insignificant based on a 10% significance threshold after we adjust for multiple hypotheses.

Robustness Checks

There are three main threats to the validity of our results. The first is that although child fixed effects account for time-invariant unobserved heterogeneity, there may remain *time-variant* unobserved heterogeneity that biases our estimates. In other words, our estimates rely on the assumption that the outcomes of children whose mothers migrate in each period would have followed a trend similar to those whose mothers do not migrate (a so-called parallel trend assumption). To explore the plausibility of the parallel trend assumption, we compare the trends in each of our outcome variables between children with migrating and nonmigrating mothers in the periods before actual migration took place. We do this by reestimating Eq. (1), adding an indicator for maternal migration in the wave subsequent to actual migration:

$$y_{it} = \alpha + \beta_1 MigrantMother_{i(t+1)} + \beta_2 MigrantMother_{it} + \beta_2 \mathbf{X}_{it} + \eta_i + w_t + s_{it} + \varepsilon_{it}. \quad (2)$$

In this regression, β_1 tests for differences in trends subsequent to treatment. Effectively this simultaneously compares (a) the Wave 1 to 2 trend between children whose mothers migrated in Wave 3 with those whose mothers never migrate or migrate in Wave 4, and (b) the Wave 2 to 3 trend between children whose mothers who migrated in Wave 4 with those whose mothers never migrated.

The results are shown in Table 3. For a more stringent test of parallel pre-trends, inference is not adjusted for multiple hypotheses as it is in the main analysis. For each outcome, pre-migration trends are similar for both types of children, as indicated by the statistically insignificant coefficients on the lead in maternal migration, $MigrantMother_{i(t+1)}$ (row 1 of the table). These findings also provide some support for the argument that reverse causality and time omitted variable bias are unlikely to bias the main results.

Table 3 Tests for parallel pre-trends

	Bayley MDI	Bayley Mental Development Delay (MDI < 80)	Bayley PDI	Bayley Psychomotor Development Delay (PDI < 80)	Social-Emotional Delay (1 = yes)	Hb (g/L)	Anemic	WAZ	HAZ	WHZ	Times Ill in Past Month
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1. $\text{MigrantMother}_{i(t+1)}$	–0.133	–0.026	–2.670	0.052	–0.018	0.541	–0.061	–0.023	0.113	–0.117	–0.035
	(1.590)	(0.040)	(1.833)	(0.035)	(0.048)	(0.954)	(0.040)	(0.039)	(0.075)	(0.075)	(0.078)
2. $\text{MigrantMother}_{it}$	–2.948*	0.099*	2.904†	–0.046	–0.013	–0.572	–0.015	0.034	–0.122†	0.136†	–0.053
	(1.483)	(0.040)	(1.725)	(0.039)	(0.045)	(1.138)	(0.041)	(0.041)	(0.070)	(0.076)	(0.087)
3. *N*	4,101	4,101	4,090	4,090	4,108	4,038	4,038	4,069	4,071	4,085	4,106

Notes: In regressions where the dependent variable is Bayley MDI or PDI, controls for Bayley tester are also included. Regressions for hemoglobin (Hb), anemia, weight-for-age *z* score (WAZ), height-for-age *z* score (HAZ), and weight-for-height *z* score (WHZ) additionally control for administering nurses. Robust standard errors, shown in parentheses, are clustered at the village level. *N* is the total number of observations in each regression. Significance levels are not adjusted for multiple hypothesis testing.

Source: Authors' survey.

† $p < .10$; * $p < .05$

The coefficients on the true *MigrantMother*$_{it}$ variable are similar to those in our basic analysis, showing the impact of mother migration on the key outcome variables. They differ slightly from the original results, however, because of the difference in survey waves used in the regressions. Although this is not a direct test of the parallel trend assumption, the lack of differences in trends prior to actual migration increases confidence that the parallel trend assumption is valid.

A second threat to the validity of our estimates comes from the potential endogeneity of maternal migration and attrition over time. In total, 30% of the children sampled in the baseline survey wave attrited from the sample at some point during the study, and 16% attrited and were not recaptured in subsequent rounds (which means that 14% of the children in the sample were recaptured in later waves of the survey). Although attrition is relatively low, differential attrition may bias estimates if it is systematically correlated with maternal migration and child outcomes. In section II of the online appendix, we show that despite differences between those who attrited and those who did not, these observed differences appear unlikely to influence estimates for the impact of migration.

A third threat concerns the definition of maternal migration. Following previous literature, we consider a mother to have migrated if she was absent for more than half of the six months preceding the survey. However, this definition may fail to adequately capture migration behavior. In section III of the online appendix, we show robustness of our primary results to alternative definitions of maternal migration using 25% and 75% of the preceding period. In our analysis sample (excluding returnees), 25.9% of mothers had migrated by Wave 4 of the survey (when children were 24–30 months of age) when migration is defined as the mother being gone more than 50% of the preceding period. When migration was measured using cutoffs of 75% and 25%, 22.5% and 27.0% of mothers had migrated.

Intermediate Outcomes

Table 4 shows two-way fixed-effects estimates of the impact of maternal migration on intermediate outcomes. Panel A shows effects on parenting practices; panel B shows effects on feeding behavior. Significance is based on *p*-values adjusted for multiple hypotheses.

We find that a child's mother migrating leads to a reduction in caregiver time engaged in stimulating activities with children. We find an 8% reduction in the number of caregivers reporting that they used toys to play with the child in the previous day. We also find a 10% reduction in caregivers reporting that they sang songs to children the previous day. These estimates imply that reduced caregiver engagement in stimulating activities with the child may contribute to our findings of negative effects of maternal migration on cognition scores.

In panel B of Table 4, we see that maternal migration has clear negative effects on nutritional quality. We find no distinguishable effects on meal frequency (a measure of quantity), but we do find significant negative effects on the dietary diversity index and on the feeding of iron-rich foods and foods that promote iron absorption (meat, green leafy vegetables, iron supplements, and fruit). Previous studies have also noted large differences in nutritional knowledge between parents and grandparents in rural China, particularly regarding micronutrient needs for young children (Tan et al. 2010).

Table 4 Fixed-effect estimates for the effect of maternal migration on intermediate outcomes

	Used Toys to Play With Baby Yesterday	Told Stories to Baby Yesterday	Read to Baby Yesterday	Sang to Baby Yesterday
	(1)	(2)	(3)	(4)
A. Stimulation				
Migrant mother	–0.080* (0.039)	–0.023 (0.022)	–0.001 (0.014)	–0.100*** (0.033)
N	4,591	4,590	4,590	4,590
	Minimum Meal Frequency	Dietary Diversity	Minimum Dietary Diversity	Iron-Rich Foods
	(1)	(2)	(3)	(4)
B. Diet				
Migrant mother	–0.008 (0.034)	–0.231* (0.111)	–0.060† (0.036)	–0.168** (0.064)
N	4,082	4,559	4,559	5,360

Notes: All regressions control for child fixed effects and wave fixed effects. Robust standard errors, shown in parentheses, are clustered at the village level. For breastfed children aged 6–8 months, minimum meal frequency is equal to 1 if fed twice the previous day; for children aged 9–11 months, meal frequency is equal to 1 if fed three or more times per day; and for non-breastfed children aged 6 months and older, minimum meal frequency is equal to 1 if fed four or more times per day. Dietary diversity is the number of the following food categories fed to the child the previous day: grains, legumes, meat, dairy, eggs, foods rich in vitamin A, and fruits. Minimum dietary diversity is equal to 1 if dietary diversity is four or more. Iron-rich foods include meat, fruits, vegetables, and iron supplements. *N* is the total number of observations in each regression. We calculate significance levels after adjusting for multiple hypotheses using the step-down procedure of Romano and Wolf (2005) to control the familywise error rate (FWER).

Source: Authors' survey.

†$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$

Timing of Out-Migration

Our primary estimates of the impact of maternal migration estimate the average effect of maternal migration on child outcomes without regard to when mothers left. We estimate the effect when mothers leave at any point during the first two years, but these estimates do not consider how effects may vary depending on when mothers migrate. Given rapid developmental changes at this age and evidence of relatively short periods of high sensitivity to environmental changes, however, the timing of mothers' migration may have varying effects.

To address this question, we report child fixed-effect regressions using subsamples of the data chosen to isolate treatment effect heterogeneity by the timing of maternal migration and the timing of the outcome measure. That is, we re-estimate the primary fixed-effects regressions but using only two waves of data at a time and including only left-behind children whose mothers migrate at a single point in time.

The results of this exercise are reported in Table 5. On measures for which we find significant or marginally significant effects in the main analysis, we show six estimates by the age of migration and age of the measured outcome. The first three columns show estimates for the effect of mothers migrating between the first and second survey wave (Period 1) on outcomes at 12–18 months, 18–24 months, and 24–30 months of age. The next two columns show estimates for the effect of mothers migrating between the second and third waves (Period 2) on outcomes at 18–24 months and 24–30 months. The final column shows the estimated impacts of maternal migration between the third and fourth waves (Period 3) on outcomes at 24–30 months.

Despite a reduction in power compared with the main estimates, a number of results are informative. First, maternal migration during Period 1 has strong effects on outcomes soon after mothers migrate. However, the effects on nutritional outcomes appear to dissipate as children age and are negligible by the time children are 24–30 months old. Effects on cognitive development are more persistent, however. We estimate that mothers migrating in Period 1 reduces scores on the MDI at 24–30 months of age by 5.24 points (0.31 SD). For comparison, recent parenting interventions in Colombia and China increased comparable measures of cognitive development by approximately 0.25 SD (Attanasio et al. 2014; Sylvia et al. 2019). The effect of migration in this early period on children at 24–30 months of age is significantly more negative than the effect of migration six months later. The last column in Table 5 shows an effect of migration during Period 3 on cognition at 24–30 months. These results are

Table 5 Effects by timing of maternal migration

Child Age When Mothers Migrated:	Between 6–12 Months and 12–18 Months (Period 1)			Between 12–18 Months and 18–24 Months (Period 2)		Between 18–24 and 24–30 Months (Period 3)
Child Age When Outcome Was Assessed:	12–18 Months	18–24 Months	24–30 Months	18–24 Months	24–30 Months	24–30 Months
	(1)	(2)	(3)	(4)	(5)	(6)
1. Bayley Mental Development Index (MDI)	–5.142* (2.121)	–3.868 (2.397)	–5.238† (2.672)	–2.363 (2.544)	1.422 (2.680)	–4.326† (2.558)
N	2,380	2,375	2,381	2,318	2,325	2,403
2. Height-for-Age *z* Score	–0.160 (0.111)	–0.153† (0.090)	–0.048 (0.099)	–0.024 (0.121)	–0.180 (0.131)	0.041 (0.107)
N	2,366	2,362	2,370	2,303	2,311	2,389
3. Weight-for-Height *z* Score	0.205† (0.108)	0.212† (0.114)	0.042 (0.117)	0.011 (0.149)	0.190 (0.173)	–0.007 (0.102)
N	2,376	2,367	2,372	2,308	2,313	2,391

Notes: The table shows coefficients and standard errors on a variable indicating maternal absence for a majority of the previous six months in regressions with outcomes at left as dependent variables. That is, the estimates in columns 1, 2, and 3 estimate the effect of migration in Period 1 on outcomes in Waves 2, 3, and 4 (respectively); the estimates in columns 4 and 5 estimate the effect of migration in Period 2 on outcomes in Waves 3 and 4; and the estimates in columns 6 estimate the effect of migration in Period 3 on outcomes in Wave 4. All regressions control for child and wave fixed effects and a cubic term in child age. Regressions in row 1 additionally control for Bayley tester and those in rows 2 and 3 additionally control for the nurse taking measurements. Standard errors, shown in parentheses, are clustered at the village level. *N* is the total number of observations in each regression.

Source: Authors' survey.

† $p < .10$; * $p < .05$

consistent with earlier migration being more detrimental to cognitive development, and also with the presence of immediate negative effects of maternal migration.

Conclusion

In this article, we study the effects of maternal migration on the development, health, and nutrition outcomes of children in rural China. Using panel data following children for two years, beginning at 6–12 months of age, we find that any maternal migration during early childhood reduces cognitive development and child nutrition. We also find that earlier migration (before children are 15 months old) has large and persistent effects on cognitive development, reducing cognitive scores by 0.31 SD when children are 24–30 months old. This effect size is on par with the effects of a recent parenting intervention (Sylvia et al. 2019) and is large enough to more than fully offset higher cognitive scores at 6–12 months initially observed among children whose mothers would later migrate.

We acknowledge several limitations to our study. First, it is possible that we do not fully address endogeneity. Although we believe that we are able to account for the most important sources of endogeneity using child fixed effects, time-variant unobserved heterogeneity could remain. Shocks that affect both the probability that mothers migrate and child outcomes could affect the validity of our estimates. Examples of this include an illness in the family or sudden financial hardship. In the case of a family illness, it is likely that estimates would be biased downward because this could increase the costs of migration and negatively affect child outcomes. Financial hardship is less clear, given that hardship could be one reason why a mother chooses to migrate to earn extra income. Second, we are unable to examine effects of paternal migration, although evidence from other contexts suggests that the effect of maternal migration is likely to be more important in early childhood (Antman 2018; Bianchi 2000; Victora et al. 2008).

Despite these caveats, we believe that our results have a number of important implications for policymakers in China. The main message is that the migration that has helped to fuel China's growth may have come with a cost in terms of lost human capital for the next generation. To mitigate these costs, investments should be made to support early childhood development in rural areas. However, although we find that migration negatively affects the outcomes of left-behind children, a large fraction of *all* rural children have delayed development outcomes. In the final wave of our survey, 52% of children were delayed in their cognitive or psychomotor development (MDI/PDI < 80). Thus, investments are needed for all children; specific targeting to those left behind is not necessarily warranted. Another policy option may be cash transfers targeting households with young children, either unconditional or conditional on mothers delaying out-migration. These may be complementary with public early childhood investments if, for example, interventions are more effective when mothers are at home.

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Ethics This study received ethical approval from the Stanford University Institutional Review Board (IRB) (Protocol ID 25734) and from the Sichuan University Ethical Review Board (Protocol ID 2013005–01). Adult study participants and caregivers of all sample children provided informed consent prior to the start of any study activities. The Stanford and Sichuan IRBs approved a waiver of written consent. Oral consent was obtained from the caregivers by trained members of the field survey team who were trained in the consent process. Consent procedures included ten minutes devoted to consent discussion, five minutes to describe the study and five minutes for questions, and followed a set script in Chinese. At the conclusion, caregivers were asked if they understood what was requested of them.

Authors' Contributions AY, YB, SR, and SS conceived of the study. All authors designed the data collection strategy. AY, YB, YS, and RL collected the data. AY, YB, and SS analyzed the data. AY, AM, and SS wrote the manuscript. All authors participated in critical revisions.

Data Availability Data and analysis code are available from the authors upon request.

Conflict of interest None of the authors have any conflicts of interest to declare.

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