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# Identifying the Effects of Migration on Parental Health: Evidence from Left-Behind Elders in China

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*This study pioneers the application of the New Economics of Labor Migration theory to outline and estimate two opposite effects of labor loss driven by the migration and remittances of adult children on the health of left-behind elderly parents through the changing rural market constraints. We use China's rural household survey data and simultaneous equation econometric techniques to estimate the effects of migration on the physical and mental health of left-behind elders. Results indicate that the loss of labor to migration has a significantly negative effect on the health of left-behind elders, but remittances from migrants can compensate for the adverse effect. This study provides a comprehensive understanding that remittances from migration relax the constraints on household resource allocations in undeveloped rural areas with imperfect market conditions. Overall, left-behind elderly parents benefit from migrant children both physically and mentally.*

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**JEL Codes:** J14, R23

#404



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This study pioneers the application of the New Economics of Labor Migration theory to outline and estimate two opposite effects of labor loss driven by the migration and remittances of adult children on the health of left-behind elderly parents through the changing rural market constraints. We use China's rural household survey data and simultaneous equation econometric techniques to estimate the effects of migration on the physical and mental health of left-behind elders. Results indicate that the loss of labor to migration has a significantly negative effect on the health of left-behind elders, but remittances from migrants can compensate for the adverse effect. This study provides a comprehensive understanding that remittances from migration relax the constraints on household resource allocations in undeveloped rural areas with imperfect market conditions. Overall, left-behind elderly parents benefit from migrant children both physically and mentally.

**Keywords:** Left-behind elders, migration, remittance, labor loss, health

**JEL codes:** I12, J14, R23

# **1 Introduction**

The rapid industrialization and urbanization drive in China are spurring the largest ever labor migration from the rural areas in world history (Rozelle et al. 1999; Huang et al. 2015). At the same time, China's rapidly aging population is expected to continue in the next few decades (Huang, Lian et al. 2015). China's population of 65 years or older accounted for 8.2% of the total population in 2010, a proportion that is predicted to increase to 30.2% by 2070 (United Nations 2011) and will become the second highest in the world. Out of the current total aging population, over 37% are left behind in the rural areas because of massive migrant labor (He and Ye 2014). The fact that economic development has outpaced the social security system for the aged in the rural areas has further complicated the situation.

Such complex phenomena in China has therefore given rise to a thorny issue as to how the migrant adult children has affected the well-being of the left-behind parents, in particular those in the rural areas. Seen from China's history, legal rules and filial piety are the dominating factor for family being the main source of informal care for the elderly. However, the rapid urbanization drive has forced the grown-up sons and daughters to migrate to the urban areas for money-making jobs. The increase of the migration from the rural areas into the urban areas has been considered a social penalty for the left-behind elderly in the form of reduced functional support and increased psychosocial isolation (Tan 1992; Rahman 1999). On the other hand, migration can be viewed as a valuable resource for improving the elder's health and well-being through the offspring's remittances to relax the constraints caused by underdeveloped markets and other relevant modern economic institutions.

However, few studies have investigated the relationship between the migration of the grown-up children and the health of the parents who are left behind in the rural areas to live on their own. Literature provides mixed results for the effects

of adult children migration on the health of the left-behind elders'. Although emerging publications have generally found better health among elders with migrant children than among those without (Beard and Kunharibowo 2001; Keasberry 2001; Nyberg-Sørensen et al. 2002; Kahn et al. 2003; Nguyen et al. 2006; Kuhn et al. 2011), evidences for the negative association between the migration and the health of the left-behind elders have been found (Antman 2010; Sharma 2013). As a successful example of the emerging economies, China has provided a case in point to study how children migration affects the health of the left-behind parents in the rural areas.

The present study will shed more light on the mechanism of how offspring migration affects the health of the left-behind elders in the countryside. The mechanism of how migration exerts an impact on the health of the left-behind elder is primarily based on a core hypothesis of whether positive effects of remittances from migrants dominate the adverse effect of migration, such as the reduction of caring time spent on the elderly. However, to the best of our knowledge, the mechanism has not been explicitly examined. The main body of literature contributes to the estimation of the net impact of offspring migration on the health of the left-behind elders, and leaves behind conflicting results in plausible discussions. By applying the New Economics of Labor Migration theory, we first elaborate on how the health of the left-behind elders is impacted by the migrant labor and remitted resources through tightening or relaxing market constraints in China's rural areas. Next, we construct a simultaneous equation system to identify the effects of migration from two channels.

The remaining part of the paper is organized as follows. Section 2 describes the relationship with previous work, while Section 3 introduces the theoretical framework for the analysis. Section 4 introduces the empirical estimation models and data sources. Sections 5 and 6 present the discussion of our empirical results and the conclusion, respectively.

## **2 Relationship with previous work**

Böhme et al. (2015) provided a good summary of the literature on the effect of migration on the health of the left-behind elders. These studies are based primarily on a key conjecture: whether the positive effect of remittances can compensate for the negative effects from family care labor loss and decreased contact with family members driven by adult children migration.

Thus far, empirical evidence on the impact of adult children migration on the physical and mental health of the left-behind elders remains vague. The deleterious impact of household migration has usually been perceived as a result of family disruption and reduced social support, which often carries detrimental consequences for the health of the left-behind elders (Lu 2013). Poor physical and mental health outcomes were likewise positively correlated to having a migrant grown-up child (Antman 2010; Kuhn, Everett et al. 2011; Sharma 2013), which are consistent with the fact that geographic distance reduces the actual incidence of all flow types between two generations (Rossi 1990).

However, the negative judgment for rural labor migration is challenged by other studies. Gibson et al. (2011) analyzed a migration lottery program and found no effect of migration on the health of elderly household members. Abas et al. (2009) and Böhme, Persian et al. (2015) found no empirical evidence to support that children migration was associated with greater depression in elderly parents in Moldova. Furthermore, an increasing number of literature has shown that adult children migration can improve left-behind parental health (e.g., Kahn, Collinson et al. (2003), Kuhn, Everett et al. (2011), and Lu (2013)).

Besides the empirical examinations, a vast amount of work has discussed the potential channels on how migration affects the health of the left-behind elders (e.g., Antman (2010), and Böhme, Persian et al. (2015)). Antman (2010) divided the impacts of migrant children on parental health into the effect of remittance,

physical support, and emotional support. However, the last two types of effects can be integrated into the impacts from the loss of household labor. It seems to be widely accepted in the literature to consider that adult children migration is detrimental to the health of the left-behind elders because of the decrease in communication and caring time spent on their parents. The role of remittances in evaluating the overall effect of migration on the health of the left-behind elders has attracted much more attention in recent years. The fundamental effects of remittances on the health of the left-behind elders are presumed through the increase of disposable income. Remittances received from migrants can support the left-behind family members by minimizing economic risks and overcoming capital constraints (Stark and Taylor 1991; Frank *et al.* 2009; Adhikari *et al.* 2011; Böhme, Persian *et al.* 2015). In addition, remittances are used primarily on the purchase of daily necessities, including food, and consumer goods (Frank, Palma-Coca *et al.* 2009; Adhikari, Jampaklay *et al.* 2011; Sharma 2013; Böhme, Persian *et al.* 2015).

This study attempts to understand the impact of grown-up children migration on the health of the left-behind elders from two channels, namely, family care labor loss and remittances. The variable to capture the effect of migrant adult children was usually captured by a dummy variable: 0 represents no migrant child, and 1 represents at least one migrant child (e.g., Adhikari, Jampaklay *et al.* (2011), Lu (2013), Böhme, Persian *et al.* (2015)). This setting makes it difficult by nature to interpret the signs of adult children migration decision. To our best knowledge, this research is the first to explicitly investigate the opposite effects for two channels of migration by using novel survey data in the Chinese context.

### **3 Theoretical framework**

We draw insights from the New Economics of Labor Migration (NELM) to describe the mechanism of how migration influences the health of the left-behind elders under the background of missing or imperfect credit and insurance

markets. Migration decisions are made collectively by family members to diversify the risks and maximize the household economic welfare, particularly in underdeveloped societies with inadequate credit systems and little institutionalized provision for insurance against such dilemmas as crop failure, illness, or loss of productivity in old age (Lu 2013). When credit and formal insurance are insufficient, the remittances provide income flow to offset the losses of labor and human capital resulting from migration (Gerber and Torosyan 2013). Some remittances are spent on productive activities, however, remittances are most consumed instead of invested. In particular, remittances can be used to improve the health care for household members (Kanaiaupuni and Donato 1999; Amuedo-Dorantes and Pozo 2011).

A simple theoretical model is first set up to represent the household-level resource allocation decision within perfect market conditions. One household with an elderly may invest fixed resources  $\bar{T}$ , such as family labor or farming land, into either a low-return or high-return activity. Let  $Q_0$  and  $Q_1$  represent the output from the two activities respectively. In a linear production possibility frontier, the given price ratio of the two outputs will drive the household to specialize in the high-return activity  $Q_1$ , and the corresponding output will be  $Q^*(\bar{T})$ . Although the exact form for the household utility is unknown, the elders' health is believed to be an important determinant in the context of rural China. Thus, elders' health can be denoted by a function  $f(Q^*(\bar{T}), Z_H)$ , where  $Z_H$  controls for household and community characteristics that determine the elder's health as well.

However, a rural household in China probably faces imperfect markets, such as constrained credit market. Let  $c(\cdot) = T_1$  denote one or more barriers that limit the household to invest partial fixed endowment  $T_1$  in the high-return activity, and the rest of the endowment is invested in the low-return activity. Without loss of generality, we use  $c(\cdot)$  to denote liquidity constraints for households that



prevent them from reaching the optimal output  $Q^*$ .

The role of migration in relaxing the constraints can be represented as follows. Without credit market, a household can send out migrant children  $M$  to work in a wage-earning job. In this way, migration can relax the households' liquidity constraints by sending back remittance  $R$ .

Thus,  $T_1$  is defined as a function of migration and remittances, which can be illustrated as  $T_1 = c(M, R)$ . The lack of perfect markets, such as credit markets, makes the household conduct both high-return and low-return activities, which can be denoted by  $Q_1^c(T_1)$  and  $Q_0^c(\bar{T} - T_1)$  respectively. Consequently, the health outcome for a left-behind elder is  $H^c = f'(Q_1^c, Q_0^c, Z_H)$ , which can be further simplified to  $H^c = g(\bar{T}, c(M, R), Z_H)$ .

The effect of migration on the health of the left-behind elders is not necessarily positive. Technically, the total derivative of migration on elders' health within a constrained credit market is

$$dH^c = \underbrace{\frac{\partial H^c}{\partial T_1} c_M dM}_{\text{Labor loss effect}} + \underbrace{\frac{\partial H^c}{\partial T_1} c_R dR}_{\text{Remittance effect}} . \quad (1)$$

The sign of  $\frac{\partial H^c}{\partial T_1}$  is assumed to be reasonably positive because elders' health outcome will benefit from the increase of family endowed resources. We further assume that derivatives  $c_M < 0$  and  $c_R > 0$  because labor loss to migration leads to the reduction in family income in local areas, whereas remittances increase family liquidities. Therefore, the labor loss effect and remittance effects shown in Equation (1) are expected to be negative and positive, respectively. Given that the relative magnitudes of  $c_M$  and  $c_R$  are unknown, the overall effect of migration on the health of the left-behind elders is ambiguous. In other words, the sign of migration effect on the health of the left-behind family members depends on whether the positive effect of remittances can compensate for the negative effect from the loss of family labor.

## 4 Empirical strategies and data

The following part will introduce a strategy of identifying the two opposite effects of migration, and discuss relevant concerns in the estimation such as endogeneity and efficiency.

### 4.1 Econometric model

If the outcome of the health of the left-behind elders is constrained because of imperfect markets in rural areas, such as credit market, and family care labor loss/number of migrants ( $M$ ) and remittances ( $R$ ) affect the health production constraints  $c(\cdot)$ , then elderly health is dependent on  $M$  and  $R$  in addition to elders' individual, household, and community characteristics,  $Z_H$ . Our equation of left-behind health is

$$H = \beta_0 + \beta_1 M + \beta_2 R + \beta_3 Z_H + \varepsilon_H. \quad (2)$$

Remittances are produced by sending out family labor through migration. The value of remittance is determined by migrant human capital, household, and community characteristics,  $Z_R$ . The total amount of remittances to sending-out household is

$$R = \alpha_0 + \alpha_1 M + \alpha_2 Z_R + \varepsilon_R. \quad (3)$$

Migration is a function of individual, household, and community characteristics,  $Z_M$ .

$$M = \gamma_0 + \gamma_1 Z_M + \varepsilon_M. \quad (4)$$

$\varepsilon_H$ ,  $\varepsilon_R$ , and  $\varepsilon_M$  are error terms in the corresponding equations.

### 4.2 Estimation

A number of econometric issues have to be addressed in the estimation. First, the number of migrants and remittances may influence health outcomes, while in the other direction, the health of a left-behind elder may influence a child's propensity to migrate or the value remitted. Thus, to overcome the endogenous bias, instrumental variables are needed to identify both labor losses and

remittances. Furthermore, an across-equation correlation is likely to appear due to the fact that all three endogenous variables in Equation (2)–(4) are possibly subject to the same shocks.

#### **4.2.1 Endogeneity**

Estimating a causal effect between children's migration and elderly parental health is naturally plagued by problems of endogeneity (Antman 2010). This problem has been well reviewed by Kuhn, Everett et al. (2011). The possible endogeneity of care-giving decision will generate a problem that migrants can differ fundamentally from non-migrants (Rammohan and Magnani 2012). Two types of potential bias sources exist for estimating the effects of migration on the health of left-behind elderly parents. First, there are potential bias sources, such as shared observable and unobservable factors between migrant children and their parents, e.g., genetic predisposition, determination, innovation, and social and economic resources, such as liquidity constraints. Second, adult children will be less likely to migrate if they have elderly parents who are in poor health (Kuhn, Everett et al. 2011; Rammohan and Magnani 2012). Overall, the impact of these bias factors can be reduced by either controlling for more cofounded variables in the estimation or through an improved modeling design, such as a panel data model.

In our equation systems (2)–(4), left-behind elderly health  $H$  will be included in  $Z_M$  and  $Z_R$  to control for the impact of elderly health on the number of migrants and remittance decision of adult children. To identify the effects of the different influence channels from family labor losses and remittances, we would also need at least one exclusive instrumental variable for each of remittance and migration decision.

This study proposed a set of instrumental variables for identifying the effects of family care labor loss and remittance on parental health. In Equation (4), besides

the individual and household characteristics  $Z_M$ , number of migrants  $M$  may be influenced by village-level migration networks and local employment opportunities. Network access in urban areas makes it more likely for individual members to decide to migrate because more information and up-front costs will be shared (Munshi 2003; Taylor *et al.* 2003). However, more employment opportunities in local villages will dampen migration incentives. Our estimates will apply the proportion of households who have migrant adults in the same village and the number of local factories as instrument variables for Equation (4). The number of local factories and the migration outflow from the village may have had an impact on local economy which could determine local health care provision and elderly medical expenses. Nevertheless, we have considered and controlled public facilities for elderly and per capita income in Equation (2) for their indirect impacts on parental health. Overall, these two instrumental variables are believed to satisfy exclusion restrictions.

Regarding the instrumental variables for remittances, village-level variables are normally used as well (e.g., Rozelle, Taylor *et al.* (1999), and Taylor, Rozelle *et al.* (2003)). First, village norms are important (Taylor, Rozelle *et al.* 2003). For example, a high proportion of remittance among migrants in the same village seems to be an important pressure for migrants remitting resources back to the people left behind. Thus, we use the proportion of remittance among migrants in the resident village as a proxy variable for the village norm. According to rural traditions in China, borrowing money to provide an elderly with health care normally occurs among relatives instead of local residents without genetic connections to left-behind elders. Therefore, the spillover effect of remittances from other households on the parental health is negligible. Second, a dummy variable is used to represent whether this household received invitations last year to attend weddings or funerals, which are hosted by relatives or neighbors in the same village, in Equation (3) as another key instrumental variable. Attending these invitations is a heavy burden for rural households in China

because presents for attending weddings and funerals are normally in the form of cash. Therefore, these invitations can be treated as an economic shock for the left-behind elderly to stimulate remittances from migrant children. On the other hand, people offer presents by following others what is a popular phenomenon in China, and it normally follows the principle of “courtesy demands reciprocity.” Offering occasional care of elderly left-behind from local residents usually happens when adult children migrate for work for a certain period of time. It is an important expression of filial piety by adult children in China. This type of mutual assistance normally depends on status of adult children migrated, not on attending weddings or funerals. Hence, it seems not affect current parental health directly.

#### **4.2.2 Econometric efficiency**

Aside from the major concern of the endogeneity problem for identifying the effects of labor losses and remittances on left-behind elderly health, error terms  $(\varepsilon_H, \varepsilon_M, \varepsilon_R)$  in equations are possibly highly correlated to one another because the realization of the elders’ health is potentially subjected to the same exogenous shocks as migration and remittance decision. Thus, we apply three-stage least squares to produce consistent estimates and elaborate on the correlation structure in the disturbances across Equations (2)–(4).

#### **4.2.3 Verification of the effects of remittances on liquidity constraints**

This study will also examine the core hypothesis of NELM that remittances can relax the liquidity constraints for a household because of the undeveloped credit market, and thereafter improve the efficiency of resource allocation to the elders’ health. The mechanism for remittances to improve the health of the left-behind elders has been mentioned in a large amount of literature. However, this channel has not been empirically verified. We first adopted the most practical method of measuring liquidity conditions (e.g., Uchida et al. (2009), and Yi et al. (2016)), which is the use of households’ liquid assets. In this study, liquid assets are

defined as fixed productive assets, loans, cash in hand, received donations, and savings. Another option to determine a liquidity-constrained household is to use the poverty line suggested by the World Bank, which states that a household suffers from poverty or liquidity constraints if its per capita daily income is below USD 1.90 a day.

The sample was first categorized into two sections according to the value of liquid assets. Afterward, we set dummy variable ( $D$ ), and let  $D = 1$  and  $D = 0$  represent a respondent without and with liquidity constraints if the value of liquid assets/daily income are above and below a critical value, respectively. Subsequently, we construct a similar health determination equation as Equation (2) by adding an interaction term between liquidity constraint dummy ( $D$ ) and remittances. The coefficient for this term for the non-liquidity constrained group is expected to dampen the positive effects of remittances on the health of the left-behind elders. The method of two-stage least squares will be used for the estimation.

### **4.3 Data**

Our empirical analysis is based on the CHARLS database. CHARLS is a nationally representative survey of persons in China who are 45 years of age or older, and their spouses, including assessments of social, economic, and health circumstances of community residents (Zhao et al. 2012). The first-wave national baseline survey was conducted between June 2011 and March 2012, and the second-wave survey was conducted in 2013. CHARLS respondents were supposed to be followed up every two years, and most baseline respondents were re-interviewed in 2013. A detailed introduction of the CHARLS survey can be found in Zhao, Hu et al. (2012).

The database is trimmed according to our analysis requirement. This study focuses on the health of the rural left-behind elders. Therefore, only the

information about the residents who are over 60 years old and living in rural areas was kept in our data set. The sample includes 3060 rural elderly observed both in 2011 and 2013, and 1218 supplement elderly respondents who were interviewed in 2013 because of the lack of 799 respondents only interviewed in 2011. The sample respondents cover 25 provinces and municipalities.

## **4.4 Variables**

### **4.4.1 Health measures**

Parental physical and mental health are usually measured (Antman 2010). However, using a single index to represent that health level has a considerable number of limitations. Giles and Mu (2007) pointed out that health is multidimensional with considerable error; and thus CHARLS collects various health status information, and typically reports self-reported health (SRH), basic activities of daily living (BADL), instrumental activities of daily living (IADL), movement limitations, and depression (Zhao, Hu et al. 2012). Other health variables, e.g., weight and height, are measurement in the field. To ensure robustness of estimation, we apply different health measures in the following analysis. Due to space limits, the detailed introduction of health variables can be found in Appendix A.

Table 1 illustrates the summary statistics for the main variables used in the following empirical results. The physical health of the elders without migrant children seems significantly worse than that of the cohort with migrant children, although cofound variables are not controlled. However, the difference of BADL between the two cohorts is not significant, which is probably driven by its relatively small variation. By simple comparison, we also did not find a significant difference for SRH, BMI, and depression scores between the two cohorts.

Due to the low proportion of within-variation in overall-variation of health

measurements, applying alternative fixed effects model to address the endogeneity has been ruled out in this study. Table B.2 shows that most of the variations (about 70%) of health measurements and migration behavior occurred among elderly, indicating that the temporal change of left-behind elders' health is quite small in the two continuous surveys. For example, the share of between-variation in physical health accounts for 78% of overall-variation, and the one for BMI has reached around 86%. Since fixed effects estimates use only within-individual differences, essentially discarding any information about differences between individuals. If dependent variables vary greatly across individuals but have little variation over time for each individual, then fixed effects estimates will be imprecise and have large standard errors.

#### **4.4.2 Explanatory variables**

Number of migrants was measured using the number of adult children who migrated for work outside the village, returned infrequently, but had the same place of residence as their elderly parents. Remittances are measured in values considering the cash and goods sent back home to their left-behind parents, such as food and clothes. Among all the respondents with migrant children, the average value of remittances to a left-behind elderly is around 3.3 thousand yuan, which is marginally less than the per capita income. Remittances very likely play an important role in the daily life of the left-behind elders. The effects of parental health shocks on migration and remitting decision are controlled for in Equations (3) and (4) as well.

Aside from the key variables of number of migrants and remittance in the health Equation (2), the left-behind individual, household, and community-level characteristics are included in the regression. Specifically, the age, marriage status, and family size of the left-behind elders are controlled for to address potential differences within respondents. Nowadays, infectious diseases have been progressively replaced by chronic diseases as the major source of poor



health and mortality (Hossain 1997; Strauss et al. 2010). Chronic diseases are heavily influenced by genetic and long-term determinants, and are thus not likely to be causally affected by rather recent migration episodes (Böhme, Persian et al. 2015). Therefore, we believe that the number of chronic diseases can capture unobserved factors that probably impact the health of elderly parents. Education may be a proxy for numerous factors, which may represent better understanding of what health inputs to choose so as to ensure good physical and mental health (Schultz 1984; Antman 2010; Strauss, Lei et al. 2010). A vector of province-year dummy variable controls both fixed province effects and time-varying macroeconomic shocks that affect elderly health. In addition, each community has factors that will affect health outcomes that are not captured by the provincial dummies. Therefore, village-level public facilities for elderly, medical facility accessibility, and number of bus lines will be included in the estimation.

Control variable  $Z_M$  includes the human capital and household demographic characteristics of adult children. The average educational attainment of adult children in the year prior to the decision to participate in the migrant labor market is included as a measure of human capital. Age and age-squared for adult children in a household are included to control life-cycle effects that may influence the number of migrants. Specifically, the likelihood of becoming a migrant increases before it declines with older age. Household-level per capita land holdings are also controlled for different migration motivations, as well as the number of children migrants. Village-level variables are controlled for different external migration conditions. These variables include the proportion of households who have migrant adults in the same village, and the number of local factories.

Migrant characteristics are included in  $Z_R$ . The proportion of remittance among migrants in the same village is treated as the village norm and used as an instrumental variable. Meanwhile, the direct inclusion of the values of presents

for weddings or funerals attended is not appropriate because they are endogenously determined by remittances. However, receiving an invitation is likely exogenous in its influence on the likelihood of remittances from migrant children.

## **5 Results**

### **5.1 Baseline results**

We first estimate the Equation systems (2)–(4) using three-stage least squares method. The p-values for all equations in the system show that each value is statistically significant. In particular, the instrumental variables for family labor losses and remittances all pass the Sargan–Hansen test for exogeneity. The F-statistics of the first-stage regression of the instruments on the endogenous variables, namely, number of migrants and remittances, are all significant at the 1% level and well above the rule-of-thumb threshold of 10 for weak instruments.

Table 2 and 3 report the estimation results for the effect of labor losses and remittances on the physical and mental health of the left-behind elders. First, Column (1) in Table 2 reports the results by using regular OLS method without considering endogenous problems. It shows opposite signs from our theoretical expectations that the number of migrants and remittances have positive and negative signs, respectively. However, the estimation for physical health in column (2)–(4) in Table 2 by using 3SLS shows that the direct effect of labor losses on the physical health of the left-behind elderly is negative and significant in Column (2). Given the family size, the number of actions that can be performed independently by elderly respondents falls by 2 items when one more adult child migrates. If there were no offsetting effects, the social security system for the rural elders would be a great concern for policy makers. These findings are consistent with the prediction of our theoretical analysis that, at least in the short run, the labor loss in a family generates a statistically significant adverse

effect on the physical health of the left-behind elders.

The results in the fourth column of Table 2 have confirmed that the health of the elders affects the migration decision of their adult children. As the proxy variable for elders' health, the number of chronic diseases has a negative effect, albeit insignificant, on the number of migrants. This result is consistent with the hypothesis that adult children are less likely to work as migrants when a parent is ill (Giles and Mu 2007; Rammohan and Magnani 2012).

The regression results in column (2)–(4) in Table 2 also illustrate that the adverse effect from less family labor will be partly compensated for by remittances from migrants. Results in Column (2) of Table 2 show that an additional thousand yuan remitted by migrant children will enable the left-behind elderly to independently accomplish around 0.3 more physical actions. Column (3) presents that the number of migrants is positively associated with remittances, a result that is also consistent with the NELM hypothesis.

Column (2) in Table 3 shows that the impacts of family labor losses on mental health are similar to the results for physical health in Table 2. Again, 3SLS estimate strategy enables the two potential effects of migration on elderly health more significant than the results generated by OLS method in Column (1) of Table 3. Specifically, the number of migrant children has a significantly negative effect on the mental health of the left-behind elders, and is normally interpreted as the result of geographic isolation from maintaining contact with their children. According to Adhikari, Jampaklay et al. (2011) and Böhme, Persian et al. (2015), advanced communication facilities may mitigate the negative effect. The left-behind elderly have cell phones and personal computers when the proxy variable is controlled for; however, the relatively large value of the adverse effect of labor losses emphasizes the importance of face-to-face contact between parents and their children. Again, remittances will partially compensate for the negative effect of labor losses on mental health. This finding is understandable in

rural China because remittances are always treated as an important emotional link between parents and biological children. Remittances are likewise an important mark to show children's filial piety and are normally disseminated in the local community. Thus, those elders who receive more remittances will have a sense of superiority in their home communities.

## **5.2 Robustness check**

A series of estimations using different health measures in Table 4 and 5 indicates that our estimates are robust. First, various measurements of physical health are also used in the estimation. In Table 4, each component of physical health indicator reported in Table 2, including BADL, IADL, and movement limitation, is examined separately in the first three columns. The signs for all estimators are consistent with our expectations. In particular, the numbers of migrants and remittances have negative and positive effects on different specific measures for physical health respectively. Columns (4) and (5) in Table 4 report the estimation when SRH and BMI are used to measure physical health. The influence directions of labor losses and remittances on SRH and BMI are consistent with the results when using other physical indicators.

Second, instead of the number of actions that the left-behind elderly can independently do, columns (1)–(3) in Table 5 report the results from the estimation that uses scores aggregated on the basis of questions answered by the respondents as dependent variables for physical health. The results are remarkably similar to those in Table 2.

The cognitive capacity shown in column (4) in Table 5 is negatively related with family labor losses and positively affected by remittances. One more migrant child makes the elderly recall less 0.2 words on average, while remittances offset this negative effect. The reason may result from the remitted income that can improve the diet nutrition and medical care of left-behind elderly, both of which

are also important for maintaining memory. Overall, the cognitive capacity estimates have similar results as the ones that use the depression score shown in Table 3.

### 5.3 Liquidity constraints

In Table 6, evidences confirming that the physical health of the left-behind elderly with liquidity constraints are more likely benefiting from remitted sources from migrants than those who have no liquidity constraints. Regarding the subjective choices of the threshold values of liquid assets, columns (1)–(4) provide four critical values of liquid assets to split the full sample at 20, 50, 80, and 100 thousand yuan. For each of these columns, the effects of remittances on left-behind elders' health with liquidity constraints are still significantly positive. However, these effects have been fully counteracted by the significantly negative coefficient of the interaction term between remittances and the high value of liquid asset dummy. A reasonable t-test can be constructed to make sure that remittances have no significant effect on the non-liquidity-constrained elderly physical health<sup>1</sup>. In other words, remittances only play an important role in improving the physical health of the left-behind elders when the elderly is facing liquidity constraints.

The results of using the poverty line to detect the potential and unknown liquidity constraint threshold are consistent with the ones using the value of liquidity assets. The positive effect of remittances can be offset by the negative value for the interaction term in Column (5) in Table 6. The similar examinations for mental health are presented in Table B.1 in the appendix. In a word, our detections for the liquidity constraints are extremely robust, and liquidity constraint is an essential condition to make remittances functional so as to compensate for the adverse effect of labor losses on the health of the left-behind

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<sup>1</sup> For example, once the threshold value of 20 thousand yuan is chosen,  $t = \frac{0.652 - 0.597}{0.248} = 0.22$  is much lower than the critical value of 95% significance.

elders.

## **5.4 Net effect of migration on left-behind elderly health**

To answer the question whether the health of the left-behind elders comprehensively benefits from migrant children, this section estimated the net effect. As remittances can, at least, partially compensate for the negative effect driven by the increase of migrants in a household, the net effect of migration on the health of the left-behind elders depends on relative magnitudes between the two opposite effects of migration. Thus, this fact makes heterogeneous effects of migration across regions that are not comparable. Under the study background in China, results in Table 7 show that migration in rural areas generally promotes the health level of the left-behind elderly. Columns (1) and (2) use whether a household had migrant children dummy, and columns (3) and (4) use the number of migrants as the proxy variables for migration to capture the net effect of migration. These two choices of proxy variables for migration have been widely used in literature (e.g., Sharma (2013), Böhme, Persian et al. (2015), and Huang, Lian et al. (2015)).

In addition, our estimates in Table 7 seems to contradict the conclusion by Huang, Lian et al. (2015), which is the only study about the migration effect in China to the best of our knowledge. Huang, Lian et al. (2015) found a negative relationship between migration and parental health. This discrepancy is probably attributed to the fact that the per capita income in our sample is one-fourth of the value in their analysis sample for the reason that they contain a large number of residents in developed urban areas who are not likely facing liquidity constraints in China. As a result, the compensation channel of migration on parental health through remittances in their study could be silent. In other words, the adverse effect from household labor reduction dominates the whole migration estimation. Overall, our estimation essentially covers the information studied by Huang, Lian et al. (2015), and the positive effects of remittances can

completely overcome the negative effect from the loss of household labor in China's rural areas.

## **6 Conclusions**

This study takes the lead to use the NELM framework to keep track on the relationship among migrant children, remittances, and the health of the left-behind elders. Our econometric findings provide evidence that the labor loss from migration adversely affects the health of the left-behind elderly in China's rural areas, while remittances can compensate for the negative effect. This pioneering empirical research explicitly shows how remitted resources by migrants mitigate the negative effect of labor loss from migration. Furthermore, the study shows that the positive effects of remittances only apply to households with liquidity constraints. Generally, we find that left-behind elderly parents benefit from migrant children both physically and mentally.

An important policy issue facing policy makers is whether migration can narrow the gap between the relatively advanced social security system for the elders in urban areas and the traditional social security system based on filial piety in the underdeveloped rural areas in China. The findings have demonstrated that migration can generally improve the health of the left-behind elders. However, our findings should not be construed to mean that the left-behind elderly are not vulnerable. For example, the pension that an elderly person receives from the new type of rural endowment insurance is negligible compared with the one received from the urban endowment insurance. Results have indicated that the positive effects of remittances are based on liquidity constraints, and the present situation, in the short run, seems impossible to solve within on the village scale. Therefore, the government needs make drastic reform on the social security system for the rural elders while the role of migration on the health of the left-behind elders should only be considered as a beneficial supplement. The limitation of this study is that we have not investigated why the increase of

remittance could raise health condition of the left-behind parents due to space limits. This is left for future investigation.

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**Table 1 Summary Statistics**

	All		Cohort without migrant children		Cohort with migrant children		Test of difference in variables between two cohorts
	Mean	S.D.	Mean	S.D.	Mean	S.D.	
<b>Health measures</b>							
Physical health: Number of actions accomplished independently	16.120	2.547	16.053	2.609	16.200	2.469	***
BADL	5.847	0.627	5.842	0.636	5.853	0.615	
IADL	4.582	0.974	4.555	1.012	4.615	0.925	***
Movement limitations	5.691	1.428	5.656	1.445	5.733	1.406	**
SRH	1.876	0.866	1.880	0.872	1.872	0.858	
Dummy variable for BMI: 1 = $18.5 \leq \text{BMI} \leq 25$ ; 0 = otherwise	0.343	0.475	0.349	0.477	0.336	0.472	
Depression score	20.679	6.324	20.725	6.328	20.624	6.318	
Cognition test score	2.739	1.746	2.689	1.751	2.798	1.737	***
<b>Individual characteristics of elderly person</b>							
Number of migrant children	0.781	1.080	—	—	1.714	0.981	—
Remittances in thousand yuan	1.512	6.535	—	—	3.320	9.369	—
Age	67.935	6.566	68.149	6.780	67.681	6.291	***
Male	0.507	0.500	0.498	0.500	0.517	0.500	***
Married	0.779	0.415	0.757	0.429	0.805	0.396	***
Education in years	3.516	3.480	3.455	3.491	3.589	3.466	***
Dummy variable for receiving pension	0.483	0.500	0.470	0.499	0.498	0.500	*
Dummy variable for work last year	0.628	0.483	0.601	0.490	0.661	0.473	***
Number of chronic disease	1.566	1.431	1.520	1.432	1.623	1.428	**
Dummy variable for receiving wedding or funeral invitations	0.171	0.376	0.148	0.356	0.198	0.398	***
<b>Household characteristics</b>							
Number of children	3.599	1.506	3.402	1.504	3.835	1.474	***
Number of household members	2.333	1.790	2.530	1.906	2.098	1.610	***
Number of grandchildren less than 16 years old	3.985	3.862	3.835	3.734	4.154	4.000	***
Average age of children	39.537	6.579	39.566	6.928	39.503	6.136	
Average education of children	7.328	2.930	7.127	2.865	7.568	2.989	***
Per capita income	4.100	11.417	4.395	12.253	3.748	10.321	*
Dummy variable for having cell phone or personal computer	0.706	0.456	0.706	0.456	0.706	0.456	
Per capita land holdings (mu)	2.017	10.970	2.192	13.204	1.807	7.466	
<b>Village-level characteristics</b>							
Public facilities for elderly	1.657	2.052	1.940	2.193	1.317	1.811	***
Dummy variable for having elderly and disabled assisting organization	0.147	0.354	0.174	0.379	0.114	0.318	***
Number of medical facilities	1.647	1.767	1.678	1.703	1.609	1.840	*
Number of bus lines	1.203	3.187	1.100	2.594	1.325	3.773	**
Proportion of remitting among migrants in the resident village (%)	51.531	19.117	46.691	19.290	57.319	17.208	***
Proportion of migration in the resident village (%)	22.067	16.601	18.818	15.623	25.951	16.901	***
Number of local factories	2.752	7.993	3.510	9.486	1.845	5.585	***
Observations	8137		4431		3706		

Notes: \*p < .10; \*\*p < .05; \*\*\*p < .01. 1 mu = 1/15 hectare.

**Table 2 Estimation of the impact of migration and remittances on the physical health of left-behind elderly**

Explanatory variables	Physical health			
	OLS	3SLS		
	(1) Physical action	(2) Physical action	(3) Remittances	(4) Number of migrants
<i>Migration effects:</i>				
Number of migrants	0.071** (0.028)	-0.460*** (0.118)	1.097*** (0.269)	
Remittances in thousand yuan	-0.005 (0.004)	0.326*** (0.058)		
<i>Individual characteristics of elderly person:</i>				
Age	-0.078*** (0.005)	-0.075*** (0.005)		
Married	-0.253*** (0.064)	-0.294*** (0.064)		
Male	0.298*** (0.057)	0.346*** (0.057)		
Education in years	0.087*** (0.009)	0.069*** (0.009)		
Number of chronic diseases	-0.352*** (0.018)	-0.378*** (0.025)	0.069 (0.049)	-0.010 (0.007)
Dummy variable for work last year	1.337*** (0.058)	1.335*** (0.063)		
<i>Household characteristics:</i>				
Per capita income	0.003 (0.002)	0.003 (0.003)	-0.001 (0.006)	
Number of children	0.034 (0.021)	0.070*** (0.027)		0.209*** (0.008)
Number of grandchildren less than 16 years old	0.008 (0.008)	0.004 (0.010)	0.099 (0.077)	-0.013*** (0.003)
Average age of children			0.212*** (0.060)	0.036*** (0.012)
Squared average age of children			-0.003*** (0.001)	-0.001*** (0.000)
Average education of children			0.233*** (0.026)	0.046*** (0.004)
Per capita land holdings (mu)				0.001 (0.002)
<i>Village-level characteristics:</i>				
Public facilities for elderly	0.073*** (0.023)	0.070*** (0.023)		
Number of medical facilities	0.051** (0.024)	0.047* (0.025)		
Number of bus lines	-0.003 (0.012)	0.001 (0.012)		0.022*** (0.004)
Dummy variable for receiving pension			0.146 (0.141)	
Dummy variable for receiving wedding or funeral invitations			0.470*** (0.159)	
Proportion of remitting among migrants in the resident village (%)			0.081 (0.534)	
Proportion of migration in the resident village (%)				0.307** (0.121)
Number of local factories				-0.006*** (0.002)
Constant	19.429*** (0.410)	19.361*** (0.505)	-6.733*** (1.435)	-1.430*** (0.261)
Year dummy	Yes	Yes	Yes	Yes
City dummy	Yes	Yes	Yes	Yes
Observations	8137	8137	8137	8137

Notes: Significance codes: \*p < .10; \*\*p < .05; \*\*\*p < .01. Standard errors are in parentheses. Physical action is defined as the total amount of actions that can be independently accomplished by the respondent, i.e., BADL+IADL+Movement limitations.

**Table 3 Estimation of the impact of migration and remittances on the mental health of left-behind elderly**

Explanatory variables	Mental health			
	OLS	3SLS		
	(1) Depression score	(2) Depression score	(3) Remittances	(4) Number of migrants
<i>Migration effects:</i>				
Number of migrants	0.034 (0.071)	-1.914*** (0.345)	1.209*** (0.267)	
Remittances in thousand yuan	0.017* (0.010)	1.082*** (0.172)		
<i>Individual characteristics of elderly person:</i>				
Age	0.002 (0.012)	-0.004 (0.014)		
Married	0.858*** (0.165)	0.743*** (0.164)		
Male	1.644*** (0.146)	1.836*** (0.147)		
Education in years	0.082*** (0.022)	0.026 (0.023)		
Number of chronic diseases	-1.122*** (0.046)	-1.207*** (0.072)	0.069 (0.049)	-0.011 (0.007)
<i>Household characteristics:</i>				
Per capita income	0.024*** (0.006)	0.022** (0.009)	-0.001 (0.006)	
Number of children	0.028 (0.054)	0.174** (0.074)		0.210*** (0.008)
Number of grandchildren less than 16 years old	0.053*** (0.020)	0.041 (0.029)	0.070 (0.077)	-0.013*** (0.003)
Average age of children			0.208*** (0.054)	0.036*** (0.012)
Squared average age of children			-0.002*** (0.001)	-0.001*** (0.000)
Average education of children			0.242*** (0.026)	0.046*** (0.004)
Dummy variable for having cell phone or personal computer	0.590*** (0.154)	0.487*** (0.174)		
Per capita land holdings (mu)				0.001 (0.002)
<i>Village-level characteristics:</i>				
Dummy variable for having elderly and disabled assisting organization	0.770*** (0.271)	0.604** (0.273)		
Number of bus lines	0.014 (0.027)	0.027 (0.029)		0.022*** (0.004)
Dummy variable for receiving pension			0.208* (0.126)	
Dummy variable for receiving wedding or funeral invitations			0.278* (0.144)	
Proportion of remitting among migrants in the resident village (%)			0.159 (0.475)	
Proportion of migration in the resident village (%)				0.307** (0.121)
Number of local factories				-0.006*** (0.002)
Constant	19.445*** (1.041)	20.180*** (1.359)	-6.988*** (1.3376)	-1.427*** (0.262)
Year dummy	Yes	Yes	Yes	Yes
City dummy	Yes	Yes	Yes	Yes
Observations	8137	8137	8137	8137

Notes: Significance codes: \*p < .10; \*\*p < .05; \*\*\*p < .01. Standard errors are in parentheses.

**Table 4 Estimation of the impact of migration and remittances on left-behind elderly physical health using different health indicators (Three-stage least squares)**

Explanatory variables	Dependent variable				
	(1) BADL	(2) IADL	(3) Movement limitations	(4) SRH	(5) BMI
<i>Migration effects:</i>					
Number of migrants	-0.045* (0.026)	-0.081** (0.040)	-0.332*** (0.071)	-0.166*** (0.037)	-0.043** (0.021)
Remittances in thousand yuan	0.035*** (0.013)	0.066*** (0.020)	0.224*** (0.035)	0.089*** (0.018)	0.024** (0.010)
<i>Individual characteristics of elderly person:</i>					
Age	-0.009*** (0.001)	-0.022*** (0.002)	-0.045*** (0.003)	-0.001 (0.002)	-0.001 (0.001)
Married	-0.092*** (0.017)	-0.125*** (0.026)	-0.076** (0.035)	-0.073*** (0.023)	0.040*** (0.015)
Male	-0.016 (0.015)	0.020 (0.023)	0.340*** (0.031)	0.086*** (0.020)	-0.087*** (0.013)
Education in years	0.007*** (0.002)	0.024*** (0.004)	0.039*** (0.005)	0.007** (0.003)	-0.003 (0.002)
Number of chronic diseases	-0.054*** (0.005)	-0.091*** (0.008)	-0.233*** (0.015)	-0.204*** (0.008)	0.034*** (0.004)
Dummy variable for work last year	0.223*** (0.017)	0.463*** (0.025)	0.649*** (0.035)	0.175*** (0.022)	-0.080*** (0.014)
<i>Household characteristics:</i>					
Per capita income	-0.000 (0.001)	-0.000 (0.001)	0.003* (0.002)	0.002*** (0.001)	0.001 (0.001)
Number of children	0.007 (0.006)	0.035*** (0.010)	0.028* (0.016)	0.016* (0.009)	-0.003 (0.005)
Number of grandchildren less than 16 years old	0.002 (0.002)	-0.000 (0.003)	0.002 (0.006)	-0.002 (0.003)	0.001 (0.002)
<i>Village-level characteristics:</i>					
Public facilities for elderly	0.010 (0.006)	0.020** (0.009)	0.040*** (0.013)	0.013 (0.008)	-0.005 (0.005)
Number of medical facilities	0.012* (0.007)	0.026*** (0.010)	0.008 (0.014)	0.019** (0.009)	-0.005 (0.006)
Number of bus lines	0.002 (0.003)	-0.001 (0.005)	0.001 (0.007)	-0.000 (0.004)	0.001 (0.003)
Constant	6.122*** (0.118)	5.472*** (0.180)	7.764*** (0.297)	2.083*** (0.165)	0.591*** (0.098)
Year dummy	Yes	Yes	Yes	Yes	Yes
City dummy	Yes	Yes	Yes	Yes	Yes
Observations	8,137	8,137	8,137	8,137	8,137

Notes: Significance codes: \*p < .10; \*\*p < .05; \*\*\*p < .01. Standard errors are in parentheses. To our result reports, this table only presents estimates of Equation (2).

**Table 5 Estimation of the impact of migration and remittances on the physical action score and cognitive capacity of left-behind elderly (Three-stage least squares)**

Explanatory variables	Physical health			Mental health		
	(1) Physical action score	(2) Remittances	(3) Number of migrants	(4) Cognitive capacity <sup>a</sup>	(5) Remittances	(6) Number of migrants
<i>Migration effects:</i>						
Number of migrants	-1.825*** (0.377)	1.100*** (0.268)		-0.219** (0.086)	1.012*** (0.272)	
Remittances in thousand yuan	1.162*** (0.187)			0.217*** (0.045)		
<i>Individual characteristics of elderly person:</i>						
Age	-0.222*** (0.017)			-0.044*** (0.004)		
Married	-0.668*** (0.192)			0.032 (0.049)		
Male	1.306*** (0.172)			-0.064 (0.043)		
Education in years	0.227*** (0.026)			0.118*** (0.007)		
Number of chronic diseases	-1.399*** (0.079)	0.070 (0.049)	-0.010 (0.007)	-0.042** (0.018)	0.056 (0.049)	-0.013 (0.008)
Dummy variable for work last year	3.911*** (0.191)					
<i>Household characteristics:</i>						
Per capita income	0.011 (0.010)	-0.001 (0.006)		0.004* (0.002)	-0.002 (0.006)	
Number of children	0.190** (0.084)		0.209*** (0.008)	0.020 (0.020)		0.218*** (0.009)
Number of grandchildren less than 16 years old	0.021 (0.032)	0.099 (0.077)	-0.013*** (0.003)	-0.021*** (0.008)	0.090 (0.079)	-0.012*** (0.004)
Average age of children		0.204*** (0.056)	0.036*** (0.012)		0.207*** (0.064)	0.043*** (0.013)
Squared average age of children		-0.002*** (0.001)	-0.001*** (0.000)		-0.003*** (0.001)	-0.001*** (0.000)
Average education of children		0.233*** (0.026)	0.046*** (0.004)		0.216*** (0.027)	0.046*** (0.004)
Dummy variable for having cell phone or personal computer				0.136*** (0.050)		
Per capita land holdings (mu)			0.001 (0.002)			0.001 (0.002)
<i>Village-level characteristics:</i>						
Public facilities for elderly	0.249*** (0.070)					
Dummy variable for having elderly and disabled assisting organization				0.193** (0.078)		
Number of medical facilities	0.134* (0.074)					
Number of bus lines	0.023 (0.038)		0.022*** (0.004)	-0.012 (0.008)		0.020*** (0.005)
Dummy variable for receiving pension		0.147 (0.132)			0.034 (0.144)	
Dummy variable for receiving wedding or funeral invitations		0.414*** (0.150)			0.790*** (0.159)	
Proportion of remitting among migrants in the resident village (%)		0.124 (0.498)			0.227 (0.560)	
Proportion of migration in the resident village (%)			0.304** (0.121)			0.201 (0.128)
Number of local factories			-0.006*** (0.002)			-0.007*** (0.002)
Constant	57.056*** (1.588)	-6.583*** (1.376)	-1.428*** (0.261)	5.057*** (0.363)	-6.416*** (1.475)	-1.602*** (0.281)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
City dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,137	8,137	8,137	7,341	7,341	7,341

Notes: Significance codes: \*p < .10; \*\*p < .05; \*\*\*p < .01. Standard errors are in parentheses. Physical action score is defined as the total points for all physical action questions. 1 mu = 1/15 hectare. <sup>a</sup> Part of observations do not report cognitive scores.

**Table 6 Estimation of the impact of migration and remittances on left-behind elderly physical health with a dummy of liquidity constraints (Two-stage least squares)**

Explanatory variables	Dependent variable: Physical action				
	Liquidity constraint thresholds				Poverty line
	Liquid asset values in thousand yuan				
	(1)	(2)	(3)	(4)	
	20	50	80	100	(5)
					\$1.9/day
<i>Migration effects:</i>					
Number of migrants	-1.269*	-0.964*	-1.005*	-0.996*	-1.016*
	(0.714)	(0.583)	(0.547)	(0.544)	(0.571)
Remittances in thousand yuan	0.652***	0.527***	0.447***	0.447***	0.535***
	(0.248)	(0.183)	(0.140)	(0.140)	(0.177)
Remittances in thousand yuan×high value of liquid assets dummy	-0.597***	-0.500***	-0.319***	-0.328***	
	(0.223)	(0.170)	(0.107)	(0.109)	
Remittances in thousand yuan×above poverty line dummy					-0.491***
					(0.157)
<i>Individual characteristics of elderly person:</i>					
Age	-0.074***	-0.070***	-0.070***	-0.070***	-0.072***
	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
Married	-0.238*	-0.261**	-0.275***	-0.274***	-0.254**
	(0.131)	(0.113)	(0.102)	(0.102)	(0.113)
Male	0.359***	0.308***	0.324***	0.324***	0.330***
	(0.105)	(0.091)	(0.094)	(0.093)	(0.094)
Education in years	0.077***	0.074***	0.067***	0.066***	0.076***
	(0.014)	(0.013)	(0.013)	(0.013)	(0.013)
Number of chronic diseases	-0.383***	-0.366***	-0.385***	-0.385***	-0.384***
	(0.033)	(0.029)	(0.034)	(0.034)	(0.031)
Dummy variable for work last year	1.546***	1.528***	1.533***	1.530***	1.566***
	(0.135)	(0.121)	(0.116)	(0.116)	(0.125)
<i>Household characteristics:</i>					
Number of children	0.192*	0.132	0.159*	0.157*	0.164*
	(0.112)	(0.092)	(0.092)	(0.092)	(0.096)
Number of grandchildren less than 16 years old	0.000	0.003	-0.005	-0.004	0.002
	(0.013)	(0.012)	(0.013)	(0.013)	(0.012)
<i>Village-level characteristics:</i>					
Public facilities for elderly	0.035	0.030	0.051	0.052	0.060*
	(0.039)	(0.035)	(0.033)	(0.033)	(0.035)
Number of medical facilities	0.070*	0.102***	0.079**	0.078**	0.066**
	(0.037)	(0.037)	(0.035)	(0.035)	(0.033)
Number of bus lines	0.015	0.019	0.025	0.025	0.013
	(0.024)	(0.025)	(0.024)	(0.024)	(0.021)
Constant	18.787***	18.621***	18.674***	18.689***	18.707***
	(0.739)	(0.682)	(0.655)	(0.654)	(0.683)
Year dummy	Yes	Yes	Yes	Yes	Yes
City dummy	Yes	Yes	Yes	Yes	Yes
Observations	8,137	8,137	8,137	8,137	8,137

Notes: Significance codes: \*p < .10; \*\*p < .05; \*\*\*p < .01. Standard errors are in parentheses. Physical action is defined as the total amount of actions that can be independently accomplished by the respondent, i.e., BADL+IADL+Movement limitations. Proportion of remittances among migrants in the resident village, proportion of migration in the resident village, number of local factories, and average age of child education are used as instruments.



**Table 7 Estimation of the net effects of migration on left-behind elderly health using different proxy variables (Three-stage least squares)**

Explanatory variables	Dependent variable: Health measures			
	(1) Physical action	(2) Depression score	(3) Physical action	(4) Depression score
<i>Migration effects:</i>				
Having migrant children dummy	4.576*** (0.801)	4.242*** (0.695)		
Number of migrants			1.183*** (0.280)	1.094*** (0.242)
<i>Individual characteristics of elderly person:</i>				
Age	-0.229*** (0.014)	0.004 (0.012)	-0.234*** (0.013)	0.001 (0.011)
Married	-0.642*** (0.194)	0.786*** (0.166)	-0.603*** (0.194)	0.826*** (0.166)
Male	1.245*** (0.169)	1.742*** (0.144)	1.203*** (0.168)	1.702*** (0.144)
Education in years	0.257*** (0.026)	0.056** (0.022)	0.274*** (0.025)	0.071*** (0.022)
Number of chronic diseases	-1.300*** (0.056)	-1.113*** (0.048)	-1.297*** (0.055)	-1.111*** (0.047)
Dummy variable for work last year	3.938*** (0.171)		3.928*** (0.171)	
<i>Household characteristics:</i>				
Per capita income	0.012* (0.007)	0.022*** (0.006)	0.012* (0.007)	0.022*** (0.006)
Number of household members	-0.067 (0.054)	0.086* (0.049)	-0.067 (0.052)	0.080* (0.046)
Number of grandchildren less than 16 years old	0.036 (0.023)	0.036* (0.020)	0.037* (0.023)	0.037* (0.019)
Dummy variable for having cell phone or personal computer		0.473*** (0.159)		0.511*** (0.157)
<i>Village-level characteristics:</i>				
Public facilities for elderly	0.258*** (0.071)		0.262*** (0.070)	
Dummy variable for having elderly and disabled assisting organization		0.754*** (0.271)		0.772*** (0.272)
Distance to local hospital in ten kilometers	0.161** (0.073)		0.158** (0.073)	
Number of bus lines	-0.026 (0.039)	-0.017 (0.029)	-0.015 (0.037)	-0.007 (0.028)
Constant	56.592*** (1.327)	18.538*** (1.108)	57.506*** (1.256)	19.268*** (1.053)
Year dummy	Yes	Yes	Yes	Yes
Province dummy	Yes	Yes	Yes	Yes
Observations	8,137	8,137	8,137	8,137

Notes: Significance codes: \*p < .10; \*\*p < .05; \*\*\*p < .01. Standard errors are in parentheses. Physical action is defined as the total amount of actions that can be independently accomplished by the respondent, i.e., BADL+IADL+Movement limitations. 1 mu = 1/15 hectare.

## Appendix A

For left-behind elderly, being able to live independently is important in the migration context. SRH has been used frequently in literature [e.g., Kuhn, Everett et al. (2011)]. CHARLS provides five options for the SRH question, from “Excellent (4 points)” to “Poor (0 point).” However, this study mainly used functional indicators, such as BADL, IADL, and movement limitations, that are focused on whether the respondent experiences difficulties in daily activities. BADL contains six questions and measures the ability to perform basic tasks, such as dressing, walking across a room, and eating on their own. IADL and movement limitation indicators have five and seven questions respectively, and focus on activities necessary to live relatively independently, such as long-distance walk, stooping, kneeling, or crouching. The options given to each question were “No difficulty (3 points),” “Have difficulty but can still do it (2 points),” “Have difficulty and need help (1 points),” and “Cannot do it (0 point).” As BADL, IADL, and movement limitation indicators describe different aspects of exercise performance, an aggregate variable must be created to measure physical health. We design two approaches to aggregate these indicators. First, we use the total number that a respondent can independently accomplish actions to represent corresponding physical health status. An alternative is to use aggregate physical action score over all questions answered by the respondents. Moreover, the higher the points a respondent has, the better his/her physical health status is. The second method will be used for robustness examination.

Body mass index (BMI) is the ratio of weight (in kilograms) to the square of height (in meters). It provides an anthropometric measure of physical health. The relationship between BMI and health condition is usually a U-shaped curve, in which a low BMI is associated with a low health status. Health status appears to increase, albeit slowly, as BMI increases above 25. We follow the World Health Organization (WHO) standard, which uses fixed cut-offs and defines low BMI as less than 18.5 (underweight) and high BMI as greater than 25 (overweight). Thus,

a BMI dummy variable is set to represent whether the BMI of the left-behind parents is in the suggested healthy range.

A 10-question version of the Center for Epidemiologic Studies-Depression (CES-D) is used in CHARLS to measure mental health status. The respondents were asked whether they faced psychological problems in the most recent week, such as feeling depressed, fearful, or lonely. The options given were "<1 day (3 points)," "1-2 days (2 points)," "3-4 days (1 point)," and "5-7 days (0 point)." The aggregate point for these questions, named depression score, is used for mental health variable. Apparently, a high value of mental health variable implies better mental health.

To assess the cognitive capacity of the left-behind elderly respondents, CHARLS conducted a short memory test, which was also used in Böhme, Persian et al. (2015). The elderly respondents were told 10 simple words, and were then asked to recall these words and count the number of words, named cognition test score. On average, respondents remember 2.7 words immediately after they were told.

## Appendix B

**Table B.1 Estimation of the impact of migration and remittances on left-behind elderly mental health with a dummy of liquidity constraints (Two-stage least squares)**

Explanatory variables	Dependent variable: Depression score				
	Liquidity constraint thresholds				
	Liquid asset values in thousand yuan				Poverty line
	(1) 20	(2) 50	(3) 80	(4) 100	(5) \$1.9/day
<i>Migration effects:</i>					
Number of migrants	-3.784* (1.995)	-2.908* (1.643)	-2.940* (1.532)	-2.904* (1.522)	-3.080* (1.620)
Remittances in thousand yuan	2.118*** (0.734)	1.737*** (0.556)	1.458*** (0.423)	1.456*** (0.422)	1.751*** (0.538)
Remittances in thousand yuan×high value of liquid assets dummy	-1.897*** (0.661)	-1.629*** (0.519)	-1.118*** (0.330)	-1.120*** (0.338)	
Remittances in thousand yuan×above poverty line dummy					-1.550*** (0.478)
<i>Individual characteristics of elderly person:</i>					
Age	-0.006 (0.028)	0.009 (0.023)	0.009 (0.021)	0.009 (0.021)	0.000 (0.024)
Married	0.889** (0.407)	0.810** (0.351)	0.762** (0.310)	0.761** (0.310)	0.851** (0.351)
Male	1.906*** (0.319)	1.741*** (0.271)	1.789*** (0.276)	1.788*** (0.276)	1.827*** (0.284)
Education in years	0.055 (0.042)	0.047 (0.038)	0.026 (0.038)	0.024 (0.038)	0.052 (0.038)
Number of chronic diseases	-1.244*** (0.096)	-1.184*** (0.085)	-1.245*** (0.097)	-1.244*** (0.097)	-1.251*** (0.091)
Dummy variable for having cell phone or personal computer	0.027 (0.370)	0.010 (0.332)	-0.070 (0.311)	-0.082 (0.313)	0.064 (0.321)
<i>Household characteristics:</i>					
Number of children	0.423 (0.304)	0.249 (0.249)	0.317 (0.248)	0.309 (0.247)	0.351 (0.264)
Number of grandchildren less than 16 years old	0.035 (0.037)	0.045 (0.033)	0.020 (0.035)	0.021 (0.035)	0.041 (0.034)
<i>Village-level characteristics:</i>					
Dummy variable for having elderly and disabled assisting organization	0.792 (0.599)	0.865* (0.513)	0.945** (0.468)	0.945** (0.467)	0.939* (0.528)
Number of bus lines	0.077 (0.068)	0.119 (0.075)	0.115* (0.066)	0.114* (0.066)	0.070 (0.059)
Constant	19.945*** (1.941)	19.541*** (1.751)	19.795*** (1.628)	19.848*** (1.629)	19.805*** (1.727)
Year dummy	Yes	Yes	Yes	Yes	Yes
City dummy	Yes	Yes	Yes	Yes	Yes
Observations	8,137	8,137	8,137	8,137	8,137

Notes: Significance codes: \*p < .10; \*\*p < .05; \*\*\*p < .01. Standard errors are in parentheses. Proportion of remitting among migrants in the resident village, proportion of migration in the resident village, number of local factory and average of children education are used as instruments.

**Table B.2 Analysis of variance of health measures and migration**

<b>Variable</b>	<b>Proportion of within- variation (%)</b>	<b>Proportion of between- variation (%)</b>
Physical health	21.62	78.38
BADL	30.06	69.94
IADL	28.39	71.61
Movement limitations	23.05	76.95
SRH	30.41	69.59
BMI	14.41	85.59
Depression score	25.99	74.01
Cognition test score	31.28	68.72
Number of migrant children	24.49	75.51
Remittance	43.68	56.32

Notes: Values are computed using balanced panel including 3060 rural elders.