



Published in final edited form as:

Jpn Econ Rev (Oxf). 2016 June ; 67(2): 192–210. doi:10.1111/jere.12102.

Effects of Informal Caregivers' Health on Care Recipients

Michio Yuda[†] and Jinkook Lee[‡]

[†]Chukyo University

[‡]University of Southern California and RAND Corporation

Abstract

Informal care is increasingly important in countries undergoing population aging. Previous research has discussed how the long-term care system may affect the behaviors of informal caregivers but has paid not much attention to how changes in caregivers' circumstances, particularly their health, affect those receiving their care. Using the Japanese Study of Aging and Retirement, we empirically examine how caregivers' health condition may affect the elderly parents receiving their care. We find empirical evidence that declining caregivers' health adversely affects care recipients' health. We see such links between informal caregivers and their in-laws, demonstrating that these effects go beyond genetic influences.

1. Introduction

In recent years, informal care provision has become increasingly important in countries that face population aging. Within a family, informal care, typically by a child for their elderly parent and increasingly by a spouse, can suit the elderly's needs in their familiar home and environment. While informal care can help alleviate the financial burden of public-health and long-term care systems, it might burden care providers, worsening their physical and psychological health, hampering their labor supply, or disrupting their leisure activities.

Previous studies on informal care tend to focus on the following areas. First, several studies have examined the relationship between informal and formal care provision (Pezzin et al., 1996; Van Houtven and Norton, 2004 and 2008; Hanaoka and Norton, 2008; Bonsang, 2009; Spillman and Long, 2009; Tamiya et al., 2011; Kikuchi, 2012; Paraponaris et al., 2012) and found that informal care substitutes for formal care although the effects differ by situation. Second, previous literature has established that providing informal care negatively affects the caregiver's labor supply (Carmichael and Charles, 1998 and 2003; Pezzin and Schone, 1999; Noguchi and Shimizutani, 2004; Carmichael et al., 2010; Hassink and Van den Berg, 2011; Tamiya et al., 2011; Otsu and Komamura, 2012; Van Houtven et al., 2013) and health (Kishida and Takagi, 2007, and Suzuki et al., 2008). Third, previous research has explored who becomes a caregiver within a family (Fontaine et al., 2009; Pezzin et al., 2009), finding that economic conditions of siblings and the relationship between children and parents

*Corresponding author: Michio Yuda (School of Economics, Chukyo University). Address: 101-2, Yagoto-Honmachi, Showa-Ward, Nagoya, Aichi, 4668666, Japan. TEL & FAX: +81-52-835-7146. Email: yudamich@mecl.chukyo-u.ac.jp. The appendices to this paper are available at the author's website: <https://sites.google.com/site/yudamichi/home/research>.

significantly affect this decision. Gervès-Pinquié et al. (2014), for example, estimate that willingness to pay to reduce caregiving time is €12.1 per hour.

These studies show how long-term care can affect caregiver behaviors but give little attention to how changes in caregiver's circumstances ultimately affect those receiving care. Informal care, can, as noted, provide several benefits to those receiving it, as well as to the finances of long-term care systems. Yet such advantages may put burdens on caregivers and ultimately affect those receiving care. Researchers and policymakers should account for such burdens and their effects in estimating the costs and benefits of informal care giving.

In this paper, we use the Japanese Study of Aging and Retirement (JSTAR) to empirically examine how burdens placed on caregivers may ultimately affect those receiving informal care. Japan is a critical setting for such research because of its rapid pace of population aging. The age of informal caregivers has indeed been increasing in Japan. *The 2013 Comprehensive Survey of Living Conditions* commissioned by the Ministry of Health, Labour, and Welfare (MHLW) in Japan shows that the proportion who are at least 60 years of age has increased from 54.4 percent in 2001 to 69.0 percent in 2013, while the proportion of those at least 75 years of age increased from 18.7 percent in 2001 to 29.0 percent in 2013. This elder-to-elder care (*ro-ro kaigo*) may worsen caregiver's health, as evident in recent headlines on tragic cases of family suicide driven by the heavy burden of caregiving.

Investigating the caregiving burden on caregivers' health and subsequent consequences for care recipients can illuminate a serious social issue in Japan and provide useful insights to policy makers in other countries facing population aging. Our results show that worsening health among informal caregivers adversely affects the health of those receiving their care. We see such links between informal caregivers and their in-laws, demonstrating that these effects go beyond genetic influences.

In the next section, we provide a brief policy background with an overview of the Japanese long-term care insurance system. In Section 3, we discuss details of the data we use. In Sections 4 and 5, we review methods and present empirical results. In Section 6 we present some robustness checks for our empirical analyses. In Section 7 we conclude.

2. Policy Background

Japan introduced its long-term care insurance (LTCI) system in April 2000 to support independent living for the elderly and decrease burden on family members who provide caregiving¹. The insurer of the LTCI is each municipality.² Prefectural and national governments also support LTCI finance and management. LTCI is compulsory for all persons at least 40 years of age, who pay earnings-related premiums. The primary insured are those at least 65 years of age, and the secondary insured are those 40 to 64 years of age. The decision process for choosing a level of care for long-term services is as follows.

¹Tsutsui and Muramatsu (2005) and National Institute of Population and Social Security Research (2014, Ch5) reviews the Japanese LTCI system in more detail. Tamiya et al. (2011) also summarize its background, how it compares to similar systems in other countries, and its current policy challenges.

²Several small municipalities organize an extended association as a regional insurer for their financial stability and administrative efficiency.

Persons 65 or older or those 40 to 64 with qualifying illnesses requiring long-term care (e.g., because they are bedridden or have dementia) or support (e.g., because they are infirm) can apply for LTCI benefits. Care level and severity of care need³ is objectively determined by a computer program and a doctor's opinion. Those qualifying receive long-term care and preventive benefits tailored to their circumstances. Recipients have a copayment of 10% of the cost⁴, and the remaining 90% is split evenly between premiums and other public funds.

The number of long-term care recipients certified by the LTCI system increased from 2.2 million in 2000 to 5.3 million in 2012. Growth in the number of recipients has been particularly great at lower levels of care need. Total LTCI cost has also increased from 362 million yen in 2000 to a budgeted 892 million yen in 2012. To alleviate fiscal burden and to make the system more efficient, policymakers have sought several reforms. These included preventive-care benefits, introduced in 2005, that seek to increase healthy life expectancy though prevention of severe disability. Yuda et al. (2013) find that these preventative-care benefits maintain or improve the level of care for the elderly. The LTCI law was revised in 2008 to prevent devious activities of care providers such as non-observance of the law or submission of bogus claims. The law was revised again in 2012 to develop locally comprehensive systems for health and long-term care, prevention, residence, and livelihood support.

3. Data

To assess how circumstances of informal caregivers affect those for whom they care, we use data from the Japan Study of Aging and Retirement (JSTAR). The JSTAR is a panel survey of elderly people conducted by the Research Institute of Economy, Trade and Industry (RIETI), Hitotsubashi University, and the University of Tokyo. The JSTAR collects information on health and socioeconomic characteristics of respondents and their family members through a self-completion questionnaire and a computer-assisted personal interview. It is comparable to the Health and Retirement Study (HRS) survey in the United States, the Survey of Health, Aging and Retirement in Europe (SHARE), and the English Longitudinal Study of Aging (ELSA) in the United Kingdom⁵. The JSTAR sampled five municipalities in 2007, which have been surveyed every two years since then, an additional two municipalities in 2009, and an additional three, bringing the total to ten municipalities, in 2011. Its respondents are persons aged 50 to 75 as randomly selected from the Basic Resident Register (*Jumin Kihon Daicho*)⁶. The first five municipalities were Adachi-Ku, Kanazawa City, Shirakawa City, Sendai City, and Takigawa City (N=4,163 in 2007 with 82% to 87% retention rates in the follow-up waves in 2009 and 2011). The two municipalities added in 2009 were Tosu City and Naha City (N=1,567 in 2009 with 70%

³The care level is classified into 8 categories (self-reliant, support level 1 and 2, and care level 1 to 5 (needing most case)). Generally, the elderly with care level 3 or higher cannot do daily activities, even if someone supports or assists them. See the Ministry of Health, Labour, and Welfare (2013, p.11) for a simple explanation.

⁴The Long-term Care Insurance Act determines the upper limit of the benefits. Benefits depend on the receiver's care level for home-care services and on the type and scale of the facility for facility-care services.

⁵See Ichimura, Shimizutani, and Hashimoto (2009) as well as the more recent and detailed information is available on the website of the *GATEWAY TO GLOBAL AGING DATA* (<http://g2aging.org>).

⁶This sampling method differs from those of the HRS, the SHARE, and the ELSA. The JSTAR uses its sampling strategy so as to allow analysts to compare economic activities of individuals under the same circumstance.

retention rate in 2011), and the three municipalities added in 2011 were Chofu City, Tonbayashi City, and Hiroshima City (N=2,184). The baseline response rates for all municipalities range from 48.5% to 52.2%.

The sample of this study consists of the JSTAR respondents and their living parents and parents-in-law at the first survey certified for long-term care and support under the LTCI system⁷. Table 1 presents the summary statistics for the study sample, including both care receivers and caregivers, and Table 2 defines the variables used in this study. The mean certified level of care at the baseline wave is relatively low, at the support level of 1.14 on a 0-to-5 scale, with 0 as “Not applicable (self-reliant)”. Among care recipients' characteristics, who have an average age of 86.8 years, 74.0 percent are female and 14.0 percent of them are institutionalized in the nursing care facility. Their subjective health is basically good, but 26 percent have ADL limitations, 18 percent have clinically significant depressive symptoms, and 15 percent have poor memory functions. In addition, 74 percent reported chronic diseases, and 59 percent are under treatment. Caregivers, who have an average age of 60.5 years, are 47.2 percent female. Among caregivers, 91.2 percent are married, and 3.2 percent are widowed. Their mean gross yearly income is 3.6 million yen and their mean amount of assets is 6.4 million yen, with 59.6 percent being a householder and 2.4 percent being a landholder, while 10.1 percent receive financial support from persons other than their spouse. On average, caregivers provide 0.1 hours of informal care on weekdays and 0.2 hours of informal care on weekends.

The right side of Table 1 summarizes the proportions of caregivers reporting specified poor health conditions by year. The proportion of care receivers certified for care increased from 29.0% to 34.3% across the three waves of the survey⁸. In addition, the proportions of caregivers with functional and IADL limitations, depression symptoms, disease under treatment and weakening grip strength increased from 2007 to 2011.

In addition, *the Survey of Long-term Care Benefit Expenditures* of the MHLW shows that 50 to 60 percent of the elderly certified for care level or higher have been admitted to a nursing facility in recent years. Because they receive formal care, there may not be strong correlations between caregiver's health and the institutionalized care for these receiving care. We therefore conduct our analyses using only the subsample of the elderly with low care levels (less than support level 2, less than care level 1, and less than care level 2) at the first survey who receive informal care at home.

4. Empirical Models

To examine how caregiver health may affect the health of those receiving care, we specify the following model.

⁷Because of troubles with survey equipment, questions regarding informal care in 2011 include only those for the respondent's parents and not the respondent's in-laws.

⁸The proportions of different cohorts of municipalities are shown in Appendix A.

$$H_{Rit} = \alpha_0 + \alpha_1 H_{Git} + \mathbf{x}_{Rit} \boldsymbol{\alpha} + \text{year}_t + \text{municipality}_i + u_{Rit} \quad (1)$$

H_R is an ordinal variable that represents care receiver i 's level of care needs as certified by municipality in year t .

H_G represents the caregiver's health condition. We employ ten proxy variables for the caregiver's physical and psychological health conditions⁹: subjective self-reported health status, grip strength, and indexes for functional limitations, ADL limitations, IADL limitations, CES-D (the Center for Epidemiologic Studies Depression Scale) scores¹⁰, poor memory function, the history of disease, and the disease under treatment. Carney et al. (2003), Siegel et al. (2004), Steffens et al. (2006), and Lee et al., (2012) find that deteriorating health of an individual adversely affects the health of other household members. Because higher values of these variables represents poor health, α_1 is estimated to be positive when deterioration of a caregiver's health leads to worse care for those receiving it.

\mathbf{x}_R is a vector of attributes for those receiving care that contains gender, age and its squares, and an indicator of nursing-facility (*kaigo hoken shisetsu*) admission. Because female life expectancy is generally longer than that for males, we expect the coefficient for the female dummy variable to be positive. We also expect the certified level of care needed to increase with age. We add a dummy variable for nursing-facility admission because the relationships of institutionalized individuals with their caregivers differ from those that non-institutionalized elderly have with their caregivers. year is a year-fixed effect and municipality is a municipal-fixed effect. u_R is an error term that we assume to be exogenous (i.e., $E[u_R|\mathbf{x}] = 0$, where \mathbf{x} includes all regressors in equation (1)).

Because the caregiver's health-status variables are also endogenous, estimated parameters may be biased. To solve this endogeneity problem, we define the following equation (2), and jointly estimate the equations (1) and (2).

$$H_{Git} = \beta_0 + \mathbf{x}_{Git} \boldsymbol{\beta} + \mathbf{x}_{Rit} \boldsymbol{\gamma} + \text{year}_t + \text{municipality}_i + u_{Git} \quad (2)$$

\mathbf{x}_G is a vector of caregiver attributes that contains gender, age and its squares, years of education, dummy variables for marriage and widow, gross yearly (marital) income, the amount of (marital) assets, dummy variables for householder and landholder, an index for having financial support from another person besides one's spouse, and the hours of informal care provision per day on a weekday and weekend¹¹. u_G are error terms that we assume to be exogenous ($E[u_G|\mathbf{z}] = 0$, where \mathbf{z} includes all regressors in equation (2)).

⁹Appendix B presents the detailed explanation.

¹⁰The JSTAR asks 20 questions to measure the CES-D score. Because they are composed of 16 negative and 4 positive questions, respondents who choose the same numbers may provide unreliable answers (see Carlson et al., 2011; and Sekizawa et al., 2013). We therefore define two types of this variable. See Table 2.

We estimate these equations by a linear panel data model with and without instrumental variables (OLS/ IV). The structure of the IV models reveals that equation (2) assumes the role of the first stage regression with instrumental variables of \mathbf{x}_G . As a care receiver's certified level of care needs is objectively determined by a municipal insurer, it is reasonable to assume that \mathbf{x}_G has sufficient power for explaining H_G but is not correlated with u_R . To consider family effects, we also estimate clustering robust standard errors that allow for correlated residuals within families.

In addition, the length of hours of informal care can be affected by various socioeconomic characteristics, which means these variables may be endogenous. To address this problem, we employ the two-step estimation method. Specifically, we first use the panel data for caregivers to estimate the following equation (3) to obtain the predicted values of the hours of informal provision. In the second step, we use the predicted values instead of original variables and estimate equations by IV (2 step IV).

$$HIF_{jit} = \delta_0 + \mathbf{x}_{G,1,it} \boldsymbol{\delta}_x + \mathbf{z}_{G,it} \boldsymbol{\delta}_z + \text{year}_t + \text{municipality}_i + e_{G,it} \quad (3)$$

HIF_j is the number hours of informal care provision per day on weekdays ($j = 1$) and weekend ($j = 2$), and \mathbf{z}_G contains the number of potential caregivers for the parents and parents-in-law. The caregiver's hours of informal care provision vary with the number of potential caregivers within a family. In this case, we need to adjust standard errors because the predicted values used in the second step estimation are the generated regressors (Wooldridge, 2010). We employ bootstrap method to obtain valid standard errors¹². We also estimate the following reduced-form (RF) equations as the robustness check on the estimation results¹³.

$$H_{R,it} = \pi_0 + \pi_1 H_{G,it} + \mathbf{x}_{G,it} \boldsymbol{\pi}_2 + \mathbf{x}_{R,it} \boldsymbol{\pi}_3 + \text{year}_t + \text{municipality}_i + u_{it} \quad (4)$$

5. Empirical Results

Table 3 shows the selected empirical results of OLS and IV models based on F and Hausman tests for panel specification¹⁴, ¹⁵, ¹⁶ The results of two test statistics for the validity of the instruments based on fixed-effect models are shown at the middle. Most of the original

¹¹For example, Kishida and Takagi (2007) and Suzuki et al. (2008) find that the burden of informal care provision may adversely affect the caregiver's health.

¹²Estimation results of equation 3 are shown in Appendix C.

¹³We also estimate the equations excluding hours of informal care provision, with results similar to our main results. See Appendix F.

¹⁴Empirical results using other subsamples of less than support level 2 and less than care level 2 are shown in Appendix D because of the space limitation.

¹⁵The first stage estimation results are shown in Appendix E.

¹⁶In addition, because 18.5 percent of the parents do not receive care, we also estimated the same models above on the 81.5 percent of parents who do receive care. We find that several health indicators for caregivers significantly and adversely affect level of care for those receiving it. See Table G1 in Appendix G. In addition, Maruyama (2015) recently find that intergenerational co-residence by elderly parents and their adult children also affects the elderly health by using the Japanese data. However, we do not use this variable because this is statistically endogenous in the original IV regressions. See Table H1 in Appendix H.

estimation results have weak instruments problem, which indicates that they have insufficient power for explaining caregiver health. To this problem, we apply the limited information maximum likelihood (LIML) estimation (Stock et al., 2002) and estimate the minimum eigenvalue statistic (Cragg and Donald, 1993; Stock and Yogo, 2002). In addition, in the most of models, we cannot reject the null hypothesis of the over-identifying restrictions test that instruments are exogenous, which indicates that the instruments are not correlated with u_R' .

We find that several worsening caregiver health conditions significantly contribute to worsening care receivers' health condition indicated by the certified level of care needed. In particular, reduction in caregiver's grip strength significantly increases the recipient's certified level of care needs in both the OLS and IV models and in both the full sample and the subsample. Because grip strength is known to predict the prognosis of survivorship and functional independence (Hashimoto, 2014), this result implies that physical decay makes it difficult for caregivers to provide informal care, increasing the level of care needs for those receiving it. Moreover, caregiver's functional limitation, depressive symptoms, and poor memory function significantly and positively affect the certified level of care for recipients.

The coefficients of other independent variable are estimated as expected; female and nursing-facility admission dummy variables are positive and care level increases with aging.

6. Robustness Checks

6.1 Exclusion of Genetic Effect

Because genes can affect health and activities (E.g., Conley, 2009; Cawley et al., 2011, Cawley and Ruhm, 2012), the empirical results in the previous subsection may reflect health deterioration of both parents and adult children resulting from shared genetic characteristics. In this subsection, we remove genetic effects from our analysis by examining the effect of caregiver's health on the health of in-laws receiving care.

The empirical results are summarized in Table 4. They show that caregiver's health, as measured by several indicators, significantly and adversely affects the level of care for recipients.

6.2 The Case of One Caregiver

The varying number of caregivers within a family results in largely different situations of informal provision of care for those receiving it. In this subsection, we check how different situations may affect our results by restricting our sample to receivers with just one potential caregiver¹⁷. The empirical results are summarized in Table 5 and show that several health indicators for sole caregivers significantly and adversely affect level of care.

¹⁷In this case, we can define the hours of formal care receiving by subtracting the total number hours of care (formal and informal) services from the caregiver's hours of providing informal care. We examine the effect of formal care utilization on the care level by adding the above variables as independent variables in equation (1). See Appendix I.

6.3 The Effect of Actual Changes in Caregiver's Health Condition

Because the JSTAR is a panel dataset, we can observe caregivers whose health status changed during the observed time period. In this subsection, we investigate in more detail how changes in caregivers' health condition may affect the elderly parents receiving their care. The empirical results are summarized in Table 6. They show that several health indicators for caregivers significantly and adversely affect level of care for those receiving it.

7. Conclusions and Implications

In this paper, we use the JSTAR to examine how the health of informal caregivers affects the care recipient's health, indicated by the level of care needs. We find that deteriorating health for a caregiver adversely affects the certified level of care needs, and that this effect persists even among individuals who are not genetically related.

These results imply that policies helping caregivers maintain good physical and psychological health may also help maintain the health of care recipients. This suggests policymakers should introduce aggressive health promotion and care prevention policies for middle-aged persons and those likely to be providing care. Some such policies have already been implemented in Japan as part of the national health screening and intervention program in 2008¹⁸. Such policies are expected to improve the health of potential caregivers. Such strengthening of the informal care system will help improve LTCI finances.

Our work has some limitations. The JSTAR does not include detailed information on the parents' formal-care utilization nor on expenditures for it. In Japan under the LTCI, there are a wide variety of formal care services available for long-term care. Therefore, deterioration of caregivers' health might increase formal care utilization. In such case, deterioration of caregiver's health may not have direct influence on care receivers' health. Some households might face budget constraint restricting access to the formal care market. Households in which middle-aged members have serious health problems may face particularly perilous financial conditions. Such households, even if having unhealthy caregivers, are not likely to substitute formal care for informal care. Because these discussions have very important policy implication for the LTCI system, future research should examine these hypotheses. In addition, information on use of health care by elderly parents is unavailable in JSTAR. Such information could help identify opportunities for cooperation in health and long-term care systems. Finally, results from the JSTAR may not be generalized because the sample is not nationally representative. Further analyses using other, nationally representative data would help confirm our findings.

Acknowledgments

We appreciate two anonymous referees, James Banks, Axel Börsch-supan, Michael Hurd, Hidehiko Ichimura, Colin R. McKenzie, Hirokazu Matsuyama, Michio Naoi, Masao Ogaki, Takashi Oshio, Yasuyuki Sawada, Miki Seko, Satoshi Shimizutani, and seminar participants at the RIETI-JER Workshop and Keio University. We also thank the JSTAR team of the RIETI for their support. This study was financially supported by research grants from the Japan

¹⁸The national health screening and intervention program targets individuals aged 40 to 74 to prevent them at a risk of lifestyle-related diseases through focusing on metabolic syndrome. See Kohro et al., (2008) for more detailed explanation.

Society for Promotion of Science (No.26780180) and from the National Institute on Aging/National Institutes of Health (R01 AG030153). The authors assume responsibility for any errors.

References

- Bonsang E. Does informal care from children to their elderly parents substitute for formal care in Europe? *Journal of Health Economics*. 2009; 28(1):143–154. [PubMed: 18950879]
- Carlson M, Wilcox R, Chou CP, Chang M, Yang F, Blanchard J, Marterella A, Kuo A, Clark F. Psychometric properties of reverse-scored items on the CES-D in a sample of ethnically diverse older adults. *Psychological Assessment*. 2011; 23(2):558–562. [PubMed: 21319906]
- Carmichael F, Charles S. The labour market costs of community care. *Journal of Health Economics*. 1998; 17(6):747–765. [PubMed: 10339251]
- Carmichael F, Charles S. The opportunity costs of informal care: does gender matter? *Journal of Health Economics*. 2003; 22(5):781–803. [PubMed: 12946459]
- Carmichael F, Charles S, Hulme C. Who will care? Employment participation and willingness to supply informal care. *Journal of Health Economics*. 2010; 29(1):182–190. [PubMed: 20004991]
- Carney RM, Blumenthal JA, Catellier D, Freedland KE, Berkman LF, Watkins LL, Czajkowski SM, Hayano J, Jaffe AS. Depression as a risk factor for mortality after acute myocardial infarction. *American Journal of Cardiology*. 2003; 92:1277–1281. [PubMed: 14636903]
- Cawley J, Ruhm, CJ. The economics of risky health behaviors. In: Pauly, MV.; McGuire, TG.; Barros, PP., editors. *Handbook of Health Economics*. Vol. 2. North Holland: Elsevier; 2012. p. 95-199.
- Cawley J, Han E, Norton EC. The validity of genes related to neurotransmitters as instrumental variables. *Health Economics*. 2011; 20(8):884–888. [PubMed: 21612000]
- Conley D. The promise and challenges of incorporating genetic data into longitudinal social science surveys and research. *Biodemography and Social Biology*. 2009; 55(2):238–251. [PubMed: 20183907]
- Cragg JG, Donald SG. Testing identifiability and specification in instrumental variable models. *Econometric Theory*. 1993; 9(2):222–240.
- Fontaine R, Gramain A, Wittwer J. Providing care for an elderly parent: interactions among siblings? *Health Economics*. 2009; 18(9):1011–1029. [PubMed: 19634124]
- Gervès-Pinquié C, Bellanger MM, Ankri J. Willingness to pay for informal care in France: the value of funding support interventions for caregivers. *Health Economics Review*. 2014; 4 Article 34.
- Hashimoto, H. Health consequences of transitioning to retirement and social participation: Evidence from JSTAR panel data. presented paper at the RIETI-JER Workshop: Economics of Aging in Japan and other Societies; 2014.
- Hassink WHJ, Van den Berg B. Time-bound opportunity costs of informal care: Consequences for access to professional care, caregiver support, and labour supply estimates. *Social Science and Medicine*. 2011; 73(10):1508–1516. [PubMed: 21982632]
- Hanaoka C, Norton EC. Informal and formal care for elderly persons: How adult children's characteristics affect the use of formal care in Japan. *Social Science and Medicine*. 2008; 67(6): 1002–1008. [PubMed: 18579273]
- Ichimura H, Shimizutani S, Hashimoto H. JSTAR First Results 2009 Report. RIETI Discussion Paper Series 09-E-047. 2009:1–305.
- JSTAR datasets, produced by the Research Institute of Economy, Trade and Industry (RIETI), Hitotsubashi University, and the University of Tokyo, are distributed by RIETI in Tokyo, Japan.
- Kikuchi, J. Does formal care substitute informal care?. In: Ihori, T.; Kaneko, Y.; Noguchi, H., editors. *New Risks in the Social Security System: Establishment of supportive measures over a lifetime*. Tokyo: The University of Tokyo Press; 2012. p. 211-230. in Japanese
- Kishida K, Tanigaki S. What's needed in at-home services? An analysis of family care burden. *Japanese Journal of Health Economic and Policy*. 2007; 19(1):21–35. in Japanese with English Abstract.
- Kohro T, Furii Y, Mitustake N, Fujii R, Morita H, Oku S, Ohe K, Nagai R. The Japanese National Health Screening and Intervention Program Aimed at Preventing Worsening of the Metabolic Syndrome. *International Heart Journal*. 2008; 49(2):193–203. [PubMed: 18475019]

- Lee J, Paddock SM, Feeney K. Emotional distress and cognitive functioning of older couples: A dyadic analysis. *Journal of Aging and Health*. 2012; 24(1):113–140. [PubMed: 21990580]
- Maruyama S. The effect of coresidence on parental health in Japan. *Journal of the Japanese and International Economics*. 2015; 35(1):1–22.
- National Institute of Population and Social Security Research. [June 20, 2014] Welfare for the elderly, Social Security in Japan 2014. 2014. available at: <http://www.ipss.go.jp/s-info/e/ssj2014/PDF/ssj2014.pdf>
- Noguchi, H.; Shimizutani, S. Economic Analyses on the Market for Long-term Care and Child Care Services: Solution for Current Situations and Policy Proposals by Using Micro Data. Tokyo: Toyo Keizai Shinposha; 2004. in Japanese
- Otsu, Y.; Komamura, K. Burden of long-term care and labor supply. In: Highchi, Y.; Miyauchi, T.; McKenzie, CR.; Panel Data Research Center at Keio University. , editors. *Parent and Child Relationship and Dynamism of Household Behavior: Education, Health, and Employment under the Public-finance Crisis*. Tokyo: Keio University Press; 2012. p. 143-159. in Japanese
- Paraponaris A, Davin B, Verger P. Formal and informal care for disabled elderly living in the community: an appraisal of French care composition and costs. *European Journal of Health Economics*. 2012; 13(3):327–336. [PubMed: 21400197]
- Pezzin LE, Kemper P, Reschovsky J. Does publicly provided home care substitute for family care? Experimental evidence with endogenous living arrangements. *Journal of Human Resources*. 1996; 31(3):650–676.
- Pezzin LE, Schone BS. Intergenerational Household Formation, Female Labor Supply and Informal Caregiving: A Bargaining Approach. *Journal of Human Resources*. 1999; 34(3):475–503.
- Pezzin LE, Pollak RA, Schone BS. Long-term care of the disabled elderly: do children increase caregiving by spouses? *Review of Economics of the Household*. 2009; 7(3):323–339. [PubMed: 20473357]
- Sekizawa Y, Yoshitake N, Goto Y. An examination of the relationship between dysphoria index and other factors using the JSTAR. RIETI Discussion Paper Series 13-J-077. 2013:1–27. in Japanese.
- Siegel MJ, Bradley EH, Gallo WT, Kasl SV. The effect of spousal mental and physical health on husbands' and wives' depressive symptoms, among older adults: Longitudinal evidence from the health and retirement survey. *Journal of Aging and Health*. 2004; 16(3):398–425. [PubMed: 15155069]
- Spillman BC, Long SK. Does high caregiver stress predict nursing home entry? *Inquiry*. 2009; 46(2): 140–161. [PubMed: 19694388]
- Steffens DC, Otey E, Alexopoulos GS, Butters MA, Cuthbert B, Ganguli M, Geda YE, Hendrie HC, Krishnan RR, Kumar A, Lopez OL, Lyketsos CG, Mast BT, Morris JC, Norton MC, Peavy GM, Petersen RC, Reynolds CF, Salloway S, Welsh-Bohmer KA, Yesavage J. Perspectives on depression, mild cognitive impairment, and cognitive decline. *Archives of General Psychiatry*. 2006; 63:130–138. [PubMed: 16461855]
- Stock JH, Yogo M. Testing for weak instruments in linear IV regression. NBER Technical Working Paper Series. 2002; (284)
- Stock JH, Wright JH, Yogo M. A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments. *Journal of Business and Economic Statistics*. 2002; 20(4):518–529.
- Suzuki W, Ogura S, Izumida N. Burden of family care-giving and the rationing in the long-term care insurance benefits of Japan. *Singapore Economic Review*. 2008; 53(1):121–144.
- Tamiya N, Noguchi H, Nishi A, Reich MR, Ikegami N, Hashimoto H, Shibuya K, Kawachi I, Campbell JC. Population ageing and wellbeing: lessons from Japan's long-term care insurance policy. *Lancet*. 2011; 378:1183–1192. [PubMed: 21885099]
- The Ministry of Health Labour Welfare in Japan. The Current Situations and the Future Directions of the Long-term Care Insurance System in Japan: With a Focus on the Housing for the Elderly. 2013. available at: http://www.mhlw.go.jp/english/policy/care-welfare/care-welfare-elderly/dl/ri_130311-01.pdf
- Tsutsui T, Muramatsu N. Care-needs certification in the long-term care insurance system of Japan. *Journal of the American Geriatrics Society*. 2005; 53(3):522–527. [PubMed: 15743300]

- Van Houtven CH, Norton EC. Informal care and health care use of older adults. *Journal of Health Economics*. 2004; 23(6):1159–1180. [PubMed: 15556241]
- Van Houtven CH, Norton EC. Informal care and medicare expenditures: testing for heterogeneous treatment effects. *Journal of Health Economics*. 2008; 27(1):134–156. [PubMed: 17462764]
- Van Houtven CH, Coe NB, Skira MM. The effect of informal care on work and wages. *Journal of Health Economics*. 2013; 32(1):240–252. [PubMed: 23220459]
- Wooldridge, JM. *Econometric Analysis of Cross Section and Panel Data*. The MIT Press; 2010.
- Yuda M, Suzuki W, Morozumi R, Iwamoto Y. The effect of introducing prevention benefits on changes in care levels of support-level 1 care receivers. *The Quarterly of Social Security Research*. 2013; 49(3):310–325. in Japanese.

Table 1

Summary Statistics

Endogenous Variables	Summary Statistics			Proportions of Poor Health Conditions by Year			Remarks
	Obs	Mean	Std. Dev.	2007	2011	2011	
Care Level	5897	1.137	1.779	29.0	34.3	[1]	
Caregiver's health status							
Self-Reported Health	5286	1.712	0.708	8.3	7.5	[2]	
Functional Limitations	5625	0.123	0.328	11.3	15.1	[3]	
ADL Limitations	4129	0.259	0.159	3.3	2.1	[3]	
IADL Limitations	5482	0.045	0.208	4.3	5.6	[3]	
Grip Strength	5089	30.334	8.692	31.5	29.6	[4]	
CES-D Score I	4762	0.178	0.383	15.7	19.7	[3]	
CES-D Score II	4650	0.183	0.386	16.1	20.1	[3]	
Poor Memory Functions	5897	0.147	0.354	31.0	5.0	[3]	
Diseases (Medical History)	4517	0.739	0.439	96.7	64.4	[3]	
Diseases (Under Treatment)	3026	0.591	0.492	63.8	72.5	[3]	
Care receiver's individual characteristics							
Female	5897	0.740	0.439				
Age	5897	86.818	6.574				
Institutioned	5897	0.140	0.347				
Hours of Formal Care Utilization (Weekday)	2009	1.271	4.089				
Hours of Formal Care Utilization (Weekend)	2009	1.245	4.077				
Caregiver's individual characteristics							
Female	5897	0.472	0.499				
Age	5897	60.523	5.850				
Education	5506	12.826	2.421				
Married	5566	0.912	0.283				

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

	Summary Statistics			Proportions of Poor Health Conditions by Year	
	Obs	Mean	Std. Dev.		
Widowed	5897	0.032	0.176		
Income	5652	0.359	0.605		
Assets	5728	0.635	1.491		
Householder & Landholder	5897	0.596	0.491		
Householder	5897	0.596	0.491		
Financial Support	5897	0.024	0.152		
Coresidence (the number of persons)	5281	0.184	0.388		
Hours of Informal Care Provision (Weekday)	5897	0.099	0.752		
Predicted value	3714	0.044	0.282		
Hours of Informal Care Provision (Weekend)	5897	0.167	0.913		
Predicted value	3714	0.028	0.655		
Number of Observations (Maximum)					5897
Number of Care Receivers (Maximum)					2808
Number of Caregivers (Maximum)					1642

Remarks: [1] The proportions of the certified care receivers. See Table 2 for the definition.

[2] The proportions of the caregivers with *Poor* and *Very Poor* health. See Table 2 for the definition.

[3] The proportions of the caregivers with more than one difficulty.

[4] Means of grip strength test score.

Table 2
Definitions of the Variables

Variables		Definition
Care Receiver's characteristics		
H_R	Care Level	The level of care needs as certified by municipality: = 0 for Not applicable (self-reliant); 1 support levels 1 or 2; 2 for care level 1; 3 for care level 2; 4 care level 3, 4, or 5; and 5 if the care receiver passes away.
x_R	Female	=1 if female; 0 otherwise
	Age	Care receiver's Age
	Institutioned	=1 if the care receiver is admitted at the nursing facility
	Hours of Formal Care Utilization (Weekday)	Hours of formal care utilization per day (weekday)
	Hours of Formal Care Utilization (Weekend)	Hours of formal care utilization per day (weekend)
Caregiver's characteristics		
H_G	Self-Reported Health	Caregiver's subjective self-reported health status; = 0 for very good; 1 good; 2 fair; 3 bad; and 4 very bad
	Functional Limitations	= 1 if the respondent with more than one functional limitations for dairy activities; 0 otherwise ⁽¹⁾
	ADL Limitations	= 1 if the respondent with more than one activities of daily living (ADL) limitations; 0 otherwise ⁽¹⁾
	IADL Limitations	= 1 if the respondent with more than one instrumental activities of daily living (IADL) limitations; 0 otherwise ⁽¹⁾
	Grip Strength (kg)	grip strength test score (kg)
	CES-D Score I	= 1 if the respondent with the CES-D score of 16 and more; 0 otherwise ⁽¹⁾
	CES-D Score II	Excluding the respondents whose choose the same answers ⁽¹⁾ .
	Poor Memory Functions	= 1 if the respondents cannot answer the memory test; 0 otherwise
	Diseases (Medical History)	= 1 if the respondent with more than one history of diseases; 0 otherwise ⁽¹⁾
	Diseases (Under Treatment)	=1 if the respondent with more than one diseases under treatment; 0 otherwise ⁽¹⁾
x_G	Female	=1 if female; 0 otherwise
	Age	Caregiver's Age
	Education	Caregiver's years of education
	Married	= 1 if married; 0 otherwise
	Widowed	=1 if widowed; 0 otherwise
	Income	Gross yearly marital income (10 million yen)
	Assets	The amount of marital assets (10 million yen)
	Householder & Landholder	=1 if householder and landholder; 0 otherwise
	Householder	= 1 if householder; 0 otherwise
	Financial Support	= 1 if having financial support from another person besides one's spouse; 0 otherwise
	Informal Care Provision (Weekday)	Hours of informal care provision per day (weekday)
	Informal Care Provision (Weekend)	Hours of informal care provision per day (weekend)

Note

(1) See Appendix B.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 3

The Effect of Informal Caregivers' Health on Their Elderly Parents' Health

Caregiver's Health			Functional Limitations															
Sample	Full sample			Less than care level 1					Less than care level 1									
	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF						
Model	RE	FE	FE (LIML)	RE	Pooled	Pooled (LIML)	Pooled (LIML)	RE	FE	RE	FE (LIML)	RE	Pooled	Pooled	RE			
Caregiver's Health	0.060 *	-0.666	0.788	0.067 *	-0.008	0.664	1.325	-0.003	-0.081	0.429	-2.156	-0.026	0.910 **	0.719	-0.050			
	0.033	0.874	6.708	0.036	0.028	0.720	9.117	0.030	0.122	0.395	33.459	0.077	0.375	0.419	0.069			
R-squared	0.125	0.070	0.141	0.149	0.148	0.054	0.000	0.163	0.102	0.135	0.123	0.151	0.113	0.169	0.162			
F/ ME statistics		48.71	2.13 w			3.19	3.17			140.23	1.22 w		10.30	8.15				
Overidentifying restrictions		9.34	3.79			9.41	7.37			10.31	4.48		13.92	8.69				
Number of Observations	5286	3625	3487	4531	4224	3629	2792	3629	5652	4824	3707	4824	3863	2965	3863			
Caregiver's Health	IADL Limitations																	
Sample	Full sample			Less than care level 1					Less than care level 1									
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV			
Model	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	FE	RE	RE	FE (LIML)	RE	Pooled	Pooled	FE			
Caregiver's Health	-0.089	-0.225	1.387	-0.099	0.298 **	-15.551	-25.328	0.280 *	-0.123	-1.794 ***	-0.984	-0.103	-0.124	-0.561	-0.184 *			
	0.351	2.653	12.017	0.361	0.145	62.204	2150.413	0.143	0.115	0.663	10.052	0.123	0.100	0.558	0.604			
R-squared	0.088	0.235	0.217	0.086	0.196	0.000	0.000	0.206	0.126	0.114	0.220	0.152	0.148	0.152	0.194			
F/ ME statistics		1.84 w	1.67 w			3.45	3.75			131.20	2.39			10.10	5.84			
Overidentifying restrictions		4.19	5.03			6.03	6.96			10.62	5.49			11.38	7.48			
Number of Observations	4129	2610	3707	3707	3297	2965	2965	2965	5482	4692	3615	4692	4368	3751	3751			
Caregiver's Health	CES-D Score I																	
Sample	Full sample			Less than care level 1					Full sample					Less than care level 1				

Caregiver's Health				Self-reported Health										Functional Limitations									
Sample		Full sample		Less than care level 1					Full sample					Less than care level 1									
Method		OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF						
Model		RE	FE	FE (LIML)	RE	Pooled	Pooled (LIML)	Pooled (LIML)	RE	FE	FE (LIML)	Pooled (LIML)	RE	Pooled	Pooled (LIML)	Pooled	RE						
Method		OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF						
Model		RE	Pooled	FE (LIML)	FE	Pooled	Pooled	Pooled	FE	RE	FE (LIML)	FE (LIML)	RE	Pooled	Pooled (LIML)	Pooled (LIML)	RE						
Caregiver's Health		-0.006 *	-0.016 ***	0.292	0.021 *	-0.004	-0.010 ***	-0.005	0.003	0.023	-1.795	-1.858	0.030	0.041	1.492	13.529	0.036						
		0.003	0.004	3.020	0.012	0.002	0.003	0.003	0.004	0.064	1.801	18.580	0.070	0.057	1.089	75.194	0.062						
R-squared		0.128	0.143	0.000	0.009	0.155	0.163	0.203	0.170	0.126	0.022	0.103	0.151	0.146	0.010	0.000	0.160						
F/ME statistics		297.38	1.70 ^w	353.41			232.47	353.41			2.78	1.48 ^w		3.38		2.15							
Overidentifying restrictions		5.66	5.62	6.36			11.40	6.36			8.33	5.28		10.42		4.32							
Number of Observations		5089	4359	3351	4539	4067	3501	2688	3501	4762	3185	3120	4098	3821	3293	2505	3293						
Caregiver's Health		CES-D Score II																					
Sample		Full sample		Less than care level 1					Full sample					Less than care level 1									
Method		OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF						
Model		RE	FE (LIML)	FE (LIML)	RE	Pooled	Pooled (LIML)	Pooled (LIML)	FE	RE	RE	FE (LIML)	RE	Pooled	Pooled (LIML)	Pooled	FE						
Caregiver's Health		0.025	-1.318	-1.431	0.035	0.046	1.527	9.578	0.042	0.156 **	0.685	-0.006	0.049	0.172 ***	2.346 ***	2.459	0.069						
		0.064	1.717	33.676	0.070	0.057	1.006	100.195	0.062	0.067	0.632	6.137	0.068	0.056	0.697	63.683	0.056						
R-squared		0.126	0.069	0.151	0.151	0.146	0.000	0.000	0.160	0.116	0.127	0.234	0.151	0.137	0.000	0.000	0.162						
F/ME statistics		2.84	1.47 ^w	3.30			3.30	2.08 ^w		56.64	3.32			4.37		2.92							
Overidentifying restrictions		8.78	5.21	4.33			10.35	4.33		10.89	5.00			14.29		8.31							
Number of Observations		4650	3090	3049	4002	3734	3215	2445	3215	5897	4831	3714	4831	4693	3869	2971	3869						
Caregiver's Health		Diseases (Medical History)																					
		Diseases (Under Treatment)																					
Sample		Full sample		Less than care level 1					Full sample					Less than care level 1									

Caregiver's Health				Self-reported Health				Functional Limitations												
Sample	Full sample				Less than care level 1				Full sample								Less than care level 1			
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF				
Model	RE	FE	FE (LIML)	RE	Pooled	Pooled (LIML)	Pooled (LIML)	RE	FE	FE (LIML)	FE (LIML)	RE	Pooled	Pooled	Pooled	RE				
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF				
Model	RE	FE	FE	RE	Pooled	Pooled	Pooled	FE	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled	Pooled	FE				
Caregiver's Health	-0.006	-1.677 **	0.519	0.047	-0.003	0.229	0.326	0.008	0.006	0.279	0.575	-0.002	0.025	0.228	0.181	0.003				
	0.067	0.659	1.033	0.074	0.069	0.335	0.544	0.076	0.129	1.050	21.969	0.129	0.056	0.297	0.356	0.060				
R-squared	0.123	0.009	0.256	0.146	0.136	0.139	0.184	0.148	0.096	0.254	0.242	0.069	0.189	0.182	0.184	0.196				
F/ME statistics		12.36	10.45			9.59	5.24			3.50	3.53			7.18	7.96					
Overidentifying restrictions		4.43	8.26			7.87	14.44 *			4.89	8.50			10.50	14.77 *					
Number of Observations	4517	3158	2774	3888	3594	3111	2215	3111	3026	1718	2774	2774	2406	2215	2215	2215				

Note:

- (1) *FE*, *RE*, and *Pooled* represent Fixed Effect model, Random Effect model, and Pooled Regression model, respectively.
- (2) *LIML* represents the results are estimated by the limited maximum likelihood estimation.
- (3) ***, **, and * represent statistical significance at the 1, 5, and 10 percent levels.
- (4) Lower values are the clustering robust standard errors that allow for correlated residuals within families in OLS, IV, and RF models. Those of the 2 step IV models are bootstrapped clustering robust standard errors (100 times reputation).
- (5) *F/ME statistics* represents the F or Minimum Eigenvalue Statistics (Cragg and Donald, 1993) as test of weak instruments, *w* represents that the models have still weak IV problem.
- (6) All equations of the OLS contain independent variables of **xR** and year and municipal fixed effects.
- (7) All equations of the IV, 2 step IV, and RF contain independent variables of **xR**, instrumental variables of **xG**, and year and municipal fixed effects.

The Effect of Informal Caregivers' Health on Their Elderly Parents' Health Excluding Genetic Effect between Parents and Children

Table 4

Caregiver's Health		Functional Limitations											
Sample		Self-reported Health				Less than care level 1				Full sample			
Method		OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model		RE	FE (LIML)	FE (LIML)	FE (LIML)	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled (LIML)	FE	FE (LIML)	FE (LIML)	Pooled (LIML)
Caregiver's Health		0.059	8.092	1.020	0.036	-0.035	0.577	1.455	-0.036	0.301 **	2.946	-1.789	0.323 **
		0.043	44.670	21.400	0.077	0.032	0.433	12.151	0.037	0.149	6.526	79.587	0.159
R-squared		0.248	0.000	0.094	0.005	0.222	0.106	0.000	0.237	0.002	0.155	0.141	0.013
F/ ME statistics			0.55 ^w	1.80 ^w			1.83 ^w	2.66			1.01 ^w	0.82 ^w	4.56
Overidentifying restrictions			5.48	3.23			6.63	3.05			5.22	3.67	7.96
Number of Observations		2370	1652	1585	2056	1874	1636	1269	1636	2522	1796	1682	2191
Caregiver's Health		ADL Limitations				I ADL Limitations				Less than care level 1			
Sample		Full sample				Less than care level 1				Full sample			
Method		OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model		FE	FE (LIML)	FE (LIML)	FE (LIML)	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled (LIML)	FE	FE (LIML)	FE (LIML)	Pooled (LIML)
Caregiver's Health		-1.057 **	-2.264	-0.276	-0.987 *	-0.029	-8.751	-20.789	0.025	0.240	-1.619	0.806	0.233
		0.511	3.630	34.038	0.518	0.175	11.235	198.168	0.170	0.190	4.060	34.476	0.206
R-squared		0.106	0.234	0.241	0.097	0.226	0.000	0.000	0.237	0.002	0.291	0.227	0.020
F/ ME statistics			1.19 ^w	1.37 ^w			1.80 ^w	2.22 ^w			1.67 ^w	1.35 ^w	4.79
Overidentifying restrictions			4.01	4.07			3.74	3.92			5.48	4.53	5.03
Number of Observations		1857	1184	1682	1682	1485	1350	1350	1350	2463	1724	1642	2135
Caregiver's Health		Grip Strength				CES-D Score I				Less than care level 1			
Sample		Full sample				Less than care level 1				Full sample			

Caregiver's Health	Functional Limitations									
Sample	Self-reported Health					Less than care level 1				
	Full sample					Full sample				
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV
Model	RE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	FE	Pooled (LIML)
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV
Model	FE	Pooled	Pooled	FE	Pooled	Pooled	Pooled	FE	Pooled	Pooled (LIML)
Caregiver's Health	0.009	-0.020 ***	-0.026 ***	0.011	-0.001	-0.006	-0.006	0.005	-0.005	1.135
	0.012	0.006	0.007	0.013	0.003	0.004	0.005	0.004	0.133	0.986
R-squared	0.002	0.258	0.212	0.022	0.231	0.239	0.244	0.247	0.003	0.102
F/ME statistics		148.30	217.31			117.40	179.68			2.00 ^w
Overidentifying restrictions		3.89	6.01			5.19	3.47			6.19
										1.77 ^w
										4.35
Number of Observations	2266	1549	1519	1970	1790	1573	1220	1573	2143	1475
										1128
										1475
Caregiver's Health	Poor Memory Functions									
Sample	Full sample					Less than care level 1				
	Full sample					Full sample				
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV
Model	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	FE	Pooled (LIML)
Caregiver's Health	-0.059	1.100	-0.810	-0.004	0.004	0.964	-277.903	-0.012	0.246 **	1.229
	0.132	2.611	60.883	0.150	0.059	0.889	186.403	0.067	0.121	0.909
R-squared	0.003	0.295	0.207	0.003	0.211	0.127	0.000	0.229	0.019	0.099
F/ME statistics		1.59 ^w	1.17 ^w			2.03 ^w	1.73 ^w			1.74 ^w
Overidentifying restrictions		7.12	5.69			7.55	4.84			7.18
										0.000
										2.29
Number of Observations	2090	1415	1384	1819	1643	1439	1099	1439	2652	1752
										1353
										1752
Caregiver's Health	Diseases (Medical History)									
Sample	Full sample					Less than care level 1				
	Full sample					Full sample				
	Diseases (Under Treatment)					Diseases (Under Treatment)				
Sample	Full sample					Less than care level 1				

Caregiver's Health		Self-reported Health				Functional Limitations									
Sample		Full sample				Less than care level 1				Full sample					
Method		OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV
Model		RE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)
Method		OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV
Model		FE	FE	FE	FE	Pooled	Pooled	Pooled	Pooled	FE	FE (LIML)	FE	RE	Pooled	Pooled (LIML)
Caregiver's Health		0.123	0.253	1.295	0.153	-0.092	0.093	0.176	-0.074	-0.120	0.707	1.701	0.023	-0.027	-0.022
		0.127	0.631	1.080	0.147	0.078	0.330	0.842	0.091	0.200	1.491	8.544	0.104	0.085	0.387
R-squared		0.008	0.367	0.214	0.007	0.230	0.231	0.213	0.238	0.105	0.230	0.173	0.206	0.216	0.214
	F/ME statistics		9.02	7.86			10.16	8.08			3.74	7.86			4.78
Overidentifying restrictions			4.94	7.89			4.68	6.56			8.53	10.40			8.78
Number of Observations		2035	1451	1274	1781	1597	1414	1017	1414	1374	796	1274	1274	1089	1017

Note:

⁽¹⁾ *FE*, *RE*, and *Pooled* represent Fixed Effect model, Random Effect model, and Pooled Regression model, respectively.

⁽²⁾ *LIML* represents the results are estimated by the limited maximum likelihood estimation.

⁽³⁾ ***, **, and * represent statistical significance at the 1, 5, and 10 percent levels.

⁽⁴⁾ Lower values are the clustering robust standard errors that allow for correlated residuals within families in OLS, IV, and RF models. Those of the 2 step IV models are bootstrapped clustering robust standard errors (100 times reputation).

⁽⁵⁾ *F/ME statistics* represents the F or Minimum Eigenvalue Statistics (Cragg and Donald, 1993) as test of weak instruments. *w* represents that the models have still weak IV problem.

⁽⁶⁾ All equations of the OLS contain independent variables of **xR** and year and municipal fixed effects.

⁽⁷⁾ All equations of the IV, 2 step IV, and RF contain independent variables of **xR**, instrumental variables of **xG**, and year and municipal fixed effects.

Table 5
The Effect of Informal Caregivers' Health on Their Elderly Parents' Health in the Case of One Caregiver

Caregiver's Health				Functional Limitations												
Sample	Full sample				Less than care level 1				Full sample				Less than care level 1			
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	RE	FE	Pooled (LIML)	Pooled (LIML)	RE	FE	Pooled (LIML)	Pooled (LIML)	RE	FE	Pooled (LIML)	Pooled (LIML)	RE	FE	Pooled (LIML)	Pooled (LIML)
Caregiver's Health	-0.005	0.220	0.220	-0.009	-0.047	1.328	1.183 *	-0.026	0.005	1.183 *	-4.216	-0.047	-0.009	1.138	0.775	-0.096
	0.057	0.875	0.892	0.114	0.050	1.848	0.611	0.054	0.121	0.611	47.584	0.216	0.113	0.879	0.878	0.117
R-squared	0.119	0.114	0.114	0.040	0.164	0.025	0.088	0.186	0.120	0.088	0.000	0.032	0.162	0.097	0.169	0.184
F/ ME statistics		15.11	14.27			3.28	64.98			64.98	1.57 w		4.00		4.58	
Overidentifying restrictions		5.85	6.41			7.73	5.48			5.48	10.17		6.44		11.03	
Number of Observations	1733	1261	1151	1488	1371	1186	1391	1186	1851	1391	1238	1579	1486	1276	987	1276
Caregiver's Health	IADL Limitations															
Sample	Full sample				Less than care level 1				Full sample				Less than care level 1			
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	FE	Pooled (LIML)	Pooled (LIML)	Pooled (LIML)	FE	Pooled (LIML)	Pooled (LIML)	Pooled (LIML)	RE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled
Caregiver's Health	0.051	-79.868	-79.868	0.049	0.187	-3.418	2.898	0.184	-0.221	2.898	2.898	0.069	-0.198	-1.563	-0.705	-0.191
	0.669	789.677	388.208	0.711	0.237	4.642	6.145	0.226	0.178	6.145	30.620	0.264	0.160	1.093	7.113	0.176
R-squared	0.062	0.000	0.000	0.030	0.207	0.172	0.014	0.221	0.119	0.014	0.014	0.031	0.163	0.122	0.193	0.184
F/ ME statistics		1.76 w	2.06 w			1.40 w	2.33 w			2.33 w	2.12 w		4.07		2.89	
Overidentifying restrictions		1.55	4.21			3.06	5.72			5.72	9.28		7.90		10.33	
Number of Observations	1364	990	1238	1238	1084	987	1319	987	1787	1319	1196	1540	1411	1225	950	1225
Caregiver's Health	Grip Strength															
Sample	Full sample				Less than care level 1				Full sample				Less than care level 1			

Table 6
The Effect of Informal Caregivers' Health on Their Elderly Parents' Health in the Case of Changing in Caregiver's Health Condition

Caregiver's Health			Self-reported Health																			
Sample			Full sample			Less than care level 1						Full sample							Less than care level 1			
Method			OLS	IV	2step IV	RF	OLS	Pooled	Pooled (LIML)	IV	2step IV	RF	OLS	Pooled	RE	2step IV	RF	OLS	IV	2step IV	RF	
Model			RE	RE	FE	RE	Pooled	Pooled (LIML)	Pooled (LIML)	RE	RE	Pooled	Pooled	RE	RE	RE	RE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	
Caregiver's Health			0.025	0.528	0.205	0.034	-0.003	-0.469	-0.886	-0.469	-0.886	0.031	-0.045	1.064	1.231	-0.066	-0.068	3.035 **	2.446	-0.067		
			0.066	0.448	0.520	0.071	0.062	0.576	16.432	0.576	16.432	0.068	0.166	0.773	0.832	0.180	0.168	1.525	68.076	0.174		
R-squared			0.151	0.141	0.277	0.177	0.147	0.117	0.059	0.117	0.059	0.164	0.157	0.122	0.200	0.199	0.190	0.000	0.042	0.235		
F/ ME statistics				37.13	6.23			2.08 ^w	2.43		2.43			26.07	16.11		1.32 ^w		1.89 ^w			
Overidentifying restrictions				8.70	9.25			8.42	14.29 *					7.52	5.02		3.87		4.90			
Number of Observations			1594	1433	1024	1443	1297	1173	832	1173	832	1173	542	476	341	480	420	378	267	378		
Caregiver's Health			IADL Limitations																			
Sample			Full sample			Less than care level 1						Full sample							Less than care level 1			
Method			OLS	IV	2step IV	RF	OLS	Pooled	Pooled (LIML)	IV	2step IV	RF	OLS	Pooled	RE	2step IV	RF	OLS	IV	2step IV	RF	
Model			RE	RE	RE	RE	Pooled	Pooled (LIML)	Pooled (LIML)	RE	RE	Pooled	RE	RE	RE	RE	RE	Pooled	Pooled (LIML)	Pooled	Pooled	
Caregiver's Health			-1.452 **	2.611	0.828	-2.417 **	-1.858 ***	4.555	3.054	-0.759	-0.627	-0.265	-0.345	-0.759	-0.627	-0.265	-0.363	-0.207	-0.237	-0.345		
			0.731	3.608	1.882	0.977	0.632	4.301	16.676	4.301	16.676	1.203	0.219	0.872	0.422	0.266	0.234	1.366	0.415	0.272		
R-squared			0.343	0.289	0.336	0.531	0.390	0.220	0.296	0.220	0.296	0.493	0.092	0.090	0.108	0.195	0.145	0.150	0.155	0.246		
F/ ME statistics				12.22	5.71 ^w			0.91 ^w	0.13 ^w		47.09			21.00				1.49 ^w	6.46			
Overidentifying restrictions				4.82	3.99			5.00	3.07		14.29			12.34 *				13.55 *	14.63 **			
Number of Observations			72	70	71	71	58	57	57	57	57	57	179	158	115	162	146	133	95	133		
Caregiver's Health			CES-D Score I																			
Sample			Full sample			Less than care level 1						Full sample							Less than care level 1			

Functional Limitations												
Sample	Full sample						Less than care level 1					
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	RE	RE	FE	RE	Pooled	Pooled (LIML)	Pooled (LIML)	RE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	RE	RE	RE	RE	Pooled	Pooled	Pooled	FE (LIML)	Pooled	Pooled (LIML)	Pooled	Pooled
Caregiver's Health	0.004	-0.011	-0.008	0.022 **	0.004	-0.004	-0.002	0.011	-0.034	-4.681	-1.039	-0.095
	0.005	0.007	0.005	0.008	0.004	0.006	0.007	0.007	0.092	11.735	60.266	0.158
R-squared	0.142	0.141	0.181	0.156	0.157	0.153	0.191	0.164	0.164	0.000	0.218	0.063
F/ ME statistics		1478.66	6044.99			173.68	146.49		1.29 w	1.29 w	1.70 w	
Overidentifying restrictions		7.61	3.63			7.04	4.74		9.14	8.39	6.62	
Number of Observations	2096	1888	1338	1896	1709	1556	1093	1556	2163	1921	1390	1950
Caregiver's Health	Poor Memory Functions											
Sample	Full sample						Less than care level 1					
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	FE	RE	RE	Pooled
Caregiver's Health	-0.188	-1.258	0.739	-0.112	0.079	0.411	1.209	0.044	0.163	1.771 *	-0.138	0.035
	0.149	5.445	44.517	0.157	0.089	1.221	10.494	0.094	0.110	1.003	0.426	0.113
R-squared	0.139	0.103	0.248	0.042	0.166	0.163	0.104	0.179	0.116	0.092	0.184	0.160
F/ ME statistics		1.42 w	1.74 w			2.57	4.37		21.59	28.00		
Overidentifying restrictions		8.35	7.30			7.79	5.05		4.55	3.69		
Number of Observations	2061	1845	1333	1870	1659	1508	1074	1508	1627	1397	1105	1483
Caregiver's Health	Diseases (Medical History)											
Sample	Full sample						Less than care level 1					
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled
Caregiver's Health	-0.188	-1.258	0.739	-0.112	0.079	0.411	1.209	0.044	0.163	2.560 **	1.638	0.129
	0.149	5.445	44.517	0.157	0.089	1.221	10.494	0.094	0.114	1.052	7.231	0.119
R-squared	0.139	0.103	0.248	0.042	0.166	0.163	0.104	0.179	0.144	0.100	0.173	0.167
F/ ME statistics		1.42 w	1.74 w			2.57	4.37		1.76 w	4.23		
Overidentifying restrictions		8.35	7.30			7.79	5.05		4.28	1.41		
Number of Observations	2061	1845	1333	1870	1659	1508	1074	1508	1287	1186	876	1186
Caregiver's Health	Diseases (Under Treatment)											
Sample	Full sample						Less than care level 1					
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled
Caregiver's Health	-0.188	-1.258	0.739	-0.112	0.079	0.411	1.209	0.044	0.289 **	2.560 **	1.638	0.129
	0.149	5.445	44.517	0.157	0.089	1.221	10.494	0.094	0.114	1.052	7.231	0.119
R-squared	0.139	0.103	0.248	0.042	0.166	0.163	0.104	0.179	0.144	0.100	0.173	0.167
F/ ME statistics		1.42 w	1.74 w			2.57	4.37		1.76 w	4.23		
Overidentifying restrictions		8.35	7.30			7.79	5.05		4.28	1.41		
Number of Observations	2061	1845	1333	1870	1659	1508	1074	1508	1287	1186	876	1186
Caregiver's Health	Diseases (Under Treatment)											
Sample	Full sample						Less than care level 1					
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled
Caregiver's Health	-0.188	-1.258	0.739	-0.112	0.079	0.411	1.209	0.044	0.289 **	2.560 **	1.638	0.129
	0.149	5.445	44.517	0.157	0.089	1.221	10.494	0.094	0.114	1.052	7.231	0.119
R-squared	0.139	0.103	0.248	0.042	0.166	0.163	0.104	0.179	0.144	0.100	0.173	0.167
F/ ME statistics		1.42 w	1.74 w			2.57	4.37		1.76 w	4.23		
Overidentifying restrictions		8.35	7.30			7.79	5.05		4.28	1.41		
Number of Observations	2061	1845	1333	1870	1659	1508	1074	1508	1287	1186	876	1186
Caregiver's Health	Diseases (Under Treatment)											
Sample	Full sample						Less than care level 1					
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled
Caregiver's Health	-0.188	-1.258	0.739	-0.112	0.079	0.411	1.209	0.044	0.289 **	2.560 **	1.638	0.129
	0.149	5.445	44.517	0.157	0.089	1.221	10.494	0.094	0.114	1.052	7.231	0.119
R-squared	0.139	0.103	0.248	0.042	0.166	0.163	0.104	0.179	0.144	0.100	0.173	0.167
F/ ME statistics		1.42 w	1.74 w			2.57	4.37		1.76 w	4.23		
Overidentifying restrictions		8.35	7.30			7.79	5.05		4.28	1.41		
Number of Observations	2061	1845	1333	1870	1659	1508	1074	1508	1287	1186	876	1186
Caregiver's Health	Diseases (Under Treatment)											
Sample	Full sample						Less than care level 1					
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled
Caregiver's Health	-0.188	-1.258	0.739	-0.112	0.079	0.411	1.209	0.044	0.289 **	2.560 **	1.638	0.129
	0.149	5.445	44.517	0.157	0.089	1.221	10.494	0.094	0.114	1.052	7.231	0.119
R-squared	0.139	0.103	0.248	0.042	0.166	0.163	0.104	0.179	0.144	0.100	0.173	0.167
F/ ME statistics		1.42 w	1.74 w			2.57	4.37		1.76 w	4.23		
Overidentifying restrictions		8.35	7.30			7.79	5.05		4.28	1.41		
Number of Observations	2061	1845	1333	1870	1659	1508	1074	1508	1287	1186	876	1186
Caregiver's Health	Diseases (Under Treatment)											
Sample	Full sample						Less than care level 1					
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled
Caregiver's Health	-0.188	-1.258	0.739	-0.112	0.079	0.411	1.209	0.044	0.289 **	2.560 **	1.638	0.129
	0.149	5.445	44.517	0.157	0.089	1.221	10.494	0.094	0.114	1.052	7.231	0.119
R-squared	0.139	0.103	0.248	0.042	0.166	0.163	0.104	0.179	0.144	0.100	0.173	0.167
F/ ME statistics		1.42 w	1.74 w			2.57	4.37		1.76 w	4.23		
Overidentifying restrictions		8.35	7.30			7.79	5.05		4.28	1.41		
Number of Observations	2061	1845	1333	1870	1659	1508	1074	1508	1287	1186	876	1186
Caregiver's Health	Diseases (Under Treatment)											
Sample	Full sample						Less than care level 1					
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled
Caregiver's Health	-0.188	-1.258	0.739	-0.112	0.079	0.411	1.209	0.044	0.289 **	2.560 **	1.638	0.129
	0.149	5.445	44.517	0.157	0.089	1.221	10.494	0.094	0.114	1.052	7.231	0.119
R-squared	0.139	0.103	0.248	0.042	0.166	0.163	0.104	0.179	0.144	0.100	0.173	0.167
F/ ME statistics		1.42 w	1.74 w			2.57	4.37		1.76 w	4.23		
Overidentifying restrictions		8.35	7.30			7.79	5.05		4.28	1.41		
Number of Observations	2061	1845	1333	1870	1659	1508	1074	1508	1287	1186	876	1186
Caregiver's Health	Diseases (Under Treatment)											
Sample	Full sample						Less than care level 1					
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled
Caregiver's Health	-0.188	-1.258	0.739	-0.112	0.079	0.411	1.209	0.044	0.289 **	2.560 **	1.638	0.129
	0.149	5.445	44.517	0.157	0.089	1.221	10.494	0.094	0.114	1.052	7.231	0.119
R-squared	0.139	0.103	0.248	0.042	0.166	0.163	0.104	0.179	0.144	0.100	0.173	0.167
F/ ME statistics		1.42 w	1.74 w			2.57	4.37		1.76 w	4.23		
Overidentifying restrictions		8.35	7.30			7.79	5.05		4.28	1.41		
Number of Observations	2061	1845	1333	1870	1659	1508	1074	1508	1287	1186	876	1186
Caregiver's Health	Diseases (Under Treatment)											
Sample	Full sample						Less than care level 1					
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled
Caregiver's Health	-0.188	-1.258	0.739	-0.112	0.079	0.411	1.209	0.044	0.289 **	2.560 **	1.638	0.129
	0.149	5.445	44.517	0.157	0.089	1.221	10.494	0.094	0.114	1.052	7.231	0.119
R-squared	0.139	0.103	0.248	0.042	0.166	0.163	0.104	0.179	0.144	0.100	0.173	0.167
F/ ME statistics		1.42 w	1.74 w			2.57	4.37		1.76 w	4.23		
Overidentifying restrictions		8.35	7.30			7.79	5.05		4.28	1.41		
Number of Observations	2061	1845	1333	1870	1659	1508	1074	1508	1287	1186	876	1186
Caregiver's Health	Diseases (Under Treatment)											
Sample	Full sample						Less than care level 1					
Method	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF	OLS	IV	2step IV	RF
Model	FE	FE (LIML)	FE (LIML)	FE	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled	Pooled	Pooled (LIML)	Pooled (LIML)	Pooled
Caregiver's Health	-0.188	-1.258	0.739	-0.112	0.079	0.411	1.209	0.044	0.289 **	2.560 **	1.638	0.129
	0.149	5.445	44.517	0.157	0.089	1.221	10.494	0.094	0.114	1.052	7.231	0.119
R-squared	0.139	0.103	0.248	0.042	0.166	0.163	0.104	0.179	0.144	0.100	0.173	0.167
F/ ME statistics		1.42 w	1.74 w			2.57	4.37		1.76 w	4.23		
Overidentifying restrictions		8.35	7.30			7.79	5.05		4.28	1.41		
Number of Observations	2061	1845	1333	1870	1659	1508	1074	1508	1287	1186	876	1186
Caregiver's Health	Diseases (Under Treatment)											
Sample	Full sample											

Caregiver's Health				Self-reported Health																					
Functional Limitations																									
Sample		Full sample						Less than care level 1																	
Method		OLS		IV		2step IV		RF		OLS		IV		2step IV		RF		OLS		IV		2step IV		RF	
Model		RE		RE		FE		FE		Pooled		Pooled (LIML)		Pooled		Pooled (LIML)		Pooled		Pooled (LIML)		Pooled (LIML)		Pooled	
Method		OLS		IV		2step IV		RF		OLS		IV		2step IV		RF		OLS		IV		2step IV		RF	
Model		RE		RE		FE		FE		Pooled		Pooled (LIML)		Pooled		Pooled (LIML)		Pooled		Pooled (LIML)		Pooled (LIML)		Pooled	
Caregiver's Health		-0.072	-0.266	0.689	0.031	-0.060	0.209	-0.185	-0.020	-0.354	0.719	0.214	-0.275	-0.177	0.213	-1.357	-0.191								
		0.106	0.509	0.651	0.120	0.117	0.451	7.389	0.129	0.286	1.086	0.827	0.306	0.319	1.287	11.665	0.325								
R-squared		0.138	0.149	0.212	0.166	0.139	0.145	0.180	0.157	0.253	0.214	0.242	0.106	0.244	0.236	0.169	0.274								
F/ ME statistics			77.24	20.63			5.59	3.50			18.48	24.86			1.36 ^w	2.45									
Overidentifying restrictions			6.50	10.77			9.10	17.72 ^{**}			7.32	12.47 [*]			6.76	11.09									
Number of Observations		1835	1613	1159	1622	1453	1239	921	1293	314	312	313	313	246	246	246	246								

Note:

(1) *FE*, *RE*, and *Pooled* represent Fixed Effect model, Random Effect model, and Pooled Regression model, respectively.

(2) *LIML* represents the results are estimated by the limited maximum likelihood estimation.

(3) ^{***}, ^{**}, and ^{*} represent statistical significance at the 1, 5, and 10 percent levels.

(4) Lower values are the clustering robust standard errors that allow for correlated residuals within families in OLS, IV, and RF models. Those of the 2 step IV models are bootstrapped clustering robust standard errors (100 times reputation).

(5) *F/ME statistics* represents the F or Minimum Eigenvalue Statistics (Cragg and Donald, 1993) as test of weak instruments. *w* represents that the models have still weak IV problem.

(6) All equations of the OLS contain independent variables of **xR** and year and municipal fixed effects.

(7) All equations of the IV, 2 step IV, and RF contain independent variables of **xR**, instrumental variables of **xG**, and year and municipal fixed effects.