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Depressive symptoms among older empty nesters in China: the moderating effects of social contact and contact with one's children

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ABSTRACT

Objectives: Mental health for older people has become a major social concern. Literature has shown that older people, especially when they become empty nesters—when a parent lives alone or lives with his/her spouse after the youngest child leaves home—may start to develop various mental health problems due to reduced contacts with their children.

Methods: Using fixed-effects, multivariate regression with a difference-in-differences approach and propensity score matching, this paper examines the relationship between being an empty nester and mental health among older people in China, and the moderating effects of social contact and contact with one's children in terms of mental health. Our data come from the China Health and Retirement Longitudinal Study of 2011, 2013, 2015 and 2018.

Results: We found that, in the short term, the mental health of older people may not be affected after they became empty nesters. But in the longer term, if they did not have regular contact with their children, their mental health would deteriorate with time. Social contact, especially cognitive activities, was beneficial to the mental health of the older empty nesters. We also found that for older empty nesters with disabilities, frequent social contact and contact with their children were more important.

Conclusion: We urge the government to promote community-based social activities for older people, especially for those with functional limitations.

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Empty nest; depressive symptoms; social contact; children contact; China

Introduction

Population ageing has become a global phenomenon in the past few decades. The United Nations Population Fund (UNPFA) estimates that people aged 60 and above will account for approximately 22% of the world's population by 2050 (UNPFA and HelpAge International, 2012). Along with global ageing, mental health for older people has become a social concern in many countries (World Health Organization, 2017a). Around the world, over 20% of the older people aged 60 and above suffer from at least one mental or neurological disorder, and 6.6% of the disabilities among those older than 60 are attributed to mental and neurological disorders (World Health Organization, 2020). In China, mental health disorders have brought significant burdens to the society during the recent decades (Liang et al., 2018; Xiang et al., 2012). Literature has shown that older people, especially when they become empty nesters—when a parent lives alone or lives with his/her spouse after the youngest child leaves home (Lowenthal & Chiriboga, 1972)—may start to develop various mental health problems due to reduced contacts with their children (Guo et al., 2016; Zhai et al., 2015). Strengthening and promoting mental health of older people has been recognised as a health system priority in many countries (World Health Organization, 2017b).

Living arrangements play an important role for older people's mental health. In high-income countries (HICs), the proportion of older people live independently is higher than in

low- and middle-income countries (LMICs). This could be attributed to cultural factors, individual choices as well as established long-term care (LTC) and public support systems (Gaymu et al., 2006). Due to the traditional norm of filial piety, older people in many East Asian countries, including China, prefer to live with their children (You et al., 2009); however, this living arrangement has changed dramatically in the past few decades according to recent data (National Bureau of Statistics of China, 2020). Empty nesters accounted for over half of the older population in 2014, and this figure is expected to reach 90% by 2030 (Chang et al., 2016). In the rural China, many older people have become empty-nesters because of the mass rural to urban migration of younger generations since the 1990s. In the urban China, the younger generations also tend to live independently due to changing family structure and pursuing of freedom (Chen, 2019; Sun et al., 2011). The association between empty-nest and mental health has been explored for decades but no consistent findings have been established. Some found that due to the sense of loss and role change, some empty-nesters may experience temporal depression because they need to adapt themselves to the new living arrangement (Aranda, 2015; Lee et al., 2017; Oliver, 1977; Xu, 2018). Others found that empty nesters have better mental health due to a sense of relief and reduction of caring burden, but only conditional on the fact that they remain frequent contacts with non-resident children (Dennerstein et al., 2002; Radloff, 1980; White & Edwards, 1990).

Social contact and contact with one's children are believed to have critical impacts on older people's mental health. According to the stress-buffering model, the availability of social contact may eliminate or weaken the negative association between perceived stress as a result of becoming an empty nester and psychological wellbeing (Gellert et al., 2018). The stress-buffering hypothesis has been tested in a number of studies, which show that social contact or social support may potentially act as a source of distress as well as a source of satisfaction (Bennett et al., 2006; Cho et al., 2016; Dias et al., 2015). Social contact, such as participation in community events and involvement in social networks, benefits mental health by receiving positive social influence (e.g. guidance about health-related behaviours, such as regular exercises), producing positive affective states (e.g. a sense of purpose, belonging and security) and modulating neuroendocrine responses to stress (Cohen & Wills, 1985; Kawachi & Berkman, 2001; Roberts et al., 1994).

No consistent conclusion has been established on the influence of contact with one's children on mental health. Studies suggest that emotional support from children will improve the mental health of older people due to increased feelings of closeness (Tosi & Grundy, 2019), but excessive children contact may harm the mental health of older people since more frequent contacts often lead to more disagreements due to varied opinions and life styles (Beckman, 1981; Litwin, 2004).

Although the existing literature has examined the determinants of older people's mental health, limited empirical evidence has been demonstrated on the moderating effects of social contact and contact with one's children for the relationship between becoming empty-nester and one's mental health. Even less is known on how this relationship varies among empty nester with different health and LTC needs, such as people with or without functional limitations. Furthermore, existing literature mainly looks at the short-term effects on older people's mental health after they become empty nesters (Lee et al., 2017; Zhai et al., 2015), but longer-term outcomes remain unassessed. Using China as an example, where filial piety and intergenerational support play crucial roles in the later periods of life, we aim to fill in these research gaps by examining this relationship and the moderating effect of social contact and contact with one's children. We are particularly interested in knowing whether older people with functional limitations are more likely to experience mental health problems after becoming empty nesters, and how the impact of becoming an empty nester on one's mental health has changes over time.

Data source and sample selection

We drew data from the CHARLS (CHARLS, 2020), a nationwide survey targeted at people aged 45 and older in China; it

provides individual-level panel data on health, socio-economic status, as well as social and family networks (Zhao et al., 2013). We used data from 2011, 2013, 2015 and 2018. In addition, we merged these longitudinal data with economic data (provincial GDP per capita) from China's National Bureau of Statistics (National Bureau of Statistics of China, 2020).

We selected 11,319 observations in our sample according to the following criteria: (1) older people aged 60 and above; (2) individuals who lived with children in all the years they were enrolled in the study (the control group), and individuals who lived with their children in the first year and lived alone or with their spouse in the last year (the treatment group). For instance, 1,537 individuals were enrolled in the survey for all four years, among whom 236, 573 and 889 became empty nesters in 2013, 2015 and 2018, respectively. In addition, we do not include individuals who only lived with their parents or grandchildren, and not lived with their children based on the definition of the empty nester. Other details of the living arrangements of the study sample are shown in Table 1.

Variable specifications

Our dependent variable was the depression score, which was calculated based on the 10-item Center for Epidemiologic Studies Depression Scale Revised (CESD-R-10). Survey participants were asked to rate eight negative statements (e.g. I felt fearful) and two positive statements (e.g. I felt hopeful) which indicates their mental health status for the past week. Each statement was measured on the following scale: 0 = less than one day, 1 = one to two days, 2 = three to four days, and 3 = five to seven days. We reverse scored the two positive statements and added up the scores of the ten statements, which enabled us to create a depressive symptoms variable ranging from 0 (no symptoms) to 30 (severe symptoms).

Our independent variable of interest is the empty nester. Following the well-established definition in the literature, we defined empty nesters as those who previously lived with their children, but then lived alone or with their spouses (Lowenthal & Chiriboga, 1972; Oliver, 1977). In this study, we defined empty nesters (the treatment group) as individuals who lived with children in the first year(s) but lived alone or with their spouses in the last year(s). We defined the control group as people who lived with their children throughout the study period. Social contact has been widely acknowledged as a main factor of mental health status (Kawachi & Berkman, 2001; Roberts et al., 1994). We considered an observation to have social contact if any of the following activities happened: interacting with friends, playing mah-jong/cards/chess, providing help to others, going to a club, taking part in a community-related organisation, doing voluntary work, caring for a sick or disabled adult, attending a course, investing in stocks, and using the Internet (0 = no social contact, 1 = at least one type of social contact). In addition, we

Table 1. Summary statistics of the living arrangements of individuals included in our sample in each year.

	Year 1 (2011)		Year 2 (2013)		Year 3 (2015)		Year 4 (2018)	
	Total sample	Empty nester						
Enrolled in Year 1-4	1,537	0	1,537	236	1,537	573	1,537	889
Enrolled in Year 1-3	366	0	366	43	366	128	–	–
Enrolled in Year 2-4	–	–	673	0	673	196	673	389
Enrolled in Year 1-2	269	0	269	45	–	–	–	–
Enrolled in Year 2-3	–	–	118	0	118	38	–	–
Enrolled in Year 3-4	–	–	–	–	640	0	640	262

Note. "–" denotes "not applicable".

divide the above activities of social contact into two types according to the literature (Stern & Munn, 2010; Weaver & Jaeggi, 2021), 1 = social activities (interacting with friends, providing help to others, going to a club, taking part in a community-related organisation, doing voluntary work, and caring for a sick or disabled adult) and 2 = cognitive activities (playing mah-jong/cards/chess, attending a course, investing in stocks, and using the Internet).

We controlled for the following variables that could influence a person's depressive symptoms. Firstly, we include a set of demographic and physical health-related variables: including age, gender, the number of chronic diseases, self-perceived health status (1 = excellent/very good, 2 = good, 3 = fair/poor), whether to have one or more activities of daily living (ADL) limitations or instrumental ADL (IADL) limitations (0 = no limitations, 1 = at least one ADL/IADL limitation), and whether one is currently feeling bodily pain (Ohrnberger et al., 2017). Secondly, we also include a set of socio-economic variables: level of education (1 = no formal education, 2 = elementary and middle school, 3 = high school or above), quartiles of equivalent income (household income divided by the square root of household size (OECD, 2011)), marital status (0 = married/cohabiting, 1 = single), provincial GDP per capita, and residence area (1 = rural, 2 = urban). We do additionally robustness check analyses by replacing provincial GDP per capita with city-level GDP per capita. Results show that our analyses are robust to it (see Appendix A).

Empirical strategies

We used fixed-effects multivariate regression by adopting a difference-in-differences (DID) approach with propensity score matching (PSM) to explore the in-depth relationship between depressive symptoms and being an empty nester. The settings were DID with staggered adoption since treatment timing varied by individuals, i.e. some became empty nesters in 2013, whereas others became empty nesters in 2015 or 2018 (Athey & Imbens, 2022; Callaway & Sant'Anna, 2021; Goodman-Bacon et al., 2019). We performed a parallel trend test between the treatment and control groups, which demonstrates that the parallel trend assumption holds (Wooldridge, 2012) (see detailed results in Appendix B). The analyses we performed are shown as follows. Besides, the varied effects of being empty nesters on depressive symptoms between the rural and the urban were also explored as presented in Appendix C.

Analyzing the impact of being an empty nester on depressive symptoms

We first assumed that the average treatment effects on the treated (ATT) would be constant across each period after treatment; in other words, we assumed that people's depressive symptoms would be equally impacted, regardless of whether they became empty nesters for one wave, two waves or three waves (Wooldridge, 2012). However, this may not be the case in real life, since mental health status may be associated with how much time has passed since a person became an empty nester. Therefore, we allowed for variation in the ATT over time to determine whether the impact of being an empty nester on depressive symptoms varies with time (Laporte & Windmeijer, 2005). The models are presented as follows (constant ATT in Model 1; varied ATTs in Model 2):

$$y_{it} = b_0 + b_1Year_t + b_2Post1_{it} + X_{it} + v_i + \varepsilon_{it} \quad (1)$$

$$y_{it} = b_0 + b_1Year_t + b_2Post2_{it} + X_{it} + v_i + \varepsilon_{it} \quad (2)$$

In the two models, y denotes the depression score, and $Year$ controls for the fixed effects of time. $Post1$ and $Post2$ indicate whether an individual i is an empty nester at time t . Specifically, assuming a constant ATT, $Post1 = 1$ indicates that a person has become an empty nester, and $Post1 = 0$ means that a person lives with his/her children. Assuming variation in the ATT, $Post2 = 3$ denotes a person being an empty nester for three waves, $Post2 = 2$ refers to a person being an empty nester for two waves, $Post2 = 1$ indicates a person being an empty nester for one wave, and $Post2 = 0$ denotes a person living with his/her children. X represents the following time-varying covariates: having social contact, having ADL/IADL limitations, number of chronic diseases, self-perceived health status, feeling bodily pain, quartiles of equivalent income, marital status and provincial GDP per capita. v controls for individual fixed effects, including both observable (such as gender, birth year, level of education—which is almost constant for people aged 60 and above—and residence area) and unobservable fixed effects. ε is the idiosyncratic error term. b_2 shows the DID estimate.

Analyzing the impact of contact with one's children on the association between depressive symptoms and being an empty nester

In the first analysis, we estimated an average treatment effect. However, varied characteristics among subgroups may modify the impact of a treatment on outcomes. Hence, we also explored the heterogeneity of the treatment effect in this second analysis (Chaisemartin & D'Haultfoeuille, 2020). To determine whether the frequency of contact with one's children after becoming an empty nester was associated with depressive symptoms (i.e. whether the impact of being an empty nester differed between the subgroups by the frequency of contact with one's children), we further divided the treatment group (the empty nesters) into two subgroups according to the literature (Stewart, 2003): 1) people who have contact with their children more than once a month, and 2) people who have contact with their children less than once every three months. The model is as follows:

$$y_{it} = b_0 + b_1Year_t + b_2Post3_{it} + X_{it} + v_i + \varepsilon_{it} \quad (3)$$

In this model, $Post3 = 1, 2$ or 3 indicates an empty nester for one wave, two waves or three waves, respectively, who has contact with his/her children more than once per month, $Post3 = 4, 5$ or 6 denotes an empty nester for one wave, two waves or three waves, respectively, who has contact with his/her children less than once every three months, and $Post3 = 0$ entails a person living with his/her children.

Analyzing the impact of social contact on the association between depressive symptoms and being an empty nester

For our third analysis, we investigated the impact of social contact on the association between depressive symptoms and being an empty nester by further adding the interaction term between social contact and whether an individual i is an empty nester at time t in the models (Imbens & Wooldridge, 2007), which are displayed below:

$$y_{it} = b_0 + b_1 Year_t + b_2 Post1_{it} + b_3 Post1_{it} * SC1_{it} + X_{it} + v_i + \varepsilon_{it} \quad (4)$$

$$y_{it} = b_0 + b_1 Year_t + b_2 Post1_{it} + b_3 Post1_{it} * SC2_{it} + Y_{it} + v_i + \varepsilon_{it} \quad (5)$$

In Model 4, $SC1$ denotes whether one has social contact. In model 5, $SC2 = 0$ denotes a person has no social contact, $SC2 = 1$ indicates one has social activities, and $SC2 = 2$ entails a person has cognitive activities. Y_{it} represents the following time-varying covariates: $SC2$, having ADLs/IADLs, number of chronic diseases, self-perceived health status, feeling bodily pain, quartiles of equivalent income, marital status and provincial GDP per capita. b_3 demonstrates the effect of social contact on the association between depressive symptoms and being an empty nester.

Analyzing the above impacts for the subgroup with at least one ADL/IADL limitation

We are interested in knowing for people with ADL/IADL limitations, when they become empty nesters, whether their mental health would be differently impacted and whether contact with one's children or social contact would alleviate this impact. This additional test is important as the mental health of older people with ADL/IADL limitations may be more affected when becoming empty nesters as their live-in children are potential caregivers. When their children leave home, their care needs may not be met, and this may create stress and anxiety for them. Therefore, we repeat the above analyses for the subgroup with at least one ADL/IADL limitation to test whether social and children contacts will moderate the effect of becoming empty nesters among this group of older people.

In our study, we combined the DID approach with PSM to lower bias (Ravallion, 2007). To avoid selection bias, we matched them on the following variables in the pre-treatment periods (Caliendo & Kopeinig, 2008): birth year, gender, marital status, equivalent income, number of chronic diseases, ADL/IADL limitations, level of education, residence area and quartiles of provincial GDP per capita. We examined the matching quality according to the following three criteria: (1) the match rates for both groups were approximately 95% (Appendix D); (2) the propensity score density distributions for the matched groups were almost identical, indicating that after matching the two groups share common propensity score to be enrolled in the treatment, i.e. the two groups are comparable after matching (Appendix E); and (3) we further examined the standardised difference between the two groups after matching, which indicated that all differences were controlled around 0.1, meaning that the two groups were well balanced after matching (Austin, 2009; Rosenbaum & Rubin, 1985) (Appendix F).

Ethics considerations

This study uses publicly available secondary data; hence, no ethics approval is needed.

Results

According to the descriptive statistics in Table 2, around half of the empty nesters had contact with their children more than once a month, whereas the rest had contact with their children

less than once every three months. In terms of social contact, more than 50% of our observations had no social contact at all. Based on the descriptive statistics, the proportion of the disabled in the group of empty nesters was smaller than that of the control group, possibly because the disabled were more likely to live with their children.

The effects of being an empty nester on depressive symptoms are listed in Table 3 (see Appendix G for full sets of regression results). Column 1 displays the DID estimate when we assumed a constant ATT, while Column 2 presents the results when we allowed for varied ATTs. When we assumed that being an empty nester would have the same effect on people's depressive symptoms, regardless of how many waves they had been empty nesters for, we found that the depression score declined, though not significantly. However, when we allowed for being an empty nester to have different influences on depressive symptoms, people's mental health was significantly negatively impacted after being an empty nester for two and three waves. In addition, we observed a more severe deterioration in mental health for empty nesters for three waves than for two waves.

In Table 4, we present our results for the impact of contact with one's children, as well as social contact, on the association between depressive symptoms and being an empty nester (see Appendix H for full sets of regression results). As outlined in Column 1, the depression score increased significantly after people became empty nesters for two and three waves, but only when they had contact with their children less than once every three months. For people who contact/are contacted by their children more than once a month, their depressive symptoms were uniquely impacted by being an empty nester. For the effect of social contact seen in Columns 2 and 3, compared to people without social contact, the impact of being an empty nester on the mental health of older people who do have social contact is different. Specifically, after becoming an empty nester, the depression score for people who have social contact declined by approximately 0.6 more than for people without social contact. When we further divide social contact into two types, we found that it is cognitive activities that contribute to the significant modification function on the effect of being an empty nester on depressive symptoms.

We focused our study on older people with disabilities, as outlined in Table 5 (see Appendix I for full sets of regression results). We found that once older people with disabilities became empty nesters, their depression scores rose significantly; the effects were greater the longer they had been empty nesters. In particular, after being an empty nester for three waves (around seven years), the depression score for older people with disabilities increased substantially by approximately 3.7. If these disabled older empty nesters had contact with their children more than once a month, it seemed that their depression status would not significantly deteriorate. However, if they had contact with each other less often, their depression score would rise significantly by approximately 2.4 on average. Finally, we found that having cognitive activities seemed to have significantly positive influence on depressive symptoms in disabled older people.

Discussion

Understanding how older people's mental health changes after they become empty nesters has significant policy implications. This paper presents compelling new findings on the association

Table 2. Descriptive statistics.

	2011, Mean (SD)		2013, Mean (SD)		2015, Mean (SD)		2018, Mean (SD)	
	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment
Depression scores	6.70 (5.27)	6.60 (5.13)	5.14 (5.14)	5.09 (5.01)	5.90 (5.56)	5.80 (5.49)	9.24 (10.9)	8.80 (9.73)
Children contact after empty-nested, %								
>1 time/month	–	–	–	45.4	–	50.4	–	50.8
<1 time/3 months	–	–	–	54.6	–	49.6	–	49.2
Social contact, %	36.7	42.1	46.0	50.6	43.5	46.9	43.4	43.2
ADL/IADL limitations, %	30.7	19.5	40.6	28.9	37.0	26.7	37.6	28.8
Feeling bodily pain, %	34.6	34.2	39.1	39.8	32.7	32.4	62.6	62.7
Marital status, %								
Married	66.6	82.5	65.8	82.5	69.2	82.1	67.3	79.8
Single	33.4	17.5	34.2	17.5	30.8	17.9	32.7	20.2
Level of education, %								
No formal education	43.6	35.7	42.7	35.6	39.1	33.3	36.3	31.4
< = middle school	50.9	58.3	51.1	58.1	54.5	60.2	57.3	61.9
> = high school	5.41	5.94	6.18	6.31	6.39	6.56	6.41	6.69
No. of chronic diseases	1.58 (1.46)	1.60 (1.51)	1.49 (1.40)	1.54 (1.46)	1.52 (1.46)	1.58 (1.47)	0.72 (0.95)	0.73 (1.04)
Self-perceived health status, %								
Excellent/very good	11.4	12.5	14.7	13.4	15.0	14.7	20.5	19.7
Good	29.5	31.9	29.0	31.1	29.3	32.3	47.0	48.5
Fair/poor	59.1	55.6	56.3	55.6	55.7	53.0	32.6	31.8
Equivalent income, RMB								
Quartile (25%)	3230	6723.8	2795.1	3128.2	375	0	4793.5	2640
Quartile (50%)	10420.1	13341.5	11124.9	11177.5	5860.1	848.5	19475	8730
Quartile (75%)	23076.7	25100	23545.8	22400	17922.1	8960	43132.1	28393.8
Age	69.5 (7.97)	66.5 (5.97)	69.8 (8.23)	66.9 (6.17)	68.7 (7.85)	67.7 (6.25)	70.6 (7.41)	70.3 (6.02)
Gender, %								
Male	45.5	50.5	45.3	50.7	44.6	50.8	43.6	50.5
Female	54.5	49.5	54.7	49.3	55.4	49.2	56.4	49.5
Residence area, %								
Rural	59.7	62.9	56.6	61.9	55.5	60.8	55.4	61.2
Urban	40.3	37.1	43.4	38.1	44.5	39.2	44.6	38.8
Obs/year/group	1,110	1,062	1,474	1,489	1,628	1,706	1,310	1,540
Obs/year	2,172		2,963		3,334		2,850	
Obs in total					11,319			

Notes. SD=Standard deviation (in parentheses); Obs=Observations; “–” denotes “not applicable”.

Table 3. The impact of being an empty nester on depressive symptoms for people over 60.

	(1)	(2)
	Constant ATT	Varied ATTs
Empty nester	–0.0473 (0.220)	
Empty nester for 1 wave		–0.0784 (0.223)
Empty nester for 2 waves		0.786** (0.327)
Empty nester for 3 waves		1.297*** (0.501)
Covariates	Yes	Yes
Obs	9,526	9,526

Notes. The estimates stem from fixed-effects (within) regression. Standard errors are in parentheses. Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Obs = Observations.

between being an empty nester and depressive symptoms with the time and moderation effects of contact with one's children and social contact in relation to this association. Our findings show that older people's mental health does not change significantly right after they become empty nesters, but in the longer term, their mental health would deteriorate significantly with time, which is consistent with existing studies (Dennerstein et al., 2002; Gao et al., 2017). We also found that regular contact with children remain important for older people's mental health after they become empty nester. One possible explanation is that one's parental role and affiliated sense of accomplishment may be affected after becoming an empty nester (Bouchard, 2014; White & Edwards, 1990), however, if empty nesters maintain regular contact with their children, their parental role may remain, even without co-habiting (White & Edwards, 1990). Furthermore, we found that older empty nesters' mental health is significantly improved if they have social contact, especially

cognitive activities. This is consistent with existing studies (Gao et al., 2017; Lam et al., 2020).

The results from our subgroup analysis on older people with ADL/IADL limitations present a different picture. When older people with functional disabilities become empty nesters and have contact with their children less than once every three months, their mental health is affected immediately after they become empty nesters, and worsens in the longer term. In China, due to a lack of formal LTC, older people with ADL/IADL limitations primarily rely on informal LTC provided by children or other relatives (Yang et al., 2021). If they become empty nesters and do not have frequent contact with their children, their LTC needs are hard to meet due to reduced care, which may in turn have negative outcomes for their physical and mental health (Mahoney et al., 2000; Zunzunegui et al., 2001). This again can be supported by the stress-buffering model which has implications on caregiving and care-receiving. For older people with disabilities, their live-in children can potentially be their caregivers. Perceived support from children who have been the carers may buffer the negative stress on older people's life, and losing such support or contact may create stress and anxiety among older people with disabilities.

This study provides fresh insight into the association between being an empty nester and mental health, as well as the moderating effects of social contact and contact with one's children, which enabled us to draw the following policy implications. First, the local community should provide older people with social contact opportunities, especially cognitive activities (Rodda et al., 2011). For instance, community events, which include walking, board games, craft making, and providing

Table 4. The impacts of contact with one's children and social contact on depressive symptoms for empty nesters.

	Contact with one's children		Social contact	
	(1)	(2)	(3)	(4)
Empty nester for 1 wave				
>1 time/month	-0.139(0.279)			
<1 time/3 months	0.0162(0.285)			
Empty nester for 2 waves				
>1 time/month	0.105(0.414)			
<1 time/3 months	1.346***(0.388)			
Empty nester for 3 waves				
>1 time/month	0.859(0.608)			
<1 time/3 months	1.824***(0.641)			
Empty nester*Social contact		-0.602*(0.316)		
Empty nester*Social contact (social)				-0.451(0.362)
Empty nester*Social contact (cognitive)				-0.826*(0.445)
Covariates	Yes	Yes	Yes	Yes
Obs	9,469	9,526	9,443	

Notes. The estimates stem from fixed-effects (within) regression. Standard errors are in parentheses. Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Obs = Observations.

Table 5. The impact of being an empty nester on depressive symptoms in people with ADL/IADL limitations.

	(1)	(2)	(3)	(4)
	Constant ATT	Varied ATTs	Contact with one's children	Social contact
Empty nester	1.275**(0.616)			1.682**(0.734)
Empty nester for 1 wave		1.239**(0.620)		
Empty nester for 2 waves		3.501***(0.934)		
Empty nester for 3 waves		3.732***(1.396)		
Children contact:			0.205(0.731)	
>1 time/month				
<1 time/3 months			2.431***(0.736)	
Empty nester*Social contact (social)				-1.075(1.000)
Empty nester*Social contact (cognitive)				-3.200*(1.734)
Covariates	Yes	Yes	Yes	Yes
Obs	2,667	2,667	2,656	2,649

Notes. The estimates stem from fixed-effects (within) regression. Standard errors are in parentheses. Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Obs = Observations.

older people with chances to communicate with others of the same age, have proved to be effective in improving older people's mental health (Forsman et al., 2011; Jorm, 2012). We have also observed that these cognitive activities have greater positive impacts on the mental health of older empty nesters with functional disabilities than the other older empty nesters. This could be due to limited activities available for the older people with functional limitations as most of the older people are not able to participate in strenuous activities. However, by participating in cognitive activities, older people with disabilities may develop social ties with other people, who may offer emotional support, comfort and interpersonal interactions. Our findings are consistent with a number of studies in the field, which stress the importance of social interactions for older people (Burmeister et al., 2016; Gaugler & Zarit, 2001).

Second, a formal LTC system should be created to support older empty nesters with functional disabilities. For this group of people, receiving informal LTC from families or friends is difficult since they do not live together. Hence, formal LTC becomes vital in maintaining their physical health and enabling them to live independently with respect, and in turn becomes important for their mental health (Muir, 2017; Yang & Tan, 2019). The LTC system in China is still in its early stages of development, and the family is the main provider of LTC (Peng, 2015). To meet the needs of older empty nesters with functional disabilities for formal LTC, day care centres could be set up in the community to provide meals and transportation services, and home-based LTC services could be provided by professional caregivers (World Health Organization, 2015).

This study has the following limitations. First, we were unable to identify a causal relationship between depressive

symptoms and being an empty nester, as becoming an empty nester is not strictly exogenous, but rather an endogenous choice made by individuals. Second, the sample size of older people with ADL/IADL limitations was not large enough, making it difficult to perform deeper analysis based on subgroups, such as further dividing the group according to marital status. We hypothesise that single empty nesters with functional disabilities may experience more depressive symptoms than married empty nesters, as married individuals may receive care from their partners.

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Appendix A: Robustness check with city-level GDP per capita

	(1)	(2)
	Constant ATT	Varied ATTs
Empty nester	-0.0491(0.220)	
Empty nester for 1 wave		-0.0815(0.223)
Empty nester for 2 waves		0.796**(0.327)
Empty nester for 3 waves		1.297***(0.501)
Year 2011 (ref)		
Year 2013	-1.639***(0.206)	-1.670***(0.206)
Year 2015	-0.750***(0.246)	-0.957***(0.252)
Year 2018	2.547***(0.342)	2.089***(0.363)
Social contact	-0.325*(0.168)	-0.346**(0.168)
ADL/IADL limitations	1.032***(0.202)	1.074***(0.202)
No. of chronic diseases	0.282***(0.0776)	0.291***(0.0776)
Health status (ref: Excellent & very good)		
Good	-0.0335(0.253)	-0.0518(0.253)
Fair & poor	0.584**(0.264)	0.575**(0.263)
Equivalent income (ref: Quartile 1)		
Quartile 2	-0.204(0.200)	-0.176(0.200)
Quartile 3	-0.250(0.217)	-0.237(0.217)
Quartile 4	-0.0136(0.258)	0.0254(0.258)
Marital status (ref: The married)		
The single	0.815*(0.419)	0.835**(0.418)
Feel pain	1.160***(0.179)	1.158***(0.179)
City-level GDP per capita	0.0793(0.0854)	0.0796(0.0853)
Constant	5.085***(0.437)	5.109***(0.437)
Obs	9,526	9,526

Notes. Estimates stem from Sfixed-effects (within) regression. Standard errors are in parentheses. Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Obs = Observations.

Appendix B: Parallel trend test

	Depression
Year 2011*Treatment (ref)	
Year 2013*Treatment	-0.304(0.400)
Year 2015*Treatment	-0.259(0.401)
Year 2018*Treatment	0.495(0.422)
Year 2011 (ref)	
Year 2013	-1.704***(0.357)
Year 2015	-1.067***(0.398)
Year 2018	1.175**(0.573)
Social contact	-0.320*(0.168)
ADL/IADL limitations	1.056***(0.202)
No. of chronic diseases	0.275***(0.0776)
Health status (Excellent & very good: ref)	
Good	-0.0371(0.253)
Fair & poor	0.589**(0.263)
Equivalent income (Quartile 1: ref)	
Quartile 2	-0.189(0.200)
Quartile 3	-0.212(0.215)
Quartile 4	0.0464(0.255)
Marital status (The married: ref)	
The single	0.830**(0.418)
Feel pain	1.161***(0.179)
Provincial GDP per capita	0.442***(0.162)
Constant	3.847***(0.632)
N	9,526

Notes. Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$.

Appendix C: Heterogeneous impacts of being an empty nester on depressive symptoms for people in rural/urban areas

1. Constant ATT and Varied ATTs.

	(1) Constant ATT	(2) Varied ATTs
Empty nester*the rural (ref)		
Empty nester*the urban	-0.739**(0.331)	
Empty nester for 1 wave*the urban		-0.416(0.363)
Empty nester for 2 waves*the urban		-1.745*** (0.498)
Empty nester for 3 waves*the urban		-0.0969(0.810)
Empty nester	0.238(0.254)	
Empty nester for 1 wave		0.0749(0.263)
Empty nester for 2 waves		1.442*** (0.377)
Empty nester for 3 waves		1.367** (0.572)
Year 2013 (ref: Year 2011)	-1.917*** (0.228)	-1.946*** (0.228)
Year 2015	-1.257*** (0.303)	-1.448*** (0.307)
Year 2018	1.476*** (0.523)	1.035* (0.535)
Social contact	-0.309* (0.168)	-0.320* (0.168)
ADL/IADL limitations	1.038*** (0.201)	1.093*** (0.202)
No. of chronic diseases	0.279*** (0.0777)	0.277*** (0.0777)
Health status (ref: Excellent & very good)		
Good	-0.0441(0.253)	-0.0771(0.253)
Fair & poor	0.568** (0.263)	0.549** (0.263)
Equivalent income (ref: Quartile 1)		
Quartile 2	-0.217(0.199)	-0.211(0.200)
Quartile 3	-0.243(0.217)	-0.245(0.217)
Quartile 4	-0.00129(0.258)	-0.00109(0.258)
Marital status (ref: The married)		
The single	0.791* (0.418)	0.788* (0.418)
Feel pain	1.150*** (0.179)	1.161*** (0.179)
Provincial GDP per capita	0.460*** (0.162)	0.452*** (0.162)
Constant	3.833*** (0.632)	3.923*** (0.631)
Obs	9,526	9,526

2. The interaction with social contact.

	Social contact	
	(2)	(3)
Empty nester*Social contact*the urban	-1.093*(0.652)	
Empty nester*Social contact (social)*the urban		0.498(0.767)
Empty nester*Social contact (cognitive)*the urban		-3.802*** (0.917)
Empty nester*Social contact	-0.121(0.404)	
Empty nester*Social contact (social)		-0.614(0.440)
Empty nester*Social contact (cognitive)		1.588** (0.678)
Empty nester*the urban	-0.159(0.462)	-0.155(0.464)
Social contact*the urban	0.112(0.416)	
Social contact (social)*the urban		-0.258(0.458)
Social contact (cognitive)*the urban		0.373(0.685)
Empty nester	0.300(0.309)	0.373(0.685)
Year 2011 (ref)		
Year 2013	-1.922*** (0.228)	-1.988*** (0.230)
Year 2015	-1.234*** (0.303)	-1.310*** (0.306)
Year 2018	1.500*** (0.523)	1.388*** (0.527)
Social contact	-0.171(0.248)	
Social contact (ref: 0 no)		-0.227(0.265)
1 social		
2 cognitive		0.345(0.469)
ADL/IADL limitations	1.011*** (0.202)	1.057*** (0.203)
No. of chronic diseases	0.283*** (0.0777)	0.260*** (0.0788)
Health status:		
Excellent & very good (ref)		
Good	-0.0395(0.253)	-0.0281(0.255)
Fair & poor	0.573** (0.263)	0.580** (0.266)
Equivalent income:		
Quartile 1 (ref)		
Quartile 2	-0.213(0.200)	-0.196(0.201)
Quartile 3	-0.250(0.217)	-0.215(0.218)
Quartile 4	-0.0349(0.258)	0.0150(0.260)
Marital status:		
The married (ref)		
The single	0.797* (0.418)	0.772* (0.421)
Feel pain	1.154*** (0.179)	1.167*** (0.180)
Provincial GDP per capita	0.447*** (0.162)	0.469*** (0.163)
Constant	3.793*** (0.635)	3.702*** (0.639)
Obs	9,526	9,443

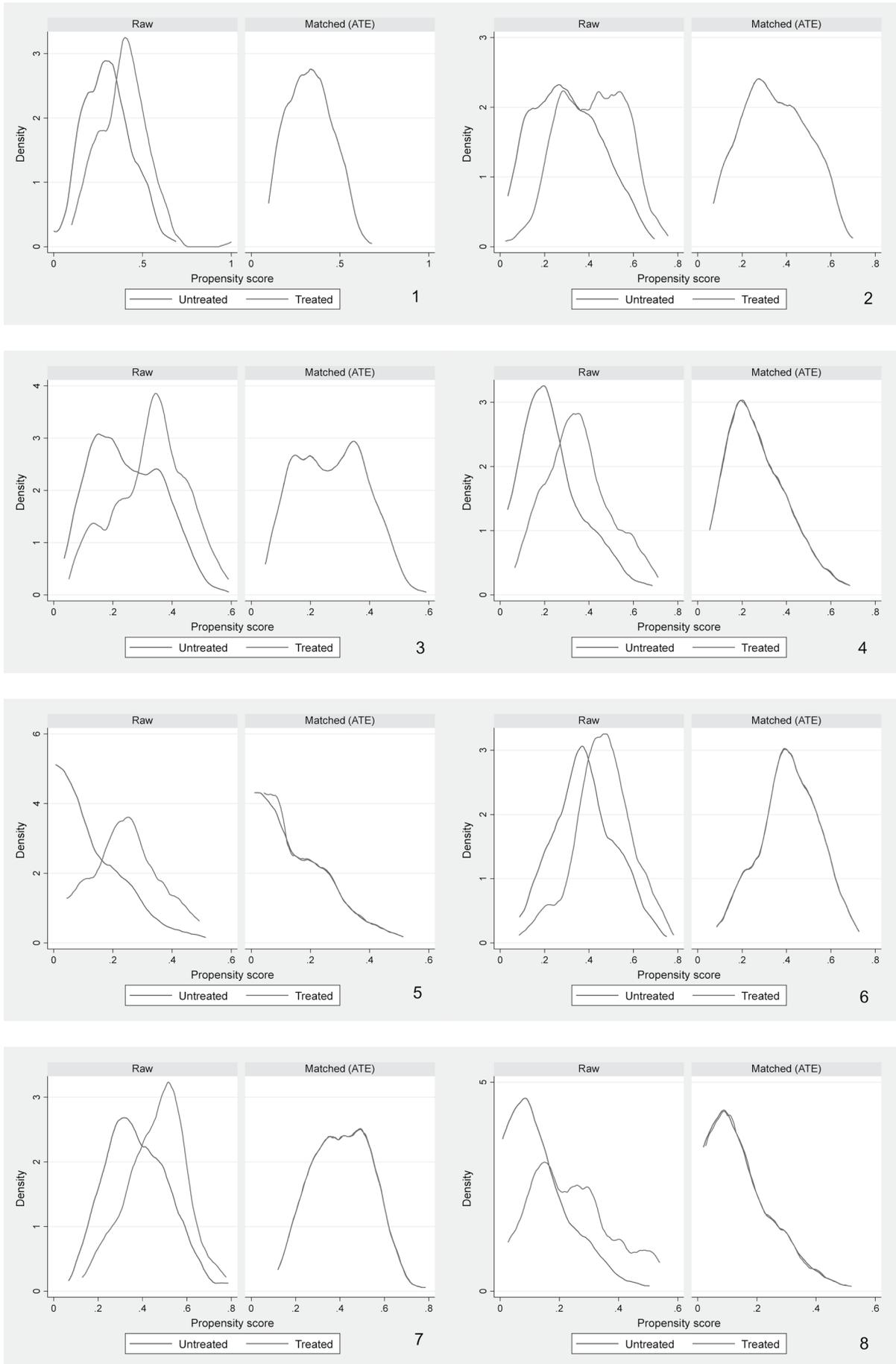
Notes. Estimates stem from fixed-effects (within) regression. Standard errors are in parentheses. Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Obs = Observations.

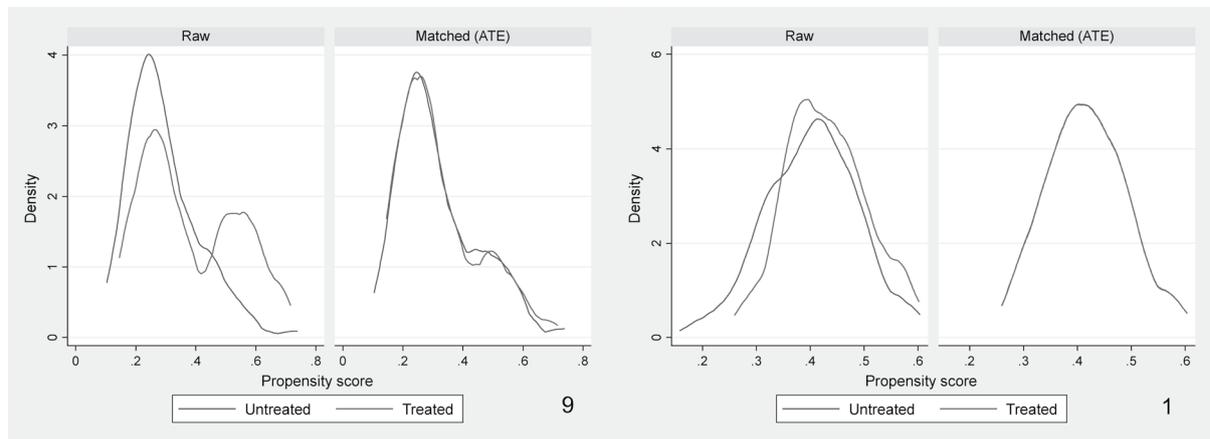
Appendix D: The matching rate for treatment and control groups

		Matched	Total	Match rate
1	Treatment group	278	296	93.9%
	Control group	565	595	95.0%
	Combined	843	891	94.6%
2	Treatment group	314	333	94.3%
	Control group	601	636	94.5%
	Combined	915	969	94.4%
3	Treatment group	224	236	94.9%
	Control group	609	638	95.5%
	Combined	833	874	95.3%
4	Treatment group	78	84	92.9%
	Control group	208	231	90.0%
	Combined	286	315	90.8%
5	Treatment group	42	43	97.7%
	Control group	227	231	98.3%
	Combined	269	274	98.2%
6	Treatment group	176	185	95.1%
	Control group	250	263	95.1%
	Combined	426	448	95.1%
7	Treatment group	184	196	93.9%
	Control group	272	281	96.8%
	Combined	456	477	95.6%
8	Treatment group	40	43	93.0%
	Control group	218	222	98.2%
	Combined	258	265	97.4%
9	Treatment group	37	38	97.4%
	Control group	80	80	100.0%
	Combined	117	118	99.2%
10	Treatment group	220	229	96.1%
	Control group	306	324	94.4%
	Combined	526	553	95.1%

Notes. 1 = for the sample enrolled in Year 1–4 and treated in Year 4; 2 = enrolled in Year 1–4, treated in Year 3; 3 = enrolled in Year 1–4, treated in Year 2; 4 = enrolled in Year 1–3, treated in Year 3; 5 = enrolled in Year 1–3, treated in Year 2; 6 = enrolled in Year 2–4, treated in Year 4; 7 = enrolled in Year 2–4, treated in Year 3; 8 = enrolled in Year 1–2; 9 = enrolled in Year 2–3; 10 = enrolled in Year 3–4.

Appendix E: Propensity score density distributions before and after the matching





Notes. 1 = for the sample enrolled in Year 1–4 and treated in Year 4; 2 = enrolled in Year 1–4, treated in Year 3; 3 = enrolled in Year 1–4, treated in Year 2; 4 = enrolled in Year 1–3, treated in Year 3; 5 = enrolled in Year 1–3, treated in Year 2; 6 = enrolled in Year 2–4, treated in Year 4; 7 = enrolled in Year 2–4, treated in Year 3; 8 = enrolled in Year 1–2; 9 = enrolled in Year 2–3; 10 = enrolled in Year 3–4.

Appendix F: Summary of standardized difference and t-Test between the treatment and control groups after matching

	1				2			
	Treatment	Control	SD	t-Test	Treatment	Control	SD	t-Test
Birth year	1944.5	1944.6	-0.005	-1.22	1944.7	1945.1	-0.060	-3.21***
Gender: female (ref: male)	0.524	0.528	-0.008	1.47	0.566	0.525	0.082	2.73***
No. of chronic diseases 2011	1.483	1.440	0.030	0.81	1.559	1.516	0.030	0.53
No. of chronic diseases 2013	1.387	1.401	-0.011	0.04	1.548	1.509	0.029	-0.10
No. of chronic diseases 2015	1.582	1.614	-0.021	-1.00				
Equivalent income 2011 (ref: Quartile 1)								
Quartile 2	0.279	0.300	-0.045	-2.90***	0.296	0.305	-0.019	-2.37**
Quartile 3	0.225	0.233	-0.019	-1.40	0.272	0.267	0.012	-2.79***
Quartile 4	0.191	0.171	0.053	-0.65	0.177	0.190	-0.033	-2.84***
Equivalent income 2013 (ref: Quartile 1)								
Quartile 2	0.227	0.255	-0.063	-3.04***	0.235	0.256	-0.048	-1.53
Quartile 3	0.287	0.305	-0.038	-4.33***	0.281	0.279	0.005	-1.04
Quartile 4	0.195	0.192	0.009	-1.00	0.200	0.201	-0.002	-0.93
Equivalent income 2015 (ref: Quartile 1)								
Quartile 2	0.252	0.246	0.014	1.38				
Quartile 3	0.332	0.333	-0.002	1.90				
Quartile 4	0.226	0.219	0.017	1.58				
With ADL/IADL limitations 2011	0.195	0.179	0.043	2.59***	0.193	0.198	-0.014	1.20
With ADL/IADL limitations 2013	0.301	0.297	0.010	2.21**	0.354	0.332	0.047	2.23**
With ADL/IADL limitations 2015	0.323	0.343	-0.043	1.10				
Marital status 2011: The single (ref: The married)	0.246	0.242	0.009	1.80*	0.212	0.171	0.104	4.39***
Marital status 2013: The single (ref: The married)	0.279	0.276	0.008	1.92*	0.268	0.196	0.174	6.09***
Marital status 2015: The single (ref: The married)	0.300	0.298	0.003	2.36**				
Education attainment 2011 (ref: No education)								
Elementary, middle school	0.629	0.618	0.022	-0.87	0.570	0.586	-0.030	-1.03
High school and above	0.037	0.038	-0.005	0.02	0.046	0.057	-0.046	-2.34
Education attainment 2013 (ref: No education)								
Elementary, middle school	0.629	0.608	0.044	-1.18	0.553	0.572	-0.039	-1.50
High school and above	0.040	0.041	-0.008	-0.30	0.047	0.059	-0.054	-2.42
Education attainment 2015 (ref: No education)								
Elementary, middle school	0.631	0.613	0.038	-1.57				
High school and above	0.040	0.041	-0.008	-0.41				
The urban (ref: The rural)	0.389	0.380	0.019	0.80	0.336	0.387	-0.105	-1.46
Region (ref: 1)								
2	0.414	0.387	0.054	0.88	0.399	0.441	-0.084	-2.11**
3	0.367	0.366	0.003	0.91	0.373	0.322	0.108	1.52
			3				4	
	Treatment	Control	SD	t-Test	Treatment	Control	SD	t-Test
Birth year	1944.4	1944.3	0.015	-1.64	1939.7	1940.3	-0.068	-1.53
Gender: female (ref: male)	0.557	0.566	-0.019	0.64	0.491	0.496	-0.010	0.20
No. of chronic diseases 2011	1.574	1.553	0.014	-0.43	1.623	1.735	-0.072	-0.58
No. of chronic diseases 2013					1.667	1.797	-0.079	-0.30
Equivalent income 2011 (ref: Quartile 1)								
Quartile 2	0.335	0.330	0.010	-3.44***	0.297	0.324	-0.058	-1.47
Quartile 3	0.225	0.251	-0.059	-3.85***	0.207	0.225	-0.043	-1.70
Quartile 4	0.170	0.164	0.016	-1.95*	0.182	0.155	0.079	0.53

(Continued)

Appendix F. Continued.

	5				6			
	Treatment	Control	SD	t-Test	Treatment	Control	SD	t-Test
Equivalent income 2013 (ref: Quartile 1)								
Quartile 2					0.318	0.289	0.067	0.77
Quartile 3					0.188	0.221	-0.077	-0.10
Quartile 4					0.142	0.152	-0.028	0.80
With ADL/IADL limitations 2011	0.249	0.229	0.048	1.09	0.364	0.330	0.071	1.19
With ADL/IADL limitations 2013					0.477	0.479	-0.004	1.18
Marital status 2011: The single (ref: The married)	0.238	0.220	0.045	3.98***	0.394	0.357	0.079	2.91***
Marital status 2013: The single (ref: The married)					0.434	0.388	0.097	3.17***
Education attainment 2011 (ref: No education)								
Elementary, middle school	0.565	0.560	0.012	-0.31	0.477	0.504	-0.053	-1.14
High school and above	0.032	0.051	-0.078	-2.62***	0.005	0.008	-0.017	-0.64
Education attainment 2013 (ref: No education)								
Elementary, middle school					0.477	0.537	-0.119	-1.60
High school and above					0.000	0.000	0.000	-
The urban (ref: The rural)	0.345	0.355	-0.020	0.93	0.343	0.362	-0.039	-0.40
Region (ref: 1)								
2	0.399	0.424	-0.050	-1.88*	0.386	0.426	-0.081	-0.88
3	0.362	0.352	0.021	0.68	0.359	0.350	0.020	0.78
Birth year	1940.4	1941.4	-0.141	-2.78***	1949.9	1950.1	-0.042	-2.14**
Gender: female (ref: male)	0.507	0.459	0.096	1.01	0.531	0.551	-0.040	-0.39
No. of chronic diseases 2011	1.929	1.709	0.146	1.11				
No. of chronic diseases 2013					1.239	1.187	0.041	0.47
No. of chronic diseases 2015					1.411	1.380	0.022	-0.02
Equivalent income 2011 (ref: Quartile 1)								
Quartile 2	0.156	0.259	-0.233	-1.82*				
Quartile 3	0.308	0.243	0.146	-0.68				
Quartile 4	0.216	0.214	0.005	-0.78				
Equivalent income 2013 (ref: Quartile 1)								
Quartile 2					0.215	0.225	-0.024	-0.61
Quartile 3					0.291	0.326	-0.078	-0.79
Quartile 4					0.289	0.282	0.016	0.23
Equivalent income 2015 (ref: Quartile 1)								
Quartile 2					0.232	0.204	0.068	-0.21
Quartile 3					0.277	0.281	-0.008	0.15
Quartile 4					0.284	0.309	-0.055	-0.75
With ADL/IADL limitations 2011	0.334	0.282	0.117	1.59				
With ADL/IADL limitations 2013					0.205	0.218	-0.031	0.39
With ADL/IADL limitations 2015					0.212	0.191	0.054	2.83***
Marital status 2011: The single (ref: The married)	0.436	0.320	0.253	2.66***				
Marital status 2013: The single (ref: The married)					0.174	0.155	0.052	1.72*
Marital status 2015: The single (ref: The married)					0.202	0.178	0.063	2.22**
Education attainment 2011 (ref: No education)								
Elementary, middle school	0.579	0.542	0.075	-0.97				
High school and above	0.027	0.052	-0.119	-1.54				
Education attainment 2013 (ref: No education)								
Elementary, middle school					0.561	0.579	-0.038	-1.39
High school and above					0.086	0.079	0.024	0.25
Education attainment 2015 (ref: No education)								
Elementary, middle school					0.574	0.595	-0.042	-1.42
High school and above					0.086	0.079	0.024	0.22
The urban (ref: The rural)	0.418	0.389	0.059	0.24	0.499	0.481	0.035	0.90
Region (ref: 1)								
2	0.427	0.486	-0.118	-0.36	0.393	0.432	-0.079	-3.39***
3	0.296	0.267	0.068	1.64	0.349	0.357	-0.017	-1.83*
Birth year	1949.9	1949.5	0.067	-0.78	1938.6	1938.1	0.063	-1.84*
Gender: female (ref: male)	0.539	0.536	0.006	1.88*	0.423	0.513	-0.180	-1.90*
No. of chronic diseases 2011					1.735	1.731	0.002	-1.08
No. of chronic diseases 2013	1.383	1.302	0.057	-0.41				
Equivalent income 2011 (ref: Quartile 1)								
Quartile 2					0.283	0.268	0.036	1.86*
Quartile 3					0.253	0.229	0.056	1.51
Quartile 4					0.251	0.243	0.017	0.70
Equivalent income 2013 (ref: Quartile 1)								
Quartile 2	0.219	0.236	-0.041	-0.13				
Quartile 3	0.293	0.292	0.004	0.18				
Quartile 4	0.246	0.244	0.006	1.32				
With ADL/IADL limitations 2011					0.420	0.409	0.025	2.77***
With ADL/IADL limitations 2013	0.250	0.265	-0.034	-0.13				
Marital status 2011: The single (ref: The married)					0.370	0.385	-0.032	1.09

(Continued)

Appendix F. Continued.

	0.201	0.164	0.101	3.55***				
Marital status 2013: The single (ref: The married)								
Education attainment 2011 (ref: No education)					0.419	0.428	-0.017	-0.54
Elementary, middle school					0.167	0.103	0.228	1.09
High school and above								
Education attainment 2013 (ref: No education)								
Elementary, middle school	0.539	0.525	0.027	0.30				
High school and above	0.082	0.075	0.025	0.74				
The urban (ref: The rural)	0.444	0.409	0.072	4.63***	0.604	0.483	0.242	0.69
Region (ref:								
1)								
2	0.423	0.387	0.074	-0.41	0.393	0.369	0.049	-0.21
3	0.311	0.346	-0.074	-0.56	0.459	0.403	0.114	0.17
	9				10			
	Treatment	Control	SD	t-Test	Treatment	Control	SD	t-Test
Birth year	1947.6	1947.6	0.000	-0.42	1953.4	1953.4	-0.011	0.04
Gender: female (ref: male)	0.547	0.497	0.100	1.65	0.526	0.508	0.037	1.10
No. of chronic diseases 2013	1.357	1.372	-0.009	-0.74				
No. of chronic diseases 2015					1.253	1.187	0.050	1.03
Equivalent income 2013 (ref:								
Quartile 1)								
Quartile 2	0.250	0.211	0.092	1.47				
Quartile 3	0.270	0.292	-0.050	2.01**				
Quartile 4	0.312	0.301	0.025	2.04**				
Equivalent income 2015 (ref:								
Quartile 1)								
Quartile 2					0.179	0.177	0.005	-0.23
Quartile 3					0.339	0.342	-0.005	0.32
Quartile 4					0.284	0.289	-0.012	0.23
With ADL/IADL limitations 2013	0.342	0.303	0.083	0.33				
With ADL/IADL limitations 2015					0.180	0.174	0.015	0.33
Marital status 2013: The single (ref: The married)	0.235	0.181	0.131	0.39				
Marital status 2015: The single (ref: The married)					0.111	0.085	0.078	1.67*
Education attainment 2013 (ref: No education)								
Elementary, middle school	0.583	0.616	-0.071	-0.42				
High school and above	0.085	0.091	-0.021	0.07				
Education attainment 2015 (ref: No education)								
Elementary, middle school					0.630	0.626	0.008	-0.56
High school and above					0.095	0.110	-0.051	-0.84
The urban (ref: The rural)	0.628	0.615	0.027	1.17	0.464	0.470	-0.011	0.50
Region (ref:								
1)								
2	0.328	0.375	-0.094	-1.05	0.403	0.403	0.000	0.12
3	0.401	0.364	0.077	-0.66	0.322	0.309	0.026	0.82

Notes. SD = Standardized difference. Results are from propensity score kernel matching. 9 = for the sample enrolled in Year 2-3; 10 = enrolled in Year 3-4. Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Appendix G: The impact of being an empty nester on depressive symptoms for people over 60

	(1)	(2)
	Constant ATT	Varied ATTs
Empty nester	-0.0473(0.220)	
Empty nester for 1 wave		-0.0784(0.223)
Empty nester for 2 waves		0.786**(0.327)
Empty nester for 3 waves		1.297***(0.501)
Year 2013 (ref: Year 2011)	-1.899***(0.228)	-1.924***(0.228)
Year 2015	-1.220***(0.303)	-1.415***(0.307)
Year 2018	1.517***(0.522)	1.084**(0.535)
Social contact	-0.325*(0.168)	-0.346**(0.168)
ADL/IADL limitations	1.040***(0.201)	1.081***(0.202)
No. of chronic diseases	0.274***(0.0776)	0.283***(0.0776)
Health status (ref: Excellent & very good)		
Good	-0.0314(0.253)	-0.0496(0.253)
Fair & poor	0.581**(0.263)	0.573**(0.263)
Equivalent income (ref:		
Quartile 1)		
Quartile 2	-0.215(0.200)	-0.188(0.199)
Quartile 3	-0.239(0.217)	-0.227(0.217)
Quartile 4	0.00723(0.258)	0.0455(0.257)
Marital status (ref: The married)		
The single	0.794*(0.418)	0.814*(0.418)
Feel pain	1.166***(0.179)	1.164***(0.179)
Provincial GDP per capita	0.445***(0.162)	0.437***(0.162)
Constant	3.873***(0.632)	3.923***(0.631)
Obs	9,526	9,526

Notes. Estimates stem from fixed-effects (within) regression. Standard errors are in parentheses. Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Obs = Observations.

Appendix H: The impacts of contact with one's children and social contact on depressive symptoms for empty nesters

	Contact with one's children		Social contact	
	(1)	(2)	(3)	
Empty nester for 1 wave				
>1 time/month	-0.139(0.279)			
<1 time/3 months	0.0162(0.285)			
Empty nester for 2 waves				
>1 time/month	0.105(0.414)			
<1 time/3 months	1.346*** (0.388)			
Empty nester for 3 waves				
>1 time/month	0.859(0.608)			
<1 time/3 months	1.824*** (0.641)			
Empty nester*Social contact		-0.602*(0.316)		
Empty nester*Social contact (social)			-0.451(0.362)	
Empty nester*Social contact (cognitive)			-0.826*(0.445)	
Empty-nester		0.237(0.266)		0.229(0.267)
Year 2011 (ref)				
Year 2013	-1.966*** (0.230)	-1.913*** (0.228)		-1.987*** (0.230)
Year 2015	-1.453*** (0.310)	-1.217*** (0.303)		-1.317*** (0.306)
Year 2018	1.059*(0.542)	1.510*** (0.522)		1.369*** (0.528)
Social contact	-0.334** (0.169)	-0.118(0.200)		
Social contact (ref: 0 no)				-0.324(0.217)
1 social				
2 cognitive				0.621*(0.342)
ADL/IADL limitations	1.087*** (0.202)	1.041*** (0.201)		1.084*** (0.203)
No. of chronic diseases	0.285*** (0.0783)	0.276*** (0.0776)		0.252*** (0.0789)
Health status:				
Excellent & very good (ref)				
Good	-0.0688(0.254)	-0.0271(0.253)		-0.0308(0.255)
Fair & poor	0.559** (0.265)	0.588** (0.263)		0.578** (0.266)
Equivalent income: Quartile 1 (ref)				
Quartile 2	-0.185(0.200)	-0.197(0.200)		-0.190(0.201)
Quartile 3	-0.210(0.218)	-0.241(0.217)		-0.213(0.219)
Quartile 4	0.0254(0.259)	-0.00837(0.258)		0.0460(0.260)
Marital status: The married (ref)				
The single	0.787*(0.421)	0.792*(0.418)		0.789*(0.421)
Feel pain	1.172*** (0.180)	1.165*** (0.179)		1.166*** (0.180)
Provincial GDP per capita	0.454*** (0.165)	0.443*** (0.162)		0.468*** (0.163)
Constant	3.890*** (0.641)	3.773*** (0.634)		3.695*** (0.639)
Obs	9,469	9,526		9,443

Notes. Estimates stem from fixed-effects (within) regression. Standard errors are in parentheses. Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Obs = Observations.

Appendix I: The impact of being an empty nester on depressive symptoms in people with ADLs/IADLs

	(1)	(2)	(3)	(4)
	Constant ATT	Varied ATTs	Contact with one's children	Social contact
Empty nester	1.275** (0.616)			1.833** (0.732)
Empty nester for 1 wave		1.239** (0.620)		
Empty nester for 2 waves		3.501*** (0.934)		
Empty nester for 3 waves		3.732*** (1.396)		
Children contact: >1 time/month			0.205(0.731)	
<1 time/3 months			2.431*** (0.736)	
Empty nester*Social contact (social)				-1.075(1.000)
Empty nester*Social contact (cognitive)				-3.200* (1.734)
Year 2013	-2.713*** (0.674)	-2.738*** (0.673)	-2.729*** (0.675)	-2.637*** (0.681)
Year 2015	-2.197** (0.923)	-2.697*** (0.935)	-2.208** (0.926)	-2.200** (0.929)
Year 2018	1.511(1.592)	0.269(1.649)	1.612(1.605)	1.437(1.601)
Social contact	-0.173(0.477)	-0.186(0.476)	-0.109(0.478)	
Social contact (ref: 0 no)				0.0432(0.589)
1 social				
2 cognitive				2.394* (1.286)
No. of chronic diseases	-0.243(0.201)	-0.330(0.202)	-0.217(0.201)	-0.281(0.205)
Health status:				
Excellent & very good (ref)				
Good	-1.174(0.924)	-1.123(0.921)	-1.097(0.924)	-1.088(0.933)
Fair & poor	0.779(0.872)	0.930(0.870)	0.808(0.872)	0.811(0.881)
Equivalent income:				
Quartile 1 (ref)				
Quartile 2	0.129(0.535)	0.234(0.534)	0.185(0.535)	0.204(0.540)
Quartile 3	-0.376(0.611)	-0.313(0.610)	-0.230(0.613)	-0.292(0.621)
Quartile 4	-0.0243(0.910)	0.00827(0.907)	-0.0628(0.909)	-0.0630(0.918)
Marital status: The married (ref)				
The single	0.214(1.111)	0.203(1.108)	0.497(1.114)	0.146(1.121)
Feel pain	0.367(0.494)	0.408(0.494)	0.270(0.496)	0.433(0.499)
Provincial GDP per capita	0.420(0.537)	0.460(0.536)	0.384(0.543)	0.454(0.540)
Constant	8.076*** (2.011)	8.020*** (2.003)	8.025*** (2.023)	7.606*** (2.035)
Obs	2,667	2,667	2,656	2,649

Notes. Estimates stem from fixed-effects (within) regression. Standard errors are in parentheses. Significance levels: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Obs = Observations.