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Family companionship and elderly suicide: Evidence from the Chinese Lunar New Year☆

Hanming Fang [a,f], Ziteng Lei [b,*], Liguo Lin [c], Peng Zhang [d], Maigeng Zhou [e]

[a] *Department of Economics, University of Pennsylvania, USA*
[b] *School of Labor and Human Resources, Renmin University of China, China*
[c] *Institute for Advanced Research, Shanghai University of Finance and Economics, China*
[d] *School of Management and Economics, The Chinese University of Hong Kong, Shenzhen, Shenzhen Finance Institute, China*
[e] *National Center for Chronic and Noncommunicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, China*
[f] *National Bureau of Economic Research, USA*

A B S T R A C T

Mental health problems among the elderly have attracted increasing attention. The most serious mental health problems may result in suicide, and lack of family companionship is often speculated to be a major cause. In this paper, we use high-frequency suicide rate data and utilize a novel temporal variation in the lunisolar calendar to provide evidence on the protective effects of the Chinese Lunar New Year (when the elderly people receive unusually high level of family companionship) on elderly suicide. We find that elderly suicide rate decreases by 8.7% during the Chinese Lunar New Year, and the protective effects are stronger in counties where the typical level of daily family companionship for the elderly is lower. In addition, the dynamic effects are different for men and for women, and men are more sensitive to the shock of the Chinese Lunar New Year. We consider a variety of alternative mechanisms, and conclude that family companionship is an important channel. Our study calls for greater attention to the mental health status and suicide problem of the elderly, especially with the rapid population aging and increasing prevalence of the "empty-nest" elderly in developing countries.

1. Introduction

The prevalence of mental health problems and suicide among the elderly has attracted increasing attention. Approximately 15% of adults age 60 and above suffer from mental disorders, and 6.6% of disability among this group is attributed to mental and neurological disorders[1]. In the extreme form, these mental disorder problems lead to suicide. The suicide rate is highest among people age 70 years old and above, and suicide and mental disorder are highly correlated among the elderly

(Wærn et al., 2002).[2] Severe mental disorder and suicide have large economic costs. For example, Shepard et al. (2016) find that the total cost for all suicides and suicide attempts in the United States in 2013 is around $93.5 billion. Therefore, understanding the causes of mental health problems and suicide among the elderly, as well as providing effective policy assistance, is urgent and crucial.[3]

The concern about the mental health among the elderly is especially serious in developing countries. Between 2010 and 2050, the elderly population in developing countries is projected to increase by more than

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* Corresponding author.
E-mail addresses: hanming.fang@econ.upenn.edu (H. Fang), leiziteng@ruc.edu.cn (Z. Lei), lin.liguo@mail.shufe.edu.cn (L. Lin), zhangpeng@cuhk.edu.cn (P. Zhang), zhoumaigeng@ncncd.chinacdc.cn (M. Zhou).

[1] https://www.who.int/news-room/fact-sheets/detail/mental-health-of-older-adults.
[2] https://www.who.int/mediacentre/news/releases/2014/suicide-prevention-report/en/.
[3] There is no absolute cutoff for the start age of the elderly people. Throughout the paper, we refer to the elderly people as individuals age 65 or above. Our results are also robust to alternative age cutoffs, for instance 60 and 55, for elderly people.

250%, compared with a 71% increase in developed countries.[4] As a prominent example, China is experiencing rapid population aging, and the share of elderly in the total population is expected to increase from 12.6% in 2020 to 27.9% in 2050.[5] At the same time, China's national elderly suicide rates are four to five times higher than the general Chinese population and more than twice the global average (Li et al., 2009; Chen and Fang 2021). With rapid urbanization and increased internal migration, the proportion of the "empty-nest" elderly who are left-behind also increases dramatically, from 50% in 2010 to nearly 90% in 2030.[6] Therefore, the mental disorder and suicide problems for the elderly are extremely challenging in China.

Among numerous potential reasons for elderly mental disorder and suicide, lack of family companionship is hypothesized to be a crucial one. Many news articles suggest the importance of family companionship for the mental health of the empty-nest elderly in China.[7] However, scientific research is lacking to establish a convincing relationship between family companionship and elderly suicide. Previous studies have mostly provided correlational evidence (Antman 2010; Chen and Short 2008; Hawkley and Cacioppo 2010; Zurlo et al., 2014; Fässberg et al., 2012; Kwon et al., 2018; Banerjee et al., 2022) or suggested the relationship between family companionship and the mental health of the elderly (Chen and Fang 2021). In addition, those studies often hypothesize similar effects of family companionship for mental disorder and for suicide (Chen and Fang 2021).

In this study, we provide more direct evidence on the relationship between family companionship and elderly suicide, using the Chinese Lunar New Year (hereinafter referred to as "CLNY") as a social experiment. The CLNY is one of the most important holidays in China, with family reunion as the most central customs. Approximately 3 billion trips are being made each year during the "Spring Festival travel rush" around the CLNY to reunite with families.[8] During the CLNY, the elderly people, on average, receive a considerably higher level of family companionship than normal weeks in the year. Our paper proceeds in three steps. First, we estimate the causal effect of the CLNY on elderly suicide rate. Second, we provide suggestive evidence that increased family companionship during the CLNY is the main channel for the reduction in elderly suicide rate. Lastly, we document the gender differences in the dynamic effects of CLNY on suicide rate.

We use a uniquely grand new dataset from the Chinese Center for Disease Control and Prevention (CCDC), which contains county-week suicide rate data by gender and age cohorts from 2013 to 2017. To distinguish CLNY effect from a calendar week effect, we utilize a novel exogenous variation in the timing of the CLNY because of the traditional Chinese lunisolar calendar. For example, during 1991–2020, the CLNY fell 11 times in January and 19 times in February, fell 4 times in the 3rd week, 6 times in the 4th week, 8 times in the 5th week, 7 times in the 6th week, and 5 times in the 7th week of the year. Our identification strategy is to compare the elderly suicide rates in otherwise similar weeks whose treatment status differs because of the Chinese lunisolar calendar conditional on other flexibly temporal controls.

We find that the elderly suicide rate decreases by 8.7% (or 0.52 cases per 1 million people) during the CLNY, when the elderly people receive unusually high level of family companionship. We refer to this as the *protective effect* of the CLNY. In contrast, we do not find similar protective effects of CLNY for young and middle-age cohorts, indicating that

income shocks or underreporting are unlikely to drive all our results.

We utilize the geographical variations in the average daily family companionship that the elderly typically receives throughout the year to provide suggestive evidence on the mechanisms underlying the protective effect of the CLNY. We construct proxy measures of average daily family companionship for the elderly based on the living arrangements with their children using two data sources, namely, individual-level data from the 2010 Census, and 2011 China Health and Retirement Longitudinal Study (CHARLS) survey data. We find that the protective effects of the CLNY for the elderly are stronger in counties with a lower level of average daily family companionship, where the elderly people are expected to receive a more dramatic increase in family companionship during the CLNY. We also show that the alternative mechanisms, including short-term population flows, symbolic effects of holidays, and self-discipline of the elderly, cannot fully explain our results.

Next, we investigate the dynamic effects of the CLNY on total elderly suicides regardless of gender by directly estimating the treatment effects of weeks before and after the CLNY. We find that the protective effects start to emerge two weeks prior to the CLNY weeks, suggesting there are anticipation effects (Rutledge et al., 2014). There is some evidence that elderly suicide rate increases in the following 1–2 weeks after the CLNY weeks, but they are statistically insignificant. The cumulative effect when we sum up all coefficients is −0.057, and it is statistically significant at 5% level. This implies that the protective effects are not fully offset in the full sample, and the CLNY is effective at preventing elderly suicide.

We then explore the gender differences in dynamic effects. We find that the cumulative effect is −0.009 and statistically insignificant for female. In contrast, the pattern of the dynamic effects for male mimics the pattern for the full sample. The cumulative effect for male is −0.060, and it is statistically significant at the 5% level. The gender difference in dynamic effects suggests that the male elderly may be more sensitive to family companionship than the female elderly, which is consistent with the findings in previous studies in psychology (Stokes and Levin 1986) that the loneliness of men is more sensitive to social network density than women.

The contributions of this study are three-fold. First, we contribute to the literature on family companionship and the mental health of the elderly, and to the broad literature on understanding mental disorder and suicide. Since the seminar work by Hamermesh and Soss (1974) which proposed an "economic theory of suicide", which argues people will commit suicide when the utility of being dead is higher than being alive, economists have long been devoted to understanding what drives suicide (Becker and Posner 2004; Cutler et al., 2009; Case and Deaton 2015; Carleton 2017; Zou 2017; Burke et al., 2018; Christian et al., 2019; Pierce and Schott 2020). We provide the first direct evidence on the relationship between family companionship and elderly suicide.

Second, we contribute to the literature on gender differences in mental health, especially for the elderly population and in the extreme form of suicide (Girgus et al., 2017, Kiely et al., 2019). Our analysis on the dynamic effects indicates that older males and females respond differently to social networks and family companionship, and extends several studies in the psychology literature (Stokes and Levin 1986; Vandervoort 2000, Yeung et al., 2007) by providing more causal evidence using observed field data.

Lastly, we contribute to the epidemiological literature on the holiday effects on suicide (Jessen and Jensen 1999; Nishi et al., 2000; Beauchamp et al., 2014). We improve the identification by utilizing a novel timing variation of lunisolar calendar holidays across different years to control for confounding temporal trends and provide convincing causal estimates. Our findings also extend the literature on the social impacts of holidays that are not based on solar calendar, such as Ramadan (Schofield 2014; Campante and Yanagizawa-Drott 2015).

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[4] https://www.who.int/ageing/publications/global_health/en/.

[5] https://news.cctv.com/2020/10/05/ARTIWAeuX1XNDELg71z9L8ZU201005.shtml (in Chinese).

[6] http://www.15lu.com/shijie/6158.html (in Chinese).

[7] For some examples, see https://opinion.huanqiu.com/article/9CaKrnJREXR, http://www.yidianzixun.com/article/0PVg0gE4, and http://news.sohu.com/20100714/n273498420.shtml (in Chinese).

[8] https://baike.baidu.com/item/%E6%98%A5%E8%BF%90/329360#15 (in Chinese).

2. Data and empirical strategy

2.1. Data

The main dataset used in this study is county-week suicide rate data by gender and age cohorts from the CCDC. The sample covers 597 counties (rural area) or districts (urban area) (6-digit administrative code) under the Disease Surveillance Point (DSP) system from 2013 to 2017.[9] The system collects death records from the surveillance locations and is representative at provincial and national levels. Under the DSP system, deaths that occurred in hospitals and at homes are reported, and the causes of death are determined according to a standard protocol by trained staff located in local hospitals or CCDC branches. The DSP system covers more than 324 million people in China, accounting for 24.3% of the country's population.[10]

We also use two additional datasets to construct the proxy measures of average daily family companionship for the elderly. The first data source is the microdata of the 2010 Chinese Population Census. The dataset contains over 4 million individual observations, which are randomly drawn from the total population in 2010. The dataset contains information on the number of people registered in the household, which we refer to as household size, and we use the average household size of the elderly people and the proportion of elderly people living in households with at least three other people at the prefecture level as proxy measures for the average level of daily family companionship that the elderly people receive.[11]

The second data source is the CHARLS survey data, which contains detailed information on the living arrangements of children of the elderly. The baseline national wave of CHARLS was fielded in 2011 and includes about 10,000 households and 17,500 individuals in 150 counties/districts.[12] We construct two measures on daily family companionship. The first is the proportion of children living in the household. The second is the proportion of the elderly people with at least one child living in the same household.[13] We discuss the variable definitions in detail in the Appendix. Note that the variations in these proxy measures are cross-sectional and only capture the geographical variation in the average daily family companionship for the elderly, potentially due to differences in labor markets, migration tendency, and social security service across different regions.

2.2. Empirical strategy

We consider the fact that the timing of the CLNY varies across different years to estimate the causal effects of the CLNY on suicide. The main specification is as follows:

$$Y_{ctmw} = \alpha + \beta CLNY_{tmw} + \mu_c + \eta_t + \delta_m + \rho_w + \varepsilon_{ctmw},$$

where Y_{ctmw} is the outcome variable of county c in year t, month m, and week w. Each observation is a county-week combination. $CLNY_{tmw}$ is a binary variable that equals 1 if the week of observation is during the CLNY. The observation is at the week level that starts on Sunday and

ends on Saturday, and the statutory holidays of the CLNY last for seven days, which usually do not perfectly coincide with a Sunday-Saturday week. Thus, we define the week as in the CLNY if at least part of the week contains the statutory holidays.[14]

The main outcome of interest is suicide rate. We specify the inverse hyperbolic sine of suicide cases per 1 million people as the dependent variable. The inverse hyperbolic sine function, $IHS(x) = log(x + \sqrt{1 + x^2})$, is approximate to log function that the marginal effects can be interpreted as percentage changes for small changes, but the function is well-defined at 0. This measure is commonly used in the literature (Barreca et al., 2021, Card and DellaVigna, 2017). We prefer the inverse hyperbolic sine model because suicide is a rare event, and around 82% of the county-week observations have zeros in elderly suicide rate.[15] Nevertheless, our results are robust if we use raw suicide rate.

We include year fixed effects η_t, month fixed effects δ_m, and week-of-month fixed effects ρ_w to control for the possible time trends and seasonality of suicide. We also control for county fixed effects μ_c to control for time-invariant differences across counties. The regression is weighed by county population, and the standard errors are clustered at the county level.

Our identification strategy is that the timing of the CLNY is based on the traditional Chinese lunisolar calendar, which varies across different years and allows us to address the potential confoundedness of temporal trends by flexibly controlling for temporal fixed effects. Table A1 presents the distribution of the timing of the CLNY in the past 30 years (1991–2020). The CLNY fell 11 times in January and 19 times in February. The timing ranges from the 3rd week to the 7th week of the year, and the distribution is more or less random. The temporal variation allows us to compare otherwise similar weeks whose treatment status differs because of the Chinese lunisolar calendar. The assumption is that the potential temporal trends in suicide are absorbed by temporal fixed effects based on the solar calendar.

One may be concerned that the temporal trends are based on the Chinese lunisolar calendar rather than the solar calendar. We cannot test this hypothesis because our suicide data are based on the solar calendar. However, Martin et al. (1992) find little evidence on the relationship between lunar cycles and suicide attempts and completions. In addition, most individual and social activities are arranged based on the solar calendar in China; thus, arguably, most time trends are absorbed by time fixed effects based on the solar calendar.

3. Results

3.1. Main results

Table 1 shows summary statistics of weekly suicide rate by gender and age cohorts. The average suicide rate for the elderly is 4.44 cases per 1 million population per week in our sample, with a standard deviation of 13.29.[16]

Table 2 presents the main results. Columns (1) and (2) show the results with total elderly (65+) suicide rate as the dependent variable. In the preferred specification (Column (1)), we use the inverse hyperbolic sine of suicide rate as the dependent variable. We also provide results using the level of suicide rate (per 1 million people) as the dependent variable in Column (2). These results suggest that the elderly suicide rate

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[9] The administrative division from high to low in China is follows: provinces/municipalities (2-digit administrative code), prefectures (4-digit administrative code), counties/districts (6-digit administrative code).

[10] Figure A1 shows the geographical distribution of the counties/districts under the DSP system, which illustrates the representativeness of our sample.

[11] We do not average at the county level because there are only a few individual observations in the county.

[12] The CHARLS data can be accessed at http://charls.pku.edu.cn/index/en.html.

[13] We use baseline survey (2011) of CHARLS to construct the measures because they are closely comparable to measures constructed from the microdata of the 2010 Population Census, and the baseline survey is most comprehensive and representative.

[14] The year 2016 is the only year in the sample that shows perfect coincidence and has only one week defined as in the CLNY, whereas the other years all have two weeks defined to be in the CLNY.

[15] Throughout the rest of the paper, we use the inverse hyperbolic sine of suicide rate as the dependent variable unless explicitly specified.

[16] We find correlational evidence that the elderly suicide rate is smaller in urban districts than in rural counties, and decreases with regional economic development (GDP per capita), healthcare access (number of hospital per capita), and educational attainment of the elderly people.

Table 1
Summary statistics for weekly suicide rate.

	Mean	S.D.	Min	Max
Panel A Total Suicide Rate				
All age cohorts	1.158	2.198	0	95.815
Age 0–19	0.179	1.752	0	87.441
Age 20–64	1.074	2.524	0	143.057
Age 65+	4.437	13.291	0	571.646
Panel B Female Suicide Rate				
All age cohorts	0.967	2.721	0	196.321
Age 0–19	0.154	2.351	0	164.907
Age 20–64	0.864	3.159	0	290.731
Age 65+	3.674	15.785	0	1101.466
Panel C Male Suicide Rate				
All age cohorts	1.341	3.144	0	95.320
Age 0–19	0.200	2.558	0	163.583
Age 20–64	1.278	3.739	0	143.441
Age 65+	5.260	19.974	0	998.942

Notes: Number of observations = 151,253. The suicide rate is measured by number of cases per 1 million people.

decreases by 8.7% (or by 0.52 cases per 1 million people) during the CLNY. Columns (3) to (6) further show the results separately by gender. During the CLNY, the suicide rate of the female elderly decreases by 6.3% (or 0.44 cases per 1 million people), and the suicide rate of the male elderly decreases by 6.7% (or 0.61 cases per 1 million people), which are statistically significant.,[17],[18] Our results are robust to various variants of specification choices, including treatment variable definition, temporal fixed effects, weighting, standard error clustering, sample construction, age cutoff definition for the elderly, and alternative specification choice other than inverse hyperbolic sine transformation (Chen and Roth 2022), and the robustness of our results are shown in Table A2-A4 and explained in detail in the Appendix. Note that we do not find gender difference in this cotemporaneous model, but we find a significant gender difference in the dynamic model, which is discussed in Section 3.3.

The effects are sizable compared with previous studies on causes of suicide. Zou (2017) shows that wind farm installation in the United States leads to a 2% increase in suicide rate in the following years. Carleton (2017) shows that for days above 20 °C in India, a 1 °C increase in a single day's temperature during the growing season increases annual suicides by 0.008 per 100,000 people, which translates to increase in suicide rate by 3.5% for a standard deviation increase in temperature. Burke et al. (2018) show that suicide rate increases by 0.7% in the United States and by 2.1% in Mexico for a 1 °C increase in monthly average temperature. Christian et al. (2019) show that an average per capita transfer of US $22.45 targeted at the poorest 10% of households causes a decrease in the suicide rate by approximately 18%, and a 1 standard deviation increase in rainfall decreases the suicide by approximately 6%. Our estimates are of similar magnitude or even more pronounced compared with previous studies.

In Table 3, we further examine the effects of the CLNY on suicide rate by gender and age cohort, no longer restricted to the elderly (65+)

group. Columns (1)–(3) present the results for age cohorts 0–19, 20–64, and 65+, respectively; and Columns (4)–(6) further divide the 20–64 group into three subgroups (i.e., 20–34, 35–49, and 50–64, respectively). Panel A presents the results for total suicide rate, and Panels B and C present the results for female and male, respectively. We find no evidence to suggest that the suicide rate decreases for teenagers or middle-age people during the CLNY.[19] The estimates are all small in magnitude and statistically insignificant.

3.2. Heterogeneous effects and mechanisms

As family reunion is the most important custom of the CLNY, increase in family companionship and emotional support from family members is the largest change for the elderly people during the CLNY. To reunite with families, around 3 billion trips are being made each year during the Spring Festival travel rush around the CLNY. Survey evidence suggests that 80% of people go back home to reunite with their families, and 70% agree that family reunion during the CLNY is a traditional custom and they keep celebrating with families every year.[20] Therefore, we can hypothesize that family companionship is one important channel for the protective effects of the CLNY on elderly suicide documented in Tables 2 and 3 In this section, we examine heterogeneous effects across geographical regions and provide *suggestive* evidence that at least the family companionship mechanism is one of the key channels. The other competing mechanisms may also be operating, but they alone cannot explain the set of facts we documented in this paper.

The key fact we consider is that change in family companionship during the CLNY is not homogeneous for all the elderly people. For the elderly who do not live with children in the same household and receive low level of daily family companionship, the change in family companionship during the CLNY is considerably more dramatic. Therefore, in counties where the elderly people receive a lower level of daily family companionship, on average, the aggregate protective effects should be larger.[21]

We examine the hypothesis in Table 4. We regress elderly suicide rate on the interaction term of the CLNY dummy and proxy measures of average daily family companionship, and we hypothesize that the coefficient of the interaction term should be positive (i.e., the protective effect of the CLNY is less pronounced in counties with more daily family companionship).[22] In Columns (1) to (2), we use the proxy measures constructed from the Census data, i.e. the average household size and the proportion of the elderly people living in household with at least three other people, respectively. In Columns (3) to (4), we use the proxy measures constructed from CHARLS data, i.e. the average proportion of children living in the household and the proportion of the elderly people having children living in the household, respectively.[23] In all regressions, we control for the CLNY dummy, county, year, month, and week-of-month fixed effects, a dummy variable for whether the unit is

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[17] Note that the effect on total elderly suicide rate is out of the convex combination of the effect on female and male elderly suicide rate, because of the inverse hyperbolic sine transformation.

[18] In order to formally test whether the effects are the same for females and males (i.e. whether the coefficients in Columns (3) and (5) are equal), we define dependent variables by gender and reshape the data to long form, and use the regression specification with all covariates (including fixed effects) interacted with gender dummy. The results of the long-form data by gender are identical to the results in Table 2, and the interaction term of CLNY and gender dummy is exactly the difference between the coefficients in Columns (3) and (5). The p-value of the test is 0.920, indicating that there is no evidence that the effects are different for females and males in the baseline specification.

[19] Using similar method as testing equality of the effects by gender, we can test whether the effects are the same for elderly (65+) and for teenagers (0–19)/ middle-aged (20–64). The p-values are 0.001 and 0.007, respectively, indicating that the effects are statistically different for elderly (65+) and for both teenagers (0–19) and middle-aged (20–64).

[20] http://finance.sina.com.cn/consume/xiaofei/2018-02-13/doc-ifyrpeie1483601.shtml (in Chinese).

[21] Ideally, we would like to investigate whether the protective effects of CLNY are different for individuals living in households with different sizes, but no such individual-level data are available in the Chinese context. Therefore, we can only investigate the relationship at the aggregate (i.e. county) level.

[22] We exclude observations of all counties/districts of direct-controlled municipalities (including Beijing, Shanghai, Tianjin, and Chongqing) in this analysis, as the administrative level of these counties/districts are higher than the normal counties/districts of prefectures and are thus not comparable.

[23] Note that CHARLS only covers around 100 prefectures; thus, the sample size is reduced by more than a half.

Table 2
Effects of Chinese lunar new year on elderly suicide rate.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Suicide Rate: Total, Age 65+		Suicide Rate: Female, Age 65+		Suicide Rate: Male, Age 65+	
	Inverse Hyperbolic Sine	Level	Inverse Hyperbolic Sine	Level	Inverse Hyperbolic Sine	Level
CLNY	−0.0867***	−0.5212***	−0.0632***	−0.4374**	−0.0666***	−0.6117***
	(0.0221)	(0.1509)	(0.0216)	(0.2029)	(0.0238)	(0.2323)
Observations	151,253	151,253	151,253	151,253	151,253	151,253
R-squared	0.258	0.294	0.199	0.194	0.204	0.170
Population Weight	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Week-of-Month FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The dependent variable is the inverse hyperbolic sine of suicide cases per 1 million people in columns (1), (3) and (5), and is the level of suicide cases per 1 million people in columns (2), (4) and (6). County fixed effects, year fixed effects, month fixed effects and week-of-month fixed effects are included as controls. The regression is weighted by county population. Standard errors are clustered at county level.

rural county or urban district and its interaction with the CLNY dummy, as well as interaction terms of the CLNY dummy and other county characteristics, including regional GDP per capita, average rural income, number of hospitals per capita, employment rate, the proportion of immigrants among the elderly, and the average years of schooling of the elderly.[24] Note that these characteristics are all cross-sectional and measured at the prefecture level.[25] We explain the variable construction in detail in the Appendix.

The results in Table 4 are in support of our hypothesis. Using different proxy measures for daily family companionship from two different data sources, the results are consistent that the protective effects decline as the average daily family companionship for the elderly increases. Specifically, a one standard deviation increase in the proxy measure of the average daily family companionship for the elderly reduces the protective effects of the CLNY by 6%–9%.[26] These results suggest that family companionship may be a crucial mechanism for the protective effects of the CLNY.

Now we discuss several competing explanations as follows.

3.2.1. Short-run population flows and Spring Festival travel rush

One potential explanation for the reduction of the elderly suicide rate during the CLNY is short-term travels. Hundreds of millions of individuals in China travel during the CLNY season to reunite with their families.[27] The reduction of suicide rate may simply reflect that individuals travel out of counties and will not be recorded as committing suicide in the county. However, this hypothesis is unlikely to explain the results for several reasons. First, the protective effects are only for the elderly group, which is the least likely group to participate in the Spring Festival travel rush. Children of the elderly are more likely to travel to visit the elderly, instead of the other way around. Second, as shown in Table 4, the protective effects do not change with the proportion of the elderly immigrants (as a proxy for the intensity of potential outflows during the Spring Festival travel rush). Therefore, short-term population flows are unlikely to explain the results.

3.2.2. Changes in income during the CLNY

Another competing explanation is that the income of the elderly may change during the seven-day statutory holiday. However, most of the elderly group has already retired and is unlikely to face income shocks or other labor market shocks during the CLNY.[28] In addition, we find no effects for the middle-age group who is more likely to face labor market shocks. Therefore, labor market shocks cannot explain the results. Another potential source of income shock is the custom of giving "red-envelope money" and gift giving during the CLNY.[29] The elderly people may give out red-envelope money to their children and their grandchildren or may also receive red-envelope money from their children who have jobs, and the net wealth change due to the exchange of red-envelope money may depend on local customs. Nevertheless, despite the possibility that the elderly may receive positive income shocks from red-envelope money and gifts during the CLNY, this does not invalidate the mechanism of family companionship. That is, red-envelope money and gifts are often from family members, usually given in person, and may be perceived as a particular form of family companionship. It is worthwhile to point out that generally the potential income shocks from red-envelope money and gifts should be independent of the level of daily family companionship received by the elderly, thus the red-envelope money and gift alone cannot explain the results of heterogeneous

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[24] Our results are robust if we drop the urban dummy and the urban-CLNY interaction. Our results are also robust when excluding interaction terms of the CLNY dummy and county characteristics.

[25] All these control variables and measures of average daily family companionship are standardized to have a mean of 0 and standard deviation of 1 to facilitate interpretation.

[26] In Table A5, we consider several alternative measures of daily family companionship. In Columns (1) and (2), we use the proportion of the elderly people living in household with no other people, and the proportion of the elderly people living in household with at most one other people (both Census measures), respectively, to capture the fraction of elderly people living alone in the city. The results are similar to Table 4, that a one standard deviation increase in the proxy measure of the average daily family companionship for the elderly reduces the protective effects of the CLNY by 4%–6%. In Columns (3) and (4), we use the proportion of the elderly people who have lost the partner by death (Census measure), and the proportion of the elderly people who are not currently living with the partner (CHARLS measure), respectively, to capture the fraction of elderly people not living with the partner in the city. The results indicate that the proportion of elderly people living with the partner is not predictive of the protective effects of CLNY.

[27] http://www.gov.cn/xinwen/2015-03/16/content_2835003.htm (in Chinese).

[28] The retirement age in China is 60 for men, and is either 55 or 50 for women depending on her occupations.

[29] A red envelope (also known as *hongbao*) is a monetary gift usually given during the CLNY, which has the symbol of good luck. See https://en.wikipedia.org/wiki/Red_envelope for more introduction on the custom of red envelope.

Table 3
Effects of Chinese lunar new year on suicide rate: By gender and age cohort.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Suicide Rate	Suicide Rate	Suicide Rate	Suicide Rate	Suicide Rate	Suicide Rate
	Age 0-19	Age 20-64	Age 65+	Age 20-34	Age 35-49	Age 50-64
Panel A Total Suicide Rate						
CLNY	−0.0079	−0.0148	−0.0867***	−0.0095	−0.0101	−0.0087
	(0.0070)	(0.0141)	(0.0221)	(0.0137)	(0.0157)	(0.0180)
Observations	151,253	151,253	151,253	151,253	151,253	151,253
R-squared	0.012	0.150	0.258	0.034	0.065	0.129
Panel B Female Suicide Rate						
CLNY	−0.0042	−0.0228	−0.0632***	−0.0115	0.0023	−0.0265
	(0.0072)	(0.0148)	(0.0216)	(0.0120)	(0.0141)	(0.0170)
Observations	151,253	151,253	151,253	151,253	151,253	151,253
R-squared	0.008	0.095	0.199	0.019	0.036	0.087
Panel C Male Suicide Rate						
CLNY	−0.0049	0.0037	−0.0666***	−0.0017	−0.0166	0.0171
	(0.0065)	(0.0168)	(0.0238)	(0.0145)	(0.0153)	(0.0204)
Observations	151,253	151,253	151,253	151,253	151,253	151,253
R-squared	0.010	0.103	0.204	0.023	0.045	0.086
Population Weight	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Week-of-Month FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The dependent variable is the inverse hyperbolic sine of suicide cases per 1 million people. County fixed effects, year fixed effects, month fixed effects and week-of-month fixed effects are included as controls. The regression is weighted by county population. Standard errors are clustered at county level.

effects by itself.[30]

3.2.3. Changes in healthcare institution access during the CLNY

Another explanation is that access to healthcare institutions may change during the seven-day statutory holiday. However, even during the seven-day statutory holidays, many public hospitals remain open and provide emergency services. Moreover, even if such effects are observed, they should lead to more, not less, attempted suicides resulting in deaths. Thus, it should only bias the results downward. In addition, we do not find evidence that the protective effects depend on healthcare institution access, measured by number of hospitals per capita (Table 4).

3.2.4. Underreporting of suicide during the CLNY

Another concern is that suicide cases may be underreported during the CLNY, potentially due to lack of officials to record the suicide deaths during statutory holidays. However, if the reduction of suicide rate is due to underreporting, we should observe similar effects for all age cohorts, which is not the case.

3.2.5. Symbolic effects of holidays

Another potential explanation of the protective effects is that holidays may represent a good symbol that improves mental health. However, it cannot explain why the protective effects depend on daily family companionship. In addition, we directly examine this hypothesis by investigating the effects of other Chinese lunisolar calendar holidays,

including Dragon Boat Festival and Mid-Autumn Festival, on elderly suicide rate. Note that the timing of these lunisolar calendar holidays also varies across different years, which enables us to control for temporal trends. The specifications are similar to our baseline specification for the CLNY. Different from the CLNY, Dragon Boat Festival and Mid-Autumn Festival are only a one-day holiday, and the day off is sometimes adjusted.[31] Young and middle-age people are considerably less likely to return home to visit their parents during these statutory holidays.

Figures A2 and A3 show the effects of Dragon Boat Festival and Mid-Autumn Festival on suicide rate by gender and age cohort. Little evidence supports the protective effects of Dragon Boat Festival and Mid-Autumn Festival on elderly suicide, thus casting doubt on the symbolic effects as a mechanism.

Here, we further discuss why strong protective effects exist for the CLNY, but not for the Dragon Boat Festival and Mid-Autumn Festival. The potential explanation is still the family companionship story. Family reunion is the core value of the CLNY. Survey evidence suggests that 80% of people go back home to reunite with their families, and 70% agree that family reunion during the CLNY is a traditional custom and they keep practicing celebrating with families every year. The seven-day statutory holiday enables most people to travel and reunite with families. In contrast, although other traditional Chinese lunisolar calendar holidays, such as Dragon Boat Festival and Mid-Autumn Festival, also have symbols of family reunion, the statutory holidays last for only three days, which impedes many people from going back home. For example, survey evidence suggests that 58% of people cannot go back home and visit their parents during the Mid-Autumn Festival.[32] In addition, survey evidence suggests that 53% of young and middle-age people living outside of hometown are only able to pay visitation to their parents for

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[30] Note that one possibility is that children who live away from home may give larger cash transfer to the elderly during the CLNY potentially because of guilt or richness, and then red-envelope money and gift may explain the results of heterogeneous effects. We are unable to directly test this hypothesis due to lack of data on cash transfer during the CLNY. However, as we explained above, the net wealth change for the elderly due to the exchange of red-envelope money is ambiguous and depends on local customs, and may often be negative, as the elderly people may not only receive red-envelope money from their children who have jobs, but also give out red-envelope money to their children and their grandchildren. In addition, the amount of red-envelope money is typically only a few hundred RMB, and red-envelope money is unlikely to form a large income shock for the elderly.

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[31] For example, if the day of the holiday is next to a weekend, then that day will usually be specified as the day off. If the day of the holiday is far from weekends, then it may be adjusted that people work on the holiday and have a three-day long weekend. As our data are at the week level, we specify the week that has the actual additional day off as the treatment week for Dragon Boat Festival and the Mid-Autumn Festival.

[32] https://news.qq.com/a/20110912/000360.htm (in Chinese).

Table 4
Heterogeneous effects by daily family companionship.

VARIABLES	(1)	(2)	(3)	(4)
	Total Suicide Rate, Age 65+			
	Proxy Measure for Daily Family Companionship:			
	Census Measures		CHARLS Measures	
CLNY	−0.0921***	−0.0918***	−0.1863***	−0.1891***
	(0.0305)	(0.0306)	(0.0456)	(0.0454)
CLNY*Average Household Size, Age 65+	0.0704** (0.0274)			
CLNY*% Household Size ≥ 4, Age 65+		0.0629** (0.0264)		
CLNY*Average Proportion of Children Living in the Household, Age 65+			0.0723** (0.0332)	
CLNY*% Having Children Living in the Household, Age 65+				0.0875** (0.0395)
CLNY*Urban District	−0.0571	−0.0558	−0.0075	−0.0041
	(0.0459)	(0.0460)	(0.0704)	(0.0703)
CLNY*GDP Per Capita	0.0109	0.0068	−0.1762*	−0.1825*
	(0.0372)	(0.0375)	(0.1058)	(0.1052)
CLNY*Average Rural Income	0.0321	0.0287	0.1686**	0.1712**
	(0.0312)	(0.0313)	(0.0792)	(0.0785)
CLNY*Number of Hospital Per Capita	0.0090	0.0077	0.0147	0.0141
	(0.0237)	(0.0237)	(0.0381)	(0.0376)
CLNY*Employment Rate	−0.0260	−0.0277	−0.0048	0.0087
	(0.0313)	(0.0318)	(0.0494)	(0.0479)
CLNY*Proportion of Immigrants, Age 65+	−0.0442	−0.0396	−0.0314	−0.0197
	(0.0300)	(0.0295)	(0.0764)	(0.0776)
CLNY*Average Years of Schooling, Age 65+	−0.0363	−0.0406	−0.0083	0.0039
	(0.0269)	(0.0271)	(0.0515)	(0.0503)
Observations	124,477	124,477	54,993	54,993
R-squared	0.244	0.244	0.269	0.269
Population Weight	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Week-of-Month FE	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1. The dependent variable is the inverse hyperbolic sine of suicide cases per 1 million people. County fixed effects, year fixed effects, month fixed effects and week-of-month fixed effects are included as controls. The regression is weighted by county population. Standard errors are clustered at county level.

3–10 days a year, which also suggests that people are less able to reunite with their families in holidays other than the CLNY.[33]

3.2.6. Self-discipline of the elderly to avoid suicide during happy events

Another alternative explanation is that the elderly people may have self-discipline to avoid committing suicide during happy events, which may create additional sadness for their family. However, as previously discussed, no similar evidence shows the protective effects for other Chinese lunisolar calendar holidays. In addition, this mechanism cannot explain why the protective effects differ across different levels of daily family companionship. If self-discipline is driving the results, then the effects should be similar regardless of whether children are living in the households.

To conclude, most contemporaneous changes during the CLNY and

alternative mechanisms cannot fully explain our results. Therefore, the results suggest family companionship as a crucial mechanism of the protective effects of the CLNY on elderly suicide.

3.3. Dynamic effects and gender differences

In this section, we explore the dynamic effects of the CLNY. There could be several reasons for why there are changes in elderly suicide rate in the weeks before and after the CLNY. First, there may exist an *anticipation effect,* that is, anticipating the family companionship in the upcoming CLNY weeks may improve the mental health of the elderly people. Rutledge et al. (2014) find that expectations for happy events can contribute to individuals' happiness before they even occur. Similar effects may exist for the anticipation of family companionship, and in that case, we expect to observe a decrease in elderly suicide rate before the CLNY. Second, there may exist a *temporal displacement* of suicide, that is, the elderly may simply postpone their suicides to later weeks. In that case, we expect to observe an increase in elderly suicide rate after the CLNY. Testing temporal displacement is important in the sense that if all the protective effects are driven by temporal displacement, the social benefit of these protective effects will be considerably smaller. Third, there may exist *separation anxiety* (Wijeratne and Manicavasagar 2003) for the elderly people after the CLNY, and separating with children after the CLNY may worsen the mental health of the elderly people. In that case, we also expect to observe an increase in elderly suicide rate after the CLNY. Finally, there may exist a *long-lasting effect* of companionship, that is, the companionship during the CLNY may improve the mental health of the elderly people even after the holiday. In that case, we expect a decrease in elderly suicide rate after the CLNY.

Therefore, the direction of dynamic effects is ex-ante unclear. We investigate the dynamic effects by directly estimating the treatment effects of weeks before and after the CLNY. We exclude year 2016 throughout this analysis, such that two weeks will be defined as in the CLNY for every year in the sample.[34] Then, we define dummy variables indicating 1–4 weeks prior to the first week defined as in the CLNY and dummy variables indicating 1–4 weeks after the last week defined as in the CLNY, and we include all of them into the regression.[35]

We start with total suicide rate regardless of gender in Fig. 1. We find that the protective effects of the CLNY start to exhibit 2 weeks prior to the CLNY weeks, suggesting there are anticipation effects. There is some evidence that elderly suicide rate increases in the following 1–2 weeks after the CLNY weeks, but they are statistically insignificant. The cumulative effect when we sum up all coefficients is −0.057, and it is statistically significant at 5% level. This implies that the protective effects are not fully offset in the full sample, and the CLNY is effective at preventing elderly suicide.

Next, we document gender differences by estimating the model separately for male and female. We find that the contemporaneous effect (week 0) for female is smaller and statistically insignificant in the dynamic model. The overall pattern is noisy. The cumulative effect is only −0.009 and statistically insignificant. In contrast, the pattern for male mimics the pattern for the full sample. In other words, we find strong anticipation effect, and relatively week evidence on temporal displacement and separation anxiety. The cumulative effect is −0.060, and it is statistically significant at the 5% level. The gender difference in dynamic effects suggests that the male elderly may be more sensitive to family companionship than the female elderly, which is consistent with the

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[33] https://cj.sina.com.cn/articles/view/1704103183/65928d0f020017mno (in Chinese).

[34] Year 2016 is excluded because it is the only year in our sample that only one week is defined to be during the CNLY, and the results are hard to interpret when year 2016 is included as the weeks before and after the CNLY weeks are not comparable in year 2016 and in other years. Nevertheless, the results are overall very similar when year 2016 is included in the analysis.
[35] There are in general no effects for weeks beyond the scope of this two-month time window.
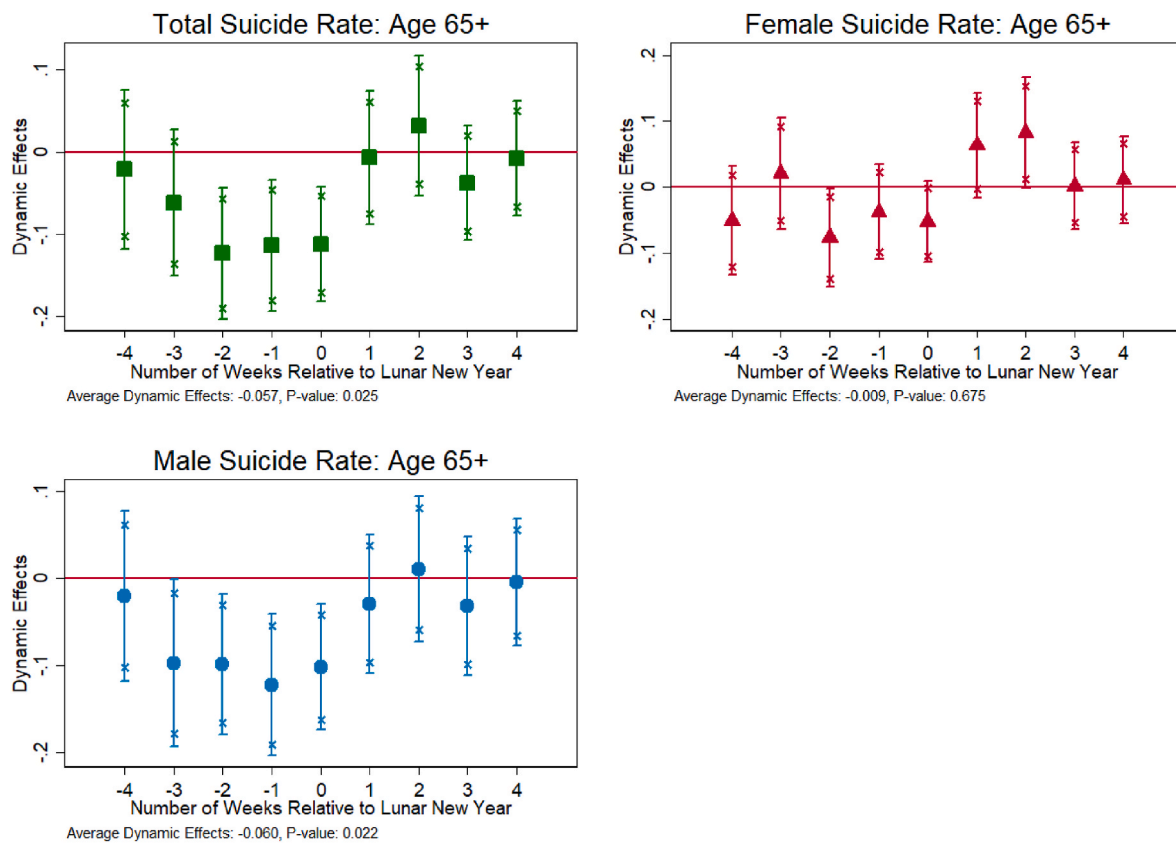
Fig. 1. Dynamic Effects of Chinese Lunar New Year on Suicide Rate

Notes: This figure plots the effects of weeks before and after Chinese lunar new year on elderly suicide. The dependent variable is the inverse hyperbolic sine of suicide cases per 1 million people. County fixed effects, year fixed effects, month fixed effects and week-of-month fixed effects are included as controls. The regression is weighted by county population. Standard errors are clustered at county level. "x" markers represent bounds of 90% confidence interval. "-" markers represent bounds of 95% confidence interval. The average dynamic effect is the average of the treatment effects of Chinese lunar new year weeks and weeks within the two-month window. The p-value is the test p-value for whether the average dynamic effect is statistically different from 0.

findings in previous studies (Stokes and Levin 1986) that the loneliness of men is more sensitive to social network density than women.

4. Conclusion

In this study, we document a novel finding that elderly suicide rate decreases by 8.7% during the CLNY, when the elderly people receive unusually high level of family companionship. In addition, the protective effects for the elderly are stronger in counties where the level of the average daily family companionship for the elderly is lower. We do not find any evidence of similar protective effects for young and middle-age cohorts. These results suggest that family companionship is an important mechanism for the protective effects of the CLNY, indicating the importance of family companionship on the mental health of the elderly.

The finding in this study is especially policy-relevant in China, given the rapidly growing population of empty-nest elderly and other countries with similar demographic structures. In fact, the revision of the *Law of the People's Republic of China on Protection of the Rights and Interests of the Elderly* has been passed in 2012, which legally requires that family members should care for the mental need of the elderly, and family members who do not live with the elderly should regularly contact and visit the elderly.[36] However, the enforcement of the law has not been highly effective because the legal responsibilities are not clearly specified, and the pressure on career and daily life also impedes the children of the elderly people from providing more daily companionship to their

elderly parents.[37] Therefore, public policies calling for attention on the importance of the family companionship for the elderly parents, or facilitating alternative types of companionship for the elderly, such as charitable visit and community care, may also be effective in preventing elderly suicide.

There are at least two limitations in our study. First, due to data constraints, we can only use proxy measures of daily family companionship at the aggregated level, and thus preventing us from exploring what types of the elderly people are most at risk and how individual characteristics interact with the protective effects of the CLNY. Second, although we are confident on the causal effect of the CLNY on elderly suicide rate because of the exogenous variation in the lunisolar calendar, we are less confident on the underlying mechanisms for the protective effects since the geographic variation in daily family companionship may be confounded with other factors related to elderly mental health. We leave these questions for future research.

Data availability

The data that has been used is confidential.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.

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[36] http://www.gov.cn/flfg/2012-12/28/content_2305570.htm (in Chinese).

[37] http://opinion.people.com.cn/n1/2017/0118/c1003-29031862.html and http://www.xinhuanet.com/2017-06/19/c_1121165931.htm (in Chinese).

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