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Research paper

A study on household headship, living arrangement, and recipient of pension among the older adults in association with suicidal risks

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ABSTRACT

Background: This study aims to examine whether variation in socioeconomic factors indicative of lower status within families in later life, such as the elderly losing their household headship, living with descendants, and having no pension are associated with suicidal risks among the older adults aged 60 years and above in the world.

Methods: Using the data from the Global Burden of Disease Study in 2015, the suicide age ratios (i.e., suicide rate ratios between older adults aged $>=60$ years versus the younger groups aged <60 years) for the 173 regions were computed and compared. The suicide age ratio rather than the actual rate is used to adjust the difference in base rates among different countries. Forest plots were performed to assess whether late-life status within families moderated the worldwide patterns of suicide age ratios. Regression analyses were used to estimate the extent to which the factors reflecting family status affect suicide age ratios. Gender-specific analyses were also performed.

Results: The results showed that higher suicide age ratios were significantly found in regions with lower percentages of the elderly being heads of households (ratios = 1.69 vs 2.73, $P<0.01$), higher percentages of co-residence of the elderly with their descendants (ratios = 2.72 vs 1.39, $P<0.01$), and lower percentages of the elderly receiving a pension (ratios = 1.42 vs 2.76, $P<0.01$). In the adjusted regression, having no pension remained to be a significant determinant for both overall population ($P = 0.01$) and men ($P<0.01$) but not for women ($P = 0.29$), and loss of household headship was only significant for men ($P = 0.05$) but not for either overall population ($P = 0.22$) or women ($P = 0.55$), whereas the elderly living with their descendants was no longer significant for either overall population ($P = 0.60$) or both genders (men: $P = 0.72$; women $P = 0.11$).

Limitations: The cross-sectional data do not allow to explore causal effect analyses.

Conclusions: This is the first global study to reveal associations between lower socioeconomic status within families and higher rates of suicide among older adults aged 60 years and above compared with the younger population. Thus, the present ecological findings suggest that strategies to enhance the socioeconomic status of older adults may be important to prevent suicides in later life both within and across countries.

1. Introduction

In most parts of the world, suicide rates in older adults are generally higher than their younger counterparts (Conwell, 2014). In order to comprehend the severity of late-life suicides, not only the absolute suicide rates but also their relative suicide age ratios (i.e., suicide rate ratios between older adults versus the younger age groups) within the respective population should be considered as well. For example, according to the Global Burden of Disease ("GBD") Study in 2015, suicide rates in the population aged 60 years and above in China, Austria and Ukraine were similar at around 28.0 per 100,000. However, due to greater variations in suicide rates among the younger age groups, the old to non-old suicide rate ratios of those three countries were 4.64, 2.29, and 1.30, respectively. Suicide age ratios vary significantly among countries and regions of the world, thus providing a new perspective to understand the meaning of suicide rates in old age across the globe. Greater understanding of the age patterns of suicides could result in potential preventive solutions (Snowdon et al., 2017). To the best of the

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authors' knowledge, there are no existing studies that have explored the global variations of suicide age ratios and their associated factors.

Families are valuable resources in not only providing caregiving but also imparting a sense of worth, lasting emotional ties, and human dignity to elders in their later years (Walsh, 2016). From a life course perspective, previous researchers have found that higher risks in late-life suicides are associated with the unique experiences of the elderly adapting to age-related challenges and family dysfunction (Chan et al., 2014; Chang et al., 2017; Duberstein et al., 2004; Park and Moon, 2016; Purcell et al., 2012; Rubenowitz et al., 2001; Van Orden et al., 2015). However, whether the socioeconomic status of older people within families is associated with suicide risks has never been properly examined. In this study, loss of socioeconomic status in the older adults within their families was measured by three critical constructs: i) loss of household headship, ii) loss of residential independence, and iii) loss of pension support.

With regard to family status in a culture-based index, being the "head of household" indicates the importance of a family member which is related to the power to control and allocate the family's economic and social resources (Phua et al., 2001). Loss of family headship therefore represents an important life-stage transition associated with the fundamental questions of independence and authority that lend sociological meaning to the concept of old age (Gordon et al., 1981).

Living with one's children reflects loss of independence, which is a valued condition. Owing to the stigma of dependency in the dominant culture, most older adults in good health prefer to maintain a separate household from their children, yet sustaining frequent contacts, reciprocal emotional ties and mutual support in a pattern aptly termed "intimacy at a distance" (Blenkner, 1965; Walsh, 2016). With the advancement of telecommunication and transportation technologies, high levels of geographic mobility in modern societies have significantly supported the aforementioned living arrangement (Phua et al., 2001). Nonetheless, the transition from independent living to co-residence with the younger generations in later life is common today, reflecting reduced autonomy of the older adults in family life.

Financial independence is important for the older adults in keeping their authority in the family. For instance, those who are more financially independent will be consulted more frequently than those who are supported economically by their children (Williams et al., 1999). In other words, economically independent elders could play a considerable role in family decisions. The pension scheme, a well-known policy to maintain financial security, led to significant reductions in poverty rates among older adults (Lloyd-Sherlock et al., 2012). Moreover, pension receipt directly affects well-being of retired older adults with a low economic status (Ju et al., 2017). Earlier studies have demonstrated that low financial status in older adults may act as a stressor that exacerbates any ongoing deterioration in psychological well-being and contributes to suicide risk (Almeida et al., 2012; Duberstein et al., 2004).

In this study, it is hypothesized that lower late-life socioeconomic status within families would significantly increase suicide rate among the older adults. In order to take into account different base rates among different countries, suicide age ratios are used instead. To be more specific, loss of household headship, dependence in residence, and receiving no pension might elevate the suicide age ratios. The aim of this study is firstly to examine the variability of suicide age ratios in the world, and secondly to illustrate the associations of suicide age ratios with potential socioeconomic factors including household headship, living arrangement, and whether in receipt of pension in later life.

2. Methods

2.1. Data and measures

Suicide age ratio was measured by the old ($>=60$ years) to non-old (<60 years) suicide rate ratios, which was our dependent variable of primary interest. The suicide data in the year of 2015 were obtained from the Global Burden of Disease ("GBD") Study (Global Burden of Disease Collaborative Network, 2016) and suicide mortality was identified by the International Classification of Diseases, 10th Revision ("ICD-10″) codes X60-X84 (self-harm). Suicide age ratios for the 173 regions were computed in the world.

In this study, lower socioeconomic status within family was conceptualized by three aspects: losing household headship, living dependently, and having no pension, which reflected the honorary, residential and economic status of older adults, respectively. Furthermore, based on the data available for consistent comparisons across the nations worldwide, we used three variables to measure older people's socioeconomic status: i) the percentages of households with heads aged 60 years and above, ii) the percentages of households with both older adults aged 60 and above and children under 15, and iii) the proportions of the population above retirement age receiving a pension.

The percentages of households with the heads aged 60 years and above were obtained from the United Nations Report on Household Size and Composition Around the World 2017. The head of household was nominated by family members in the census or survey. Elderly headship rate is calculated by dividing the number of heads aged 60 years or over identified on the household roster of the census or survey by the total number of household heads (United Nations, 2017). The data were the latest available estimates (i.e. the data for the most recent years) between 1990 and 2015 for 141 regions and ranged from 12% in North Korea to 44% in Italy.

The percentages of households with both older adults aged 60 and above and children under 15 were also obtained from the United Nations Report on Household Size and Composition Around the World 2017. It is calculated by dividing the number of households with at least one member under age 15 years and at least one member aged 60 years or over by the total number of households (United Nations, 2017). The data represented estimates from 1990 to 2015 for 125 regions and ranged from near 0% in Germany and the Netherlands to 34% in Gambia.

The proportions of the population above retirement age receiving a pension were extracted from the United Nations Statistics Division. It is calculated by dividing the number of population above retirement age receiving a pension by the total number of population above retirement age (United Nations Statistics Division, Department of Economic and Social Affairs, 2017). Among the latest available data from 132 regions of the world during the period 2010–2016, the values on pension ranged from 0.93% in Myanmar to 100% in many European Countries.

2.2. Analytic strategies

Suicidal rates for each country were age-standardized by the standard structure of the world population in 2015. In this study, the threshold of the older adults was 60 years and above. In order to take into account the respective suicide rates in each of the countries, suicide age ratios were calculated and a world map was constructed according to the different levels of suicide age ratios including <1.0, [1.0, 2.0), [2.0, 3.0), [3.0, 4.0), and $>=4$. Scatterplots of three exposure variables (i.e., household headship, living with descendants, and recipient of pension) and log-transformed suicide age ratios were presented in the figures in the Appendix (Appendix Figs. A1–A3).

Forest plots were performed to assess whether elderly household headship, living with descendants, and recipient of pension moderated the worldwide patterns of suicide age ratios. Three exposure factors were not modeled as continuous variables as the relationships between them and suicide age ratios were not linear. In the moderation analyses, percentages of the elderly heads were modeled as a dichotomized variable by the first quarter point: the higher ($>19\%$) versus the lower ($<=19\%$). Similarly, regions were classified by median value into higher ($>11\%$) versus lower ($<=11\%$) percentages of late-life co-residence of the elderly with their descendants. Percentages of the elderly

receiving a pension above retirement age were also grouped as a dichotomized variable by median value: the higher (>73%) versus the lower (< =73%). It could be seen clearly that from the United Nations Report on Household Size and Composition around the World 2017, the vast majority of countries in Africa and Asia had the very low percentages of elderly headship less than the first quarter point at 19%. Unlike the population in these Africa and Asia countries shared with the common practice of multi-generational living arrangements, older adults in other countries prefer to maintain a separate household from their children, which leads to higher percentages of elderly headship than 19%. Therefore, on the cultural and empirical bases, the first quarter point is preferable to the median split as the cut-off for the household headship variable. Pooled suicide age ratios with 95% confidence interval of associations between the suicide age ratios and the potential affecting factors were calculated using the Comprehensive Meta-Analysis software program. The software program takes population size of each analyzed region into account. Total between-group variance ("Total Q_b") was then calculated to examine the differential moderation effect among the different subgroups. Gender-specific forest plots were also constructed to examine the variance of the moderation effect between men and women.

Crude and adjusted regression analyses were then utilized to estimate the extent to which elderly household headship, living with descendants, and recipient of pension affect suicidal age ratios in the world. Stratified analyses were also performed based on gender-specific data. The outcome variable was log-transformed as according to the Kline's rule, i.e., skew index absolute value <3; kurtosis index absolute values <10 (Kline, 2005), the distribution of suicide age ratios was not normal. The countries with missing data on the independent variables were handled by the Listwise Deletion method and were not used in the analyses.

3. Results

From Fig. 1, there were significant variations of suicide age ratios across different regions in the world. On the whole, the suicide age ratios were higher than 1.00 in most parts of world, indicating that worldwide, suicide rates in older adults were generally higher than the younger population. The highest old to non-old suicide rate ratios were found in the Western Pacific and African regions.

Appendix Table 1 shows that there were strong correlations among the suicide age ratios and the potential factors. To be specific, higher suicide age ratio was significantly correlated with lower percentage of elderly household head ($r = -0.36$, $P < 0.01$), higher percentage of co-residence of the elderly with their descendants ($r = 0.37$, $P < 0.01$), and lower percentage of the population receiving a pension above retirement age ($r = -0.51$, $P < 0.01$). Scatterplots of three exposure variables, i.e., household headship, living with descendants, recipient of pension, and log-transformed suicide age ratios were presented in Appendix Figs. A1–A3, respectively.

Fig. 2 presents the forest plots of suicide age ratios between countries with the higher versus the lower percentages of household heads aged 60 and above. Regions with higher elderly headship percentages had the lower suicide age ratio (1.69), whereas regions with lower percentages of elderly headship had the higher suicide age ratio (2.73). There was a significant difference between the higher and lower subgroups ($Q_b = 7.57$, $P = 0.01$). In terms of the gender-specific analyses, the impact of household headship on suicide age ratios was only found in men (ratios = 1.77 vs. 2.92, $P = 0.02$) but not in women (ratios = 2.10 vs. 2.54, $P = 0.55$).

Fig. 3 shows the forest plots of suicide age ratios among countries with higher versus lower percentages of co-residence of the elderly with their descendants. As to the overall population, regions with higher percentages of co-residence of the elderly with their descendants had the higher suicide age ratio (2.72), whereas regions with lower percentages of co-residence of the elderly with their descendants had lower suicide age ratio (1.39). There was a significant difference between the higher and the lower subgroups ($Q_b = 12.14$, $P < 0.01$). In addition, the impact of co-residence of the elderly with their descendants on suicide age ratios could be observed in men (ratios = 2.83 vs. 1.56, $P = 0.01$) but not in women (ratios = 1.88 vs. 1.57, $P = 0.16$).

Referring to the forest plots of suicide age ratios in countries with higher versus lower percentages of older adults receiving a pension (Fig. 4), regions with higher percentages of the elderly receiving a pension had lower old to non-old suicide rate ratios, whereas regions with lower percentages of the elderly receiving a pension had higher old to non-old suicide rate ratios. The significant impact of pension on suicide age ratios could be observed in the overall population (ratios = 1.42 vs. 2.76, $P < 0.01$), men (ratios = 1.56 vs. 2.91, $P < 0.01$), and women (ratios = 1.64 vs. 2.66, $P < 0.01$).

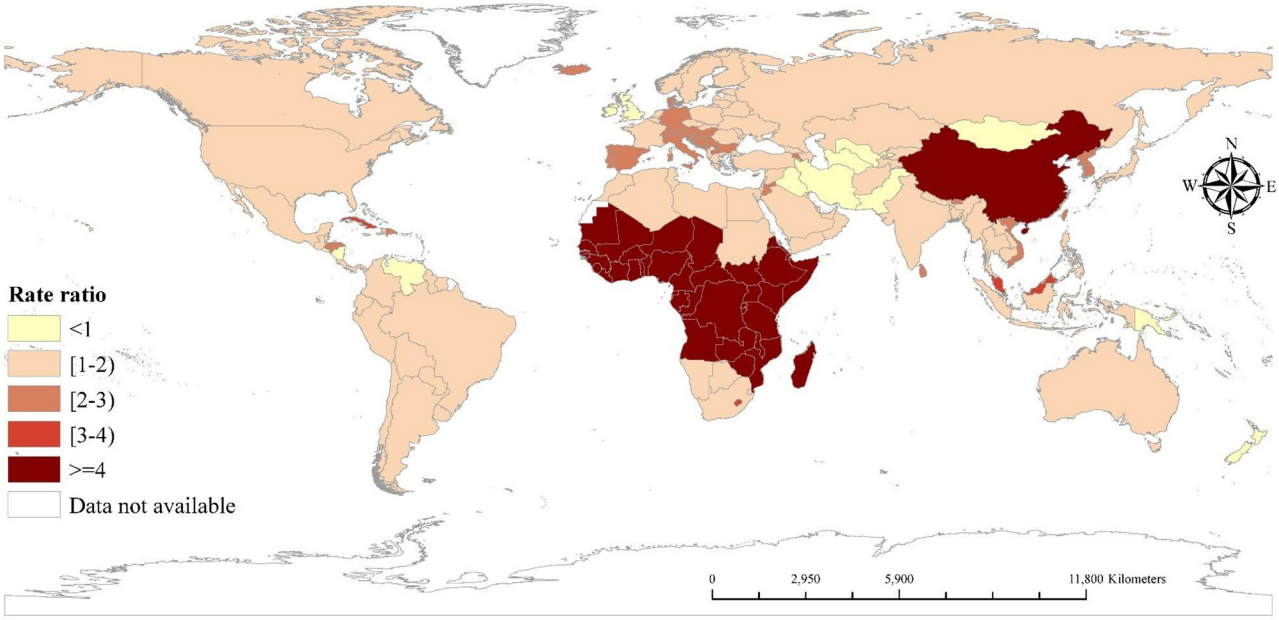

Fig. 1. World map of suicide rate ratios between older adults aged > =60 years versus the younger groups aged <60 years, 2015.

Table 1
Regression analyses on the associations between suicide age ratios and the exposure factors.

Variables	Model 1			Model 2			Model 3			**Model 4**		
	B	SE	p-value	B	SE	p-value	B	SE	p-value	B	SE	p-value
Both Sexes												
Percentages of headship (60+)												
Higher vs. lower	**−0.43**	**0.11**	**0.00**							−0.18	0.14	0.22
Percentages of co-residence of the elderly (60+) with their descendants												
Higher vs. lower				**0.48**	**0.12**	**0.00**				0.08	0.15	0.60
Proportions of the population above retirement age receiving a pension												
Higher vs. lower							**−0.47**	**0.39**	**0.00**	**−0.40**	**0.15**	**0.01**
Men												
Percentages of headship (60+)												
Higher vs. lower	**−0.40**	**0.11**	**0.00**							**−0.23**	**0.14**	**0.05**
Percentages of co-residence of the elderly (60+) with their descendants												
Higher vs. lower				**0.36**	**0.11**	**0.00**				−0.05	0.14	0.72
Proportions of the population above retirement age receiving a pension												
Higher vs. lower							**−0.43**	**0.09**	**0.00**	**−0.40**	**0.14**	**0.00**
Women												
Percentages of headship (60+)												
Higher vs. lower	**−0.39**	**0.13**	**0.00**							−0.11	0.17	0.55
Percentages of co-residence of the elderly (60+) with their descendants												
Higher vs. lower				**0.53**	**0.13**	**0.00**				0.28	0.18	0.11
Proportions of the population above retirement age receiving a pension												
Higher vs. lower							**−0.37**	**0.11**	**0.00**	−0.19	0.18	0.29

Note. The outcome variable was log-transformed suicide age ratios.

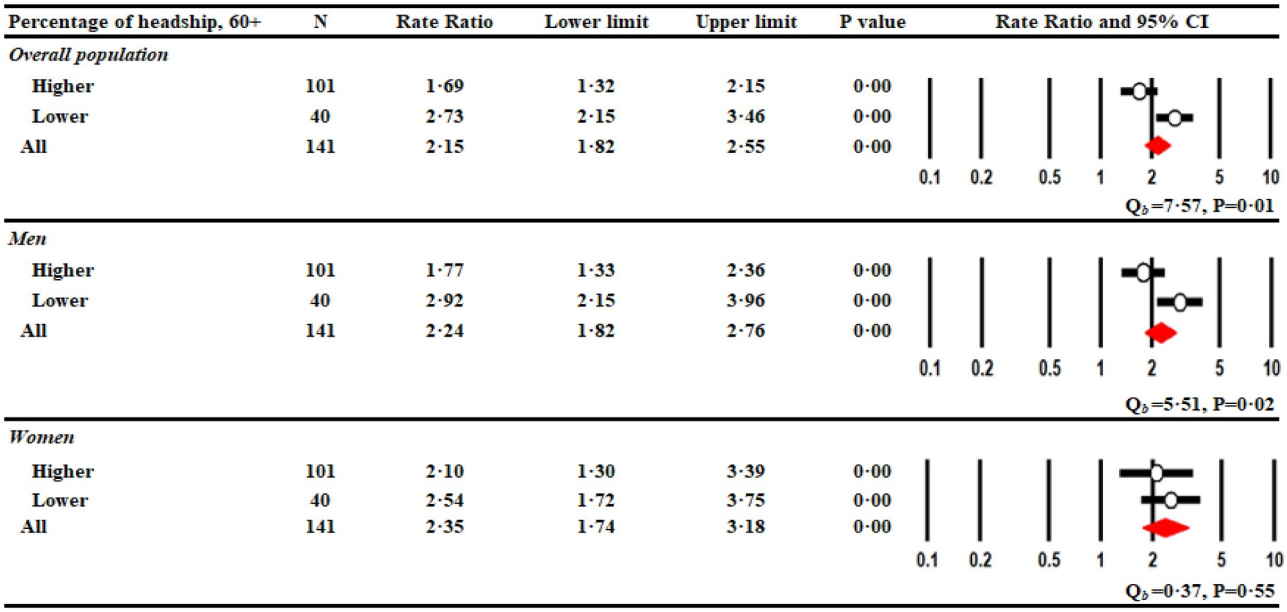

Fig. 2. Forest plots of the suicide age ratios between the regions with the higher vs. the lower percentages of headship, 60+.

As seen from Models 1–3 in Table 1, the crude regression analyses showed that the lower status of the elderly within a family in terms of the loss of household headship, dependent dwelling and having no pension, were significantly associated with higher suicide age ratios in overall population and both genders ($P<0.01$). Since the factors were correlated with each other, adjustments had also been made to the regression analyses. In the adjusted model (Model 4), receiving no pension remained to be a significant determinant for both overall population ($P = 0.01$) and men ($P<0.01$) but not for women ($P = 0.29$), and loss of household headship was only significant for men ($P = 0.05$) but not for either overall population ($P = 0.22$) or women ($P = 0.55$), whereas the elderly living with their descendants was no longer significant for either overall population ($P = 0.60$) or both genders (men: $P = 0.72$; women $P = 0.11$).

4. Discussion

The present study reveals that worldwide variations in suicide age ratios were associated with constructs reflecting the socioeconomic status of the older adults within families. Relatively higher suicidal risks in later life were linked to loss of domestic headship/authority, living with their descendants, and receiving no pension. In the case of the absence of pension provision, it showed robust effects on higher suicide age ratios worldwide. The culture-based indicator of intra-family status revealed that household headship was more sensitive in men than in women. The impact of co-residence with the younger generations on suicide age ratios was however controlled by the elderly economic status and household headship.

Many previous ecological studies have examined how certain factors such as mental health funding and mental health service provision (Shah and Bhat, 2008), life expectancy and markers of socioeconomic

Percentage of co-residence of elders with both children and grandchildren	N	Rate Ratio	Lower limit	Upper limit	P value	Rate Ratio and 95% CI
Overall population						
Higher	77	2·72	2·19	3·40	0·00	
Lower	48	1·39	1·02	1·89	0·04	
All	125	2·17	1·81	2·60	0·00	
						0.1 0.2 0.5 1 2 5 10
						Q_b=12·14, P=0·00
Men						
Higher	77	2·83	2·14	3·74	0·00	
Lower	48	1·56	1·09	2·22	0·02	
All	125	2·25	1·81	2·80	0·00	
						0.1 0.2 0.5 1 2 5 10
						Q_b=6·77, P=0·01
Women						
Higher	77	2·70	1·88	3·88	0·00	
Lower	48	1·57	0·81	3·04	0·18	
All	125	2·38	1·73	3·27	0·00	
						0.1 0.2 0.5 1 2 5 10
						Q_b=1·99, P=0·16

Fig. 3. Forest plots of the suicide age ratios between the regions with the higher vs. the lower percentages of co-residence with their descendants.

Proportion of population above retirement age receiving a pension	N	Rate Ratio	Lower limit	Upper limit	P value	Rate Ratio and 95% CI
Overall population						
Higher	66	1·42	1·08	1·87	0·01	
Lower	66	2·76	2·22	3·43	0·00	
All	132	2·14	1·80	2·54	0·00	
						0.1 0.2 0.5 1 2 5 10
						Q_b=13·59, P=0·00
Men						
Higher	66	1·56	1·13	2·15	0·00	
Lower	66	2·91	2·20	3·83	0·00	
All	132	2·23	1·81	2·75	0·00	
						0.1 0.2 0.5 1 2 5 10
						Q_b=8·30, P=0·00
Women						
Higher	66	1·64	0·93	2·90	0·09	
Lower	66	2·66	1·86	3·83	0·00	
All	132	2·32	1·71	3·15	0·00	
						0.1 0.2 0.5 1 2 5 10
						Q_b=6·41, P=0·01

Fig. 4. Forest plots of the suicide age ratios between the regions with the higher vs. the lower proportions of the population above retirement age receiving a pension.

status and health care (Shah et al., 2008), and elderly dependency ratios (Shah et al., 2008) are specifically associated with suicide rates in later life but without considering the relative suicide rate ratios. The present findings suggested that certain socioeconomic factors may lead to higher suicide rates in older adults and consequently higher suicide age ratios. Based on the present research, for cross-national comparison, the ratio was more robust than the rate itself. Suicide age ratio was used as it was a better-chosen indicator to compare the prevalence rates of two specific population groups, namely, the older adults versus the non-older adults. In addition, as the quality of GBD suicide rates data was not so reliable in low- and middle-income countries, presuming that there is no differential underreporting by age, exploring suicide age ratios may be better able to address concerns about potential underreporting of absolute age-specific suicide rates.

The family life cycle theory has placed the nuclear family as a group with its regular patterns of expansion, transition, and contraction (Mattessich and Hill, 1987). The present findings can well be understood from the family developmental perspective. Families in later life are facing the graying transitions and challenges. With the structural contraction of a family from a multi-generational household to an elderly couple or single parent, changes brought about by retirement, grandparenthood, illnesses, deaths, widowhood and so on, alter complex relationships within a household, often requiring family support, adjustments to losses, reorientations, and reorganizations (Walsh, 2016). Many disturbances such as mental problems are associated with losses in family adaptation and moving to the stages of “empty nest” and “aging families” such as loss of household headship, loss of independent residence and loss of financial security.

This study is the first to detect that loss of household headship, the culture-based indicator of domestic status, was significant to the suicide age ratios in men but not in women. The potential explanation lies in the cultural construction of traditional gender roles in a family, namely, the patriarchal authority of masculinity, but there was no such cultural expectation for women. According to traditional culture, patriarchy was mainly based on the construction of the norm of the male as breadwinner (Seccombe, 1986). Other family members may also have difficulty with the retirement of the male head, accompanied by losses of his job-related status and social network (Walsh, 2016). The loss of the elderly male as the household head signified loss of authority, and with it his self-esteem, and replaced by his adult children within the family. The role of the male gender tends to emphasize greater levels of strength and independence, and reinforcement of this gender role often deters the males from seeking help in suicidal thoughts, feelings, as well as depression (Zhang, 2014). The present study suggests the need for further research on how to enhance the resilience of the males in later life and how to renegotiate their relationships to achieve a new balance with other family members after their loss of headship.

This study further illustrates that the impact of the suicide risk of the elderly living with the younger generations was relatively mitigated by the recipient of pension and household headship of the elderly. Predominantly, recipient of pension showed robust effects on higher old to non-old suicide rate ratios in both men and women in the world. In other words, depending on the late-life status of the elderly, especially on whether in receipt of pension, living with their descendants has dual effects on the well-being of the elderly within the family. If the seniors have economic independence such as a pension, they do not have to become a financial burden on their children, and can even provide better grandparenthood, which in turn benefits their health. On the other hand, having no pension can significantly strain relationships with cohabited descendants. Therefore, those older adults who have lost their jobs and benefits should find new work or make contributions to the family such as housework and caring for the grandchildren, but they should always be aware of facing age discrimination. Owing to the stigma of dependency in the dominant culture, based on the Interpersonal Theory of Suicide, perceived burdensomeness could increase the suicide risks for the older adults (Jahn et al., 2011).

According to previous studies, living arrangement for the elderly also yielded the most inconsistent and mixed effects on late-life suicidal risks (Chang et al., 2017). Thus, the present observation on the associations between the elderly living with their descendants and late-life suicide risk should be highly context dependent. For instance, living with children in the Chinese community is more than an indication of dependency, however, it is usually a cultural expectation that children take responsibility to support their older parents and show their filial piety. This seems to contradict the intention to measure loss of residential independence. Another problem is that our measurement of living arrangement would include households with only older adults and children, which indicates that grandparents supporting grandchildren with the absence of parents, in contrast to older adults with a loss of residential independence as intended to be measured as well. Moreover, as the Interpersonal Theory of Suicide posits, perceived burdensomeness and thwarted belonging are both powerful drivers of suicide in later life (Jahn et al., 2011). Hence, there should be more future studies to examine the effects of suicide on the older adults living with family members.

The present ecological findings suggest that strategies to enhance the socioeconomic status of older adults may be important to prevent suicides in later life both within and across countries on a grand scale. At the base of a 5-tier health impact pyramid, interventions with the greatest potential impact are efforts to address the socioeconomic determinants of health (Frieden, 2010). The present findings provide important evidence to highlight the substrata role of socioeconomic factors in public health as well as late-life suicide prevention across countries. Although the exact mechanisms by which socioeconomic status exerts its effects are not always apparent, lower status such as the elderly losing the domestic headship/authority, dependently living with their descendants and being without receiving pension, could ostensibly increase exposure to environmental hazards (Wood, 2003). Moreover, it should be noted that social policies to enhance the late-life socioeconomic status are highly context dependent. For example, the present results revealed that higher suicide age ratios could be found in Western Pacific and African regions rather than other places in the world. According to the collected data, the proportions of the population above retirement age receiving a pension were especially low in most Western Pacific and African countries, as opposed to nearly 100% in most European countries. Therefore, in many middle- and low-income countries, priorities in social policies may include concentrating on alleviating late-life poverty and keeping financial security. By contrast, whereas in the well-off regions, eliminating socio-cultural ageism by education and legislation would be more imminent.

Nonetheless, the present ecological findings could have important implications for suicide research and prevention on older adults at individual and family levels. Firstly, in future research and interventions, both qualitative and quantitative investigations need be made on how particular risk factors such as loss of headship, living with their descendants and receiving no pension increase the likelihood of older adults at some point displaying suicidal behaviors, and how protective factors such as family support build resilience against suicidal behaviors and thoughts. In addition, as is well known, the first driver of decreased suicide mortality is early detection of individuals at risk. With the benefit of this study, risk factors relating to lower domestic status such as loss of headship and receiving pension ought to be the main target of early detection efforts in the prevention of suicides in older adults. Thirdly, this study strongly highlights the gatekeeper role of family in late-life suicide prevention. Relational resilience can be strengthened as family members pull together to reshape the elders' lives, plan their financial security, and explore new interests to provide meaning and satisfaction for them (Walsh, 2016).

However, it is worth noting that this present study has several limitations. Firstly, there is the issue of the quality of the data on suicides, which is often lower in developing countries and may lead to underestimation of suicide deaths (WHO, 2014). Estimates from GBD for many countries, particularly locations in sub-Saharan Africa, have uncertain validity because there are limited vital registration data in these countries, and thus available data from a few neighboring countries may be used to impute the missing data, leading to similar estimates in these sub-Saharan African countries. Therefore, sensitivity analyses were conducted to check the robustness of our findings by excluding countries without vital registration as indicated in 2014 WHO report of suicide (WHO, 2014). The results of the sensitivity analyses showed that higher suicide age ratios were significantly found in countries with lower percentages of the elderly being heads of households (ratios = 1.50 vs 2.62, $Q_b = 9.10$, $P = 0.003$), higher percentages of co-residence of the elderly with their descendants (ratios = 2.50 vs 1.38, $Q_b = 8.77$, $P = 0.003$), and lower percentages of the elderly receiving a pension (ratios = 1.41 vs 2.58, $Q_b = 10.27$, $P = 0.001$). The findings of the sensitivity analyses were generally the same as the analyses with overall countries, which indicated the robustness of our findings. Secondly, as in prior GBD studies, the accuracy of the estimates depends on the availability of data for each age-sex-year-location. Due to delays in data reporting, estimates for more recent years rely on additional data and trends from prior years. Thus, the GBD data for 2015 in the present study may in some instances reflect rates from earlier years as well. Thirdly, due to the cross-sectional study design, caution should be exercised in the attribution of causal relationships. Fourthly, the cutoff point at 60 years old may have different implications in different countries where life expectancies and cultural formulations of 'old age' differ so much. Last but not least, it should be borne in mind that the three independent indices were the latest available estimates from 1990 to 2015 (United Nations, 2017), which

had data deficiencies and limitations in validity. However, to date, these data are the best available data for consistent comparisons across the nations worldwide.

5. Conclusion

Socioeconomic factors have important impacts on public health as well as late-life suicide prevention. The present study suggests that a set of negative transitions of socioeconomic status that the older adults frequently experience, such as loss of the domestic headship, dependently living with their descendants, and receiving no pension, may lead to higher elderly suicide rates. The present ecological findings suggest that strategies to enhance the socioeconomic status of older adults may be important to prevent suicides in later life both within and across countries on a grand scale. Therefore, priority ought to be given to facilitate efforts of older adults, families, and societies to reposition their roles in a household, enhance financial independence, and explore new meanings and expectations in the elderly people's later life.

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Conflict of interest

None declared.

Ethics approval

No ethics approval is needed as it involves the open data sources.

CRediT authorship contribution statement

Qingsong Chang: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Resources, Software, Visualization, Writing - original draft, Writing - review & editing. **Yeates Conwell:** Conceptualization, Resources, Writing - review & editing. **Donghui Wu:** Data curation, Resources, Writing - review & editing. **Yingqi Guo:** Software, Visualization, Writing - review & editing. **Paul S.F. Yip:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing - review & editing.

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Appendix

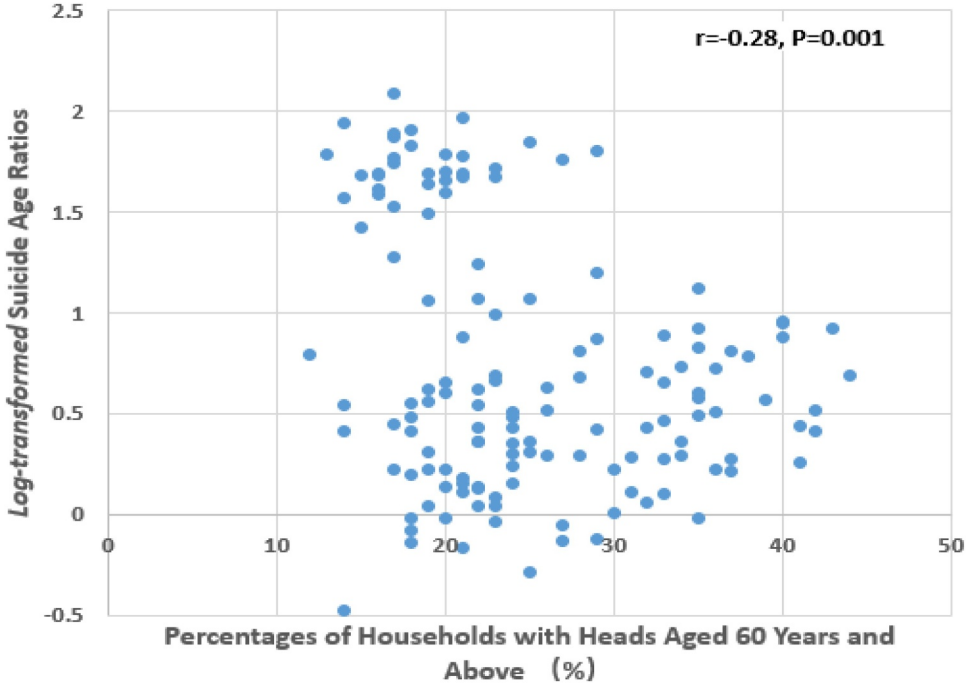

Fig. A.1. Scatter plot of percentages of the elderly heads and log-transformed suicide age ratios.

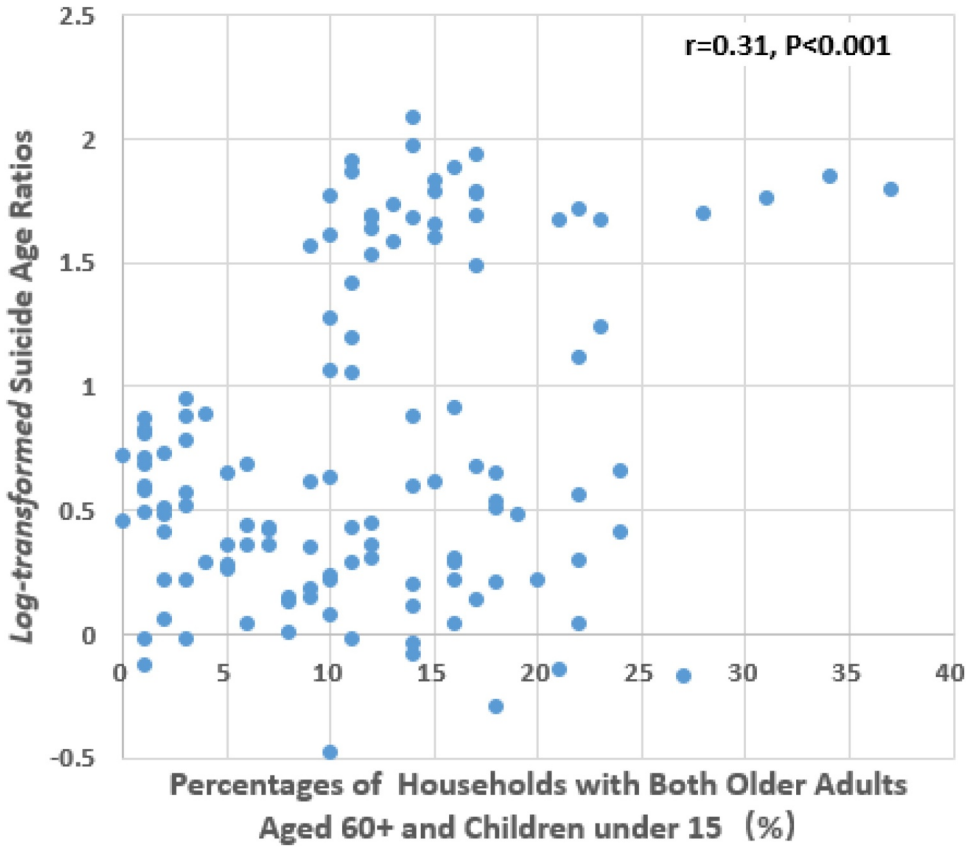

Fig. A.2. Scatter plot of percentages of households with both older adults aged 60+ and children under 15 and log-transformed suicide age ratios.

Fig. A.3. Scatter plot of the proportions of the population above retirement age receiving a pension and log-transformed suicide age ratios.

Table A.1
Pearson's correlations among the variables used in the analyses.

Pearson's Correlation	1. Suicide age ratios	2. Percentages of headship, 60+,%s	3. Percentages of co-residence of the elderly with both their children and grandchildren,%s	4. Percentages of the population above retirement age receiving a pension,%s
1	1.00			
2	−0.36*	1.00		
3	0.37*	−0.48*	1.00	
4	−0.51*	0.59*	−0.55*	1.00

* $P < 0.05$.

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