

# DEMOGRAPHIC RESEARCH

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*Research Article*

### **Loneliness and all-cause mortality in community-dwelling elderly Singaporeans**

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## **Loneliness and all-cause mortality in community-dwelling elderly Singaporeans**

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### **Abstract**

#### **BACKGROUND**

Loneliness is a significant risk factor for mortality among older adults. There are several pathways through which loneliness may operate to increase mortality risk, ranging from biological responses and individual perceptions to social interactions and environmental factors. The proportion of single older (65+) person households has doubled in the last ten years in Singapore. Yet little is understood about the relationship between loneliness, social isolation, and mortality risk among older adults, in Singapore and in Asian contexts in general.

#### **OBJECTIVE**

To assess the impact of loneliness and social isolation on the risk of all-cause mortality over a four-year period, controlling for demographic characteristics and health status at baseline.

#### **METHODS**

We used data from a longitudinal survey of community-dwelling Singaporean elderly (N=4,522). Loneliness was assessed using the UCLA three-item loneliness scale. Unadjusted and adjusted Cox proportional hazards regressions were used to estimate mortality risk.

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## RESULTS

In the final adjusted model, living arrangements and social networks outside the household were not associated with all-cause mortality. Loneliness increased the risk of all-cause mortality; those sometimes lonely and mostly lonely were 44.0% ( $p=0.005$ ) and 39.0% ( $p=0.059$ ) more likely to die compared to those not lonely.

## CONCLUSIONS

Loneliness is associated with higher mortality risks among Singaporean elderly. Mental health among the older population is a major public health concern and community interventions are needed to more efficiently identify, raise awareness of, and increase care for the lonely elderly in the community.

## 1. Introduction

As the world's population ages, loneliness has been highlighted as a global public health concern and a significant risk factor for morbidity and mortality among older adults (Basu 2012; Holt-Lunstad, Smith, and Layton 2010; Seeman 2000). Loneliness may increase mortality risk through a variety of pathways, ranging from biological responses and individual perceptions to social interactions and environmental factors. Lonely older adults are at higher risk than their peers of cardiovascular disease, high blood pressure, decreased immunity, and cognitive impairment (Cacioppo, Hawkley, and Berntson 2003; Holt-Lunstad, Smith, and Layton. 2010; Luo *et al.* 2012; Luo and Waite 2014). Lonely older adults also interpret stressors more negatively compared to their peers and may receive poorer medical care (Cacioppo *et al.* 2003). Previous research has shown that increasing age is associated with a higher prevalence of loneliness among older adults (Simon *et al.* 2014). Current economic and social changes are resulting in increasing proportions of older adults living alone; the speed of this change is particularly evident in Asia. In Singapore, as in many developed Asian societies, the proportion of older (65+) single person households has doubled in the last ten years. Yet little is understood about the relationship between loneliness, social isolation, and mortality among older adults in Singapore and in Asian contexts in general. We first assess the relationship between loneliness and social isolation (measured by strength of social networks outside the household and living arrangements). Secondly, we assess how loneliness and social isolation predict all-cause mortality over a four-year period in a population of older Singaporeans aged 60 and above.

*Existing research on loneliness and mortality*

Loneliness has consistently been shown to be linked with mortality. Studies from North America, Europe, and Asia have shown that older adults who express feelings of loneliness are more likely to die (Holt-Lunstad, Smith, and Layton 2010; Luo et al. 2012; Luo and Waite 2014; Mazella et al. 2010; Shiovitz-Ezra and Ayalon 2010; Steptoe et al. 2013; Wen, Cagney, and Christakis 2005). Cacioppo et al. summarize succinctly the pathways through which loneliness may impact mortality. The authors conclude that lonelier adults in their study were more likely to report higher levels of perceived stress compared to their non-lonely counterparts, although the psychological stressors were comparable. Lonelier individuals were also less likely to derive pleasure from social interactions and to find social interactions supportive compared to their non-lonely counterparts. Lonely participants had higher blood pressure levels, higher urinary measures of cortisol, and higher morning levels of adrenocorticotrophic hormone compared to their non-lonely counterparts (Cacioppo et al. 2003; Cacioppo et al. 2002). While the literature largely supports the link between loneliness and mortality, in some studies the effects of loneliness disappeared once health variables were accounted for (Steptoe et al. 2013).

*Existing research on indicators of social isolation and mortality*

Social isolation is distinct from loneliness. This is supported by recent work which shows that while loneliness is a relatively independent and significant predictor of mortality, the association of indicators of social isolation such as social networks and living arrangements with mortality is relatively weak or inconsistent (Holt-Lunstad, Smith, and Layton 2010; Luo et al. 2012).

Studies exploring the links between social networks and mortality use various measures and have uncovered inconsistent associations. Generally, there is evidence of a connection between social networks and mortality. (Bowling 1998; Eriksson et al. 1999; Glass et al. 1997; Olsen et al. 1991; Seeman and Berkman 1988; Seeman et al. 1987). Studies have shown that social participation, especially in formalized organizations, decreases mortality risk amongst the elderly (Sugisawa, Liang, and Liu 1994; Tucker et al. 1999). Other studies have explored gender differences in social networks and found that men and women get support and mortality-risk protection from their social networks in different ways that warrant further exploration (Hessler et al. 1995; Iwasaki et al. 2002; Shye et al. 1995).

Previous studies have shown that while living arrangements are associated with mortality, the strength of association is not always significant and may vary by culture and gender. In addition, studies on living arrangements find that it is not simply living

with others that is protective against mortality risk, but the quality and type of relationships occurring with co-residence that offer protection from or exposure to mortality risk (Davis et al. 1997; Li, Zhang, and Liang 2009; Lund et al. 2002).

In Singapore, despite high co-residence rates, many older people reported feeling lonely, suggesting that living with family members is not enough to ward off feelings of loneliness (Basu 2012; Chan 1997). Using data from a longitudinal survey of community-dwelling elderly in Singapore, we assessed how loneliness and social isolation (measured by living arrangements and social networks outside the household) predict the risk of all-cause mortality.

## **2. Methods**

### **2.1 Dataset**

Data from a longitudinal (two waves: 2009 and 2011–12) survey on the physical, mental, and social health of community-dwelling elderly Singaporeans was utilized, combined with information on the date of death of Wave 1 participants from the Singapore Registry of Births and Deaths. Details of Wave 1 (Social Isolation, Health and Lifestyles Survey, SIHLS), conducted in 2009, including its sampling strategy, are available elsewhere (Malhotra et al. 2011). Briefly, single-stage stratified (by age/sex/ethnicity) random sampling was used to select the survey sample from a national database of dwellings. A total of 4,990 elderly Singaporeans aged 60 years or above or their proxy respondents (for 458 [9.2%] elderly unable to respond due to health reasons) were interviewed face-to-face at their residences after informed consent at Wave 1. Of these 4,990, a total of 3,103 elderly or their proxy respondents were re-interviewed at Wave 2 (Panel on Health and Ageing of Singaporean Elderly, PHASE), conducted in 2011–2012, approximately 2 years after Wave 1. The longitudinal survey and matching with the Singapore Registry of Births and Deaths were approved by the Institutional Review Board of the National University of Singapore.

Scales assessing loneliness and social networks outside the household were not administered to proxy respondents. Thus, the analytical sample was restricted to the 4,522 elderly who had information on both these scales in Wave 1. Compared to those included in the analysis, those excluded (N=468) were more likely to be older, female, widowed, and reported having more diseases and Activities of Daily Living (ADL) limitations.

## **2.2 Variables**

### **2.2.1 Loneliness**

The University of California, Los Angeles' (UCLA) three-item loneliness scale was used to assess loneliness in the elderly participants (Hughes et al. 2004). Proxy respondents were not administered this scale. The three items were: How often do you feel you lack companionship? How often do you feel left out? How often do you feel isolated from others? Each item had five possible responses (always, fairly often, occasionally, rarely, and never), scored from 0 (for always) to 4 (for never). The score for each item was reverse coded, and the scores from all three items were added up. A higher total score indicated greater extent of loneliness. The Cronbach's alpha of the scale in our dataset was 0.92. Exploratory factor analysis of the three items in our dataset supported the presence of one factor with high factor loadings (0.90 to 0.94) of the three items.

Nearly half of our analytical sample (49.0%) reported a cumulative score of zero, emphasizing the skewed nature of this variable. We thus divided the score into three categories: never lonely (those who had a cumulative score of zero), sometimes lonely (those who had a score of one to three, three being the median of the rest of the sample which did not have a score of zero), and mostly lonely (those with scores from four to twelve).

### **2.2.2 Living arrangements**

Based on the information from the household roster, participants were categorized into the following five living arrangements: living alone, living with spouse, living with child(ren), living with spouse and child(ren), and living only with others (domestic helpers, siblings, cousins, and grandparents).

### **2.2.3 Social networks outside the household**

A modified version of Lubben's revised social network scale was used to assess the social networks of the respondents outside the household (Lubben and Gironda 2003). Again, this scale was not administered to proxy respondents. The scale consisted of 12 items (six each for social networks with friends and with relatives outside the household) evaluating the size of network, frequency of contact, closeness, and perceived support from friends and relatives outside the household. Scores from all 12

items were added up, a higher score indicating stronger social networks. The factor structure of the scale as well as a high Cronbach's alpha (0.92) has been previously confirmed in our data (Chan et al. 2011). The cumulative score was divided into quartiles for the analysis. Those in the first quartile were considered isolated, those in the second at high risk of isolation, those in the third at moderate risk of isolation, and those in the fourth at low risk of isolation (Lubben 1988)

#### **2.2.4 Outcome variable: All-cause mortality**

The outcome of interest was all-cause mortality till end-December 2012 among Wave 1 participants. It was assessed primarily from de-identified matched mortality data from the national Registry of Births and Deaths databases, supplemented by data from Wave 2 of the survey.

#### **2.2.5 Covariates**

A number of covariates were adjusted for that have been considered in previous analyses of the association of loneliness and mortality (Holt-Lunstad et al. 2010; Luo et al. 2012; Steptoe et al. 2013). The socio-demographic covariates considered were age, gender, ethnicity, marital status, housing type, and education, the last two being indicators of socioeconomic status. The health status covariates considered were number of self-reported diseases, ADL limitations, instrumental ADL (IADL) limitations, smoking status, depressive symptoms score from the 11-item Center for Epidemiological Studies Depression Scale (Kohout et al. 1993), dichotomized using a cut-off score of 6/7 into clinically significant depressive symptoms (yes/no), and cognitive impairment score from the Short Portable Mental Status Questionnaire (Pfeiffer 1975), categorized into cognitively intact (score: 0–2), mildly (3–4), or moderately (5–7) impaired.

### **2.3 Statistical analysis**

All analyses, conducted using Stata 12 (StataCorp., College Station, Texas), were weighted using Wave 1 survey weights. Weighted percentages and means, as applicable, of the key predictor variables and covariates were calculated. Cross-tabulations of loneliness and the two indicators of social isolation were carried out.

Further, correlation between scores on the scales for loneliness and social networks outside the household was assessed through Pearson's correlation coefficient.

Given the prospective nature of the study and the fact that the participants contributed variable amounts of follow-up time, survival analysis was used to assess the association of loneliness and social isolation at baseline with subsequent all-cause mortality. The time-to-event variable was time since Wave 1 interview to either date of death (for those dead by 31<sup>st</sup> December 2012) or 31<sup>st</sup> December 2012 (for those alive at that date), and ranged from 6 to 1,459 days. Of the 4,522 participants in the analytical sample, 435 (9.6%) had died by 31<sup>st</sup> December 2012. Date of death for those who died during the follow-up period was obtained through data-linkage with the national Registry of Births and Deaths databases. Self-reported information, including national identification number, name, date of birth, and gender, which were reported by the respondent or their proxy in the Wave 1 interview, were used for the data-linkage with the deaths databases. For the majority (414; 95.2%) of those dead by end-December 2012, the date of death was available in the deaths databases and was used. For those (6,435; 1.4%) who were reported as dead on contact at Wave 2 but could not be located in the deaths databases, the date of death reported by the next-of-kin in a decedent questionnaire at Wave 2 was utilized. For the rest (15,435; 3.4%), who were reported as dead on contact at Wave 2 but could not be located in the deaths databases or whose exact date of death was not available, the date of death was assigned as the mid-point between the date of their Wave 1 interview and date of contact at Wave 2 with the next-of-kin. The inability to locate some of those who had died in the deaths databases is likely the result of missing or incorrect/misspelt values in the variables (national identification number, name, date of birth, and gender) used for the data-linkage, since these variables were self-reported by the respondent or their proxy in Wave 1. Participants who were still alive on 31<sup>st</sup> December 2012 were censored.

Unadjusted Kaplan-Meier survival curves were determined for loneliness and the two indicators of social isolation. The semi-parametric Cox proportional hazards model was used to assess the unadjusted and adjusted association of loneliness and the two indicators of social isolation with all-cause mortality. In the adjusted analysis, three sequential models were fitted. The first model included loneliness and the two indicators of social isolation; the second model additionally adjusted for socio-demographic covariates, and, finally, the third model included health status covariates. A *p* value of <0.05 was considered to be statistically significant. Tests and plots based on Schoenfeld residuals were used to test the proportional hazard assumption globally, as well as for loneliness and the two indicators of social isolation (Schoenfeld 1980).

In our primary analysis, described above, we operationalized the variables for loneliness and social networks outside the household as categorical variables. In some previous studies they have been represented as continuous variables (Steptoe et al.

2013). Thus, in sensitivity analysis we ran the unadjusted and adjusted Cox proportional hazards models, as detailed above, using continuous scores for loneliness and social networks outside the household.

### 3. Results

Table 1 summarizes the characteristics of the analytical sample. Nearly half (49%) of the elderly reported no feelings of loneliness, 32% felt lonely some of the time, and 19% were mostly lonely. The majority (52%) of the elderly lived with both their spouse and child(ren) and 7% lived alone. Based on our variable measuring strength of social networks outside the household, we found that 24% of the sample had the lowest level of support from social networks (1<sup>st</sup> quartile; isolated) and 27% of the sample had high levels of support (4<sup>th</sup> quartile; low risk for isolation). The majority of the participants were between 60 and 70 years old, Chinese, married, lived in public housing flats with at least three rooms, had no ADL or IADL limitations, and had never smoked. The majority of the sample was female (53%) and 29% had had no formal education. The mean number of self-reported diseases was 1.8.

Table 2 describes the distribution of the indicators for social isolation within each category of loneliness. There was an increase in the proportion living alone with greater extent of loneliness: while only 4.7% of those who reported never feeling lonely lived alone, this proportion was 13.1% among those classified as most lonely. And there was a decrease in the proportion living with spouse and child(ren) with greater extent of loneliness (54.9% among those never feeling lonely and those sometimes lonely, and 36.8% among those mostly lonely). Similarly, the percentage of those at low risk of isolation (most social networks outside the household) was higher in those with no feelings of loneliness (28.7%) compared to those mostly lonely (13.7%). Pearson's correlation coefficient assessing the correlation between the continuous scores on the scales for loneliness and social networks outside the household was 0.3, indicating low or weak correlation.

**Table 1: Sample characteristics**

Variable	Weighted mean [SE]/ Weighted percentage (N=4522)
Loneliness	
Never lonely	49.0
Sometimes lonely	32.0
Mostly lonely	19.0
Living arrangements	
Alone	6.5
With spouse	17.0
With child(ren)	19.4
With spouse and child(ren)	51.5
With others only	5.6
Social networks outside the household	
Isolated	23.8
High risk of isolation	22.4
Moderate risk of isolation	27.2
Low risk of isolation	26.6
Age (years)	
60-70	64.8
71-80	27.0
81-90	7.6
91 and above	0.6
Gender	
Men	46.6
Women	53.4
Ethnicity	
Chinese	83.3
Malay	9.2
Indian	6.1
Other	1.4
Marital Status	
Married	65.1
Widowed	26.4
Separated	0.7
Divorced	2.5
Never married	5.3
Housing Type	
Public flats, 1-2 rooms	7.2
Public flats, 3 rooms and above	79.9
Private housing	12.4
Others	0.5
Education	
No formal education	28.8
Primary education	37.3
Secondary and above	33.9
Total number of diseases (Range: 0-10) <sup>A</sup>	1.79 [0.03]
Activities of Daily Living limitations	
None	93.8
1	3.3
2 or more	2.9

**Table 1: (Continued)**

Variable	Weighted mean [SE]/ Weighted percentage (N=4522)
<b>Instrumental Activities of Daily Living limitations</b>	
None	91.3
1	3.5
2 or more	5.1
<b>Smoking status</b>	
Current smoker	12.1
Former smoker	14.4
Never smoked	73.5
<b>Clinically Significant Depressive Symptoms</b>	
Yes	15.2
No	84.8
<b>Cognitive impairment categories</b>	
Intact	85.6
Mildly impaired	11.6
Moderately impaired	2.8

<sup>A</sup> Diseases include: Heart problems, cancer, cerebrovascular disease, dementia, high blood pressure, diabetes, respiratory illness, digestive illness, kidney and liver ailments, and osteoporosis and arthritis.

Note: Percentages were weighted to account for oversampling.

**Table 2: Distribution of social networks outside the household and living arrangements by extent of loneliness**

	Loneliness		
	Never lonely N=2253	Sometimes lonely N=1384	Mostly lonely N=885
<b>Social networks outside the household</b>			
Isolated	25.8 <sup>1</sup>	17.6	29.3
High risk of isolation	22.1	22.9	22.1
Moderate risk of isolation	23.5	28.4	34.9
Low risk of isolation	28.7	31.0	13.7
<b>Living arrangements</b>			
Alone	4.7	5.5	13.1
With spouse	17.4	18.0	14.1
With child(ren)	18.3	15.3	29.2
With spouse and child(ren)	54.9	54.9	36.8
With others only	4.7	6.4	6.8

<sup>1</sup>The numbers reflect weighted column %

**Table 3: Unadjusted and adjusted associations of loneliness, living arrangements, and social networks outside the household with all-cause mortality (N=4,522)**

Variables / Model	Unadjusted model	Adjusted models		
	HR (95% CI)	Model 1 HR (95% CI)	Model 2 HR (95% CI)	Model 3 HR (95% CI)
<b>Loneliness</b>				
Not lonely	Ref.	Ref.	Ref.	Ref.
Sometimes lonely	1.50* (1.18, 1.92)	1.55* (1.21, 1.99)	1.41* (1.09, 1.82)	1.44* (1.12, 1.86)
Mostly lonely	1.91* (1.46, 2.51)	1.82* (1.38, 2.40)	1.62* (1.22, 2.14)	1.34 (0.99, 1.82)
<b>Living arrangements</b>				
Alone	0.98 (0.61, 1.57)	0.79 (0.49, 1.28)	0.47* (0.25, 0.91)	0.71 (0.35, 1.41)
With spouse	0.85 (0.61, 1.17)	0.85 (0.61, 1.18)	0.90 (0.64, 1.26)	0.90 (0.64, 1.26)
With child(ren)	1.19 (0.91, 1.54)	1.07 (0.83, 1.40)	0.62* (0.43, 0.91)	0.97 (0.65, 1.44)
With spouse and child(ren)	Ref.	Ref.	Ref.	Ref.
With others only	1.73* (1.12, 2.68)	1.52 (0.98, 2.36)	0.91 (0.53, 1.56)	1.31 (0.76, 2.24)
<b>Social network outside the household</b>				
Isolated	2.07* (1.50, 2.85)	1.97* (1.42, 2.73)	1.45* (1.03, 2.04)	1.28 (0.90, 1.82)
High risk of isolation	1.87* (1.34, 2.60)	1.77* (1.26, 2.47)	1.39 (0.99, 1.94)	1.19 (0.84, 1.67)
Moderate risk of isolation	1.46* (1.05, 2.04)	1.35 (0.96, 1.89)	1.38 (0.98, 1.95)	1.36 (0.97, 1.91)
Low risk of isolation	Ref.	Ref.	Ref.	Ref.
<b>Age</b>				
60 – 70 years	-	-	Ref.	Ref.
71 – 80 years	-	-	1.99* (1.52, 2.61)	1.76* (1.33, 2.33)
81 – 90 years	-	-	3.84* (2.80, 5.25)	2.90* (2.08, 4.05)
91 and above	-	-	9.43* (5.44, 16.35)	6.26* (3.59, 10.93)
<b>Gender</b>				
Male	-	-	Ref.	Ref.
Female	-	-	0.47* (0.36, 0.62)	0.60* (0.43, 0.82)
<b>Ethnicity</b>				
Chinese	-	-	Ref.	Ref.
Malay	-	-	1.46* (1.11, 1.91)	1.40* (1.06, 1.83)
Indian	-	-	1.17 (0.80, 1.69)	1.15 (0.79, 1.68)
Other	-	-	1.78 (0.68, 4.64)	1.61 (0.61, 4.24)

**Table 3: (Continued)**

<b>Marital status</b>				
Married	-	-	Ref.	Ref.
Widowed	-	-	1.73* (1.17, 2.54)	1.14 (0.76, 1.71)
Separate	-	-	1.57 (0.31, 8.00)	1.26 (0.25, 6.44)
Divorced	-	-	2.03 (0.90, 4.59)	1.57 (0.68, 3.61)
Never married	-	-	2.08* (1.03, 4.19)	1.49 (0.73, 3.04)
<b>Housing type</b>				
HDB (1 – 2 rooms)	-	-	Ref.	Ref.
HDB (3 rooms and above)	-	-	0.75 (0.51, 1.11)	0.75 (0.51, 1.09)
Condominiums	-	-	0.61 (0.36, 1.02)	0.65 (0.39, 1.10)
Others	-	-	0.24 (0.03, 1.85)	0.26 (0.03, 2.05)
<b>Education level</b>				
No formal education	-	-	Ref.	Ref.
Primary education	-	-	0.94 (0.72, 1.22)	0.97 (0.74, 1.27)
Secondary education and above	-	-	0.56* (0.40, 0.81)	0.61* (0.43, 0.86)
<b>ADL</b>				
No limitation	-	-	-	Ref.
1 limitation	-	-	-	2.01* (1.28, 3.15)
2 or more limitations	-	-	-	2.41* (1.41, 4.13)
<b>IADL</b>				
No limitation	-	-	-	Ref.
1 limitation	-	-	-	1.86* (1.18, 2.93)
2 or more limitations	-	-	-	1.51 (0.89, 2.55)
<b>Comorbidities (0 – 10)</b>	-	-	-	1.09* (1.02, 1.17)
<b>Smoking status</b>				
Current smoker	-	-	-	Ref.
Former smoker	-	-	-	0.88 (0.63, 1.23)
Never smoked	-	-	-	0.46* (0.33, 0.63)
<b>Clinically Significant Depressive Symptoms</b>				
No	-	-	-	Ref.
Yes	-	-	-	1.11 (0.82, 1.50)

**Table 3: (Continued)**

Cognitive impairment categories				
Intact	-	-	-	Ref. 1.02
Mildly impaired	-	-	-	(0.75, 1.39) 0.96
Moderately impaired	-	-	-	(0.63, 1.47)

\* for  $p < 0.05$

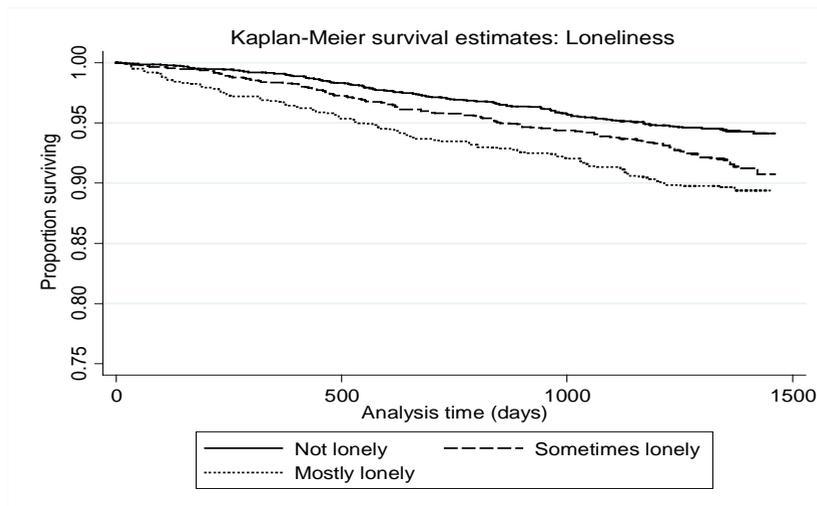
Model 1: Individual-level + Household-level + Societal-level loneliness

Model 2: Model 1 + socio-demographic variables

Model 3: Model 2 + health status indicators

Figure 1 presents the unadjusted Kaplan-Meier survival curves for loneliness, living arrangements, and social networks outside the household. For loneliness, at any time point the probability of dying from any cause was the lowest among those not lonely at baseline and the highest among those most lonely. With regard to living arrangements, this probability was the lowest among those living with spouse only and the highest among those living with others. Finally, in the context of social networks outside the household, the lowest likelihood of all-cause mortality was for those at low risk of isolation at baseline.

**Figure 1: Unadjusted Kaplan-Meier survival curves for loneliness, living arrangements, and social networks outside the household**



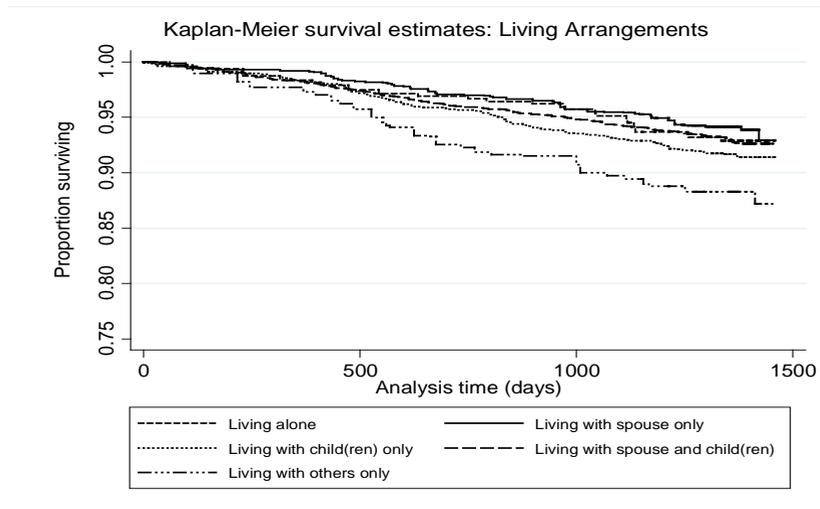
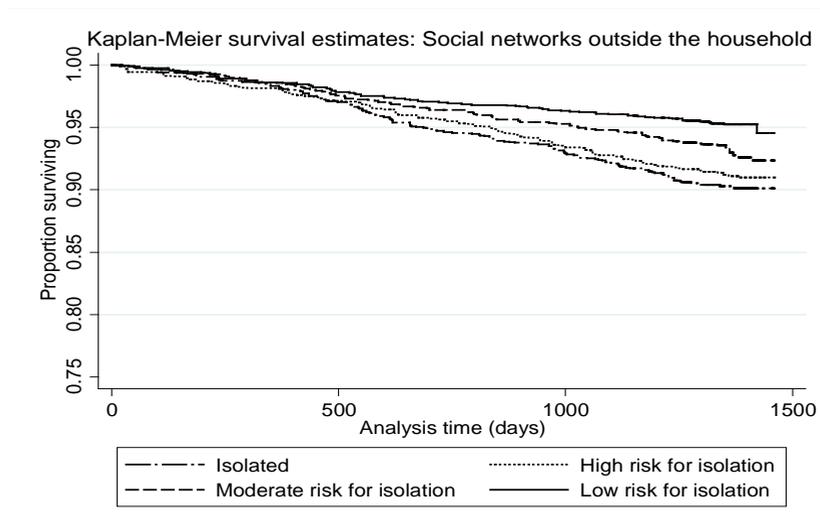


Figure 1: (Continued)



In the unadjusted Cox proportional hazard models, loneliness and the two indicators of social isolation had a significant association with all-cause mortality. The significant association of loneliness with all-cause mortality, though attenuated, was maintained through the sequential adjusted models (Table 3). In the final model (Model 3), even after adjusting for the two indicators of social isolation, socio-demographics and health status indicators, the likelihood of dying was significantly higher for those sometimes lonely (1.44 [1.12-1.86]) and marginally significant ( $p=0.059$ ) for those mostly lonely (1.34 [0.99-1.82]), relative to those not lonely. While living arrangement was not associated with all-cause mortality after adjusting for loneliness and social networks outside the household (Model 1), on further adjustment for socio-demographics (Model 2), those living alone (0.47 [0.25-0.91]) and those living with child(ren) (0.62 [0.43-0.91]) had a significantly lower likelihood of dying relative to those living with spouse and child(ren). However, these significant associations became non-significant on controlling for health status indicators (Model 3). Similarly, the significant association of social networks outside the household with all-cause mortality (Models 1 and 2), with greater risk for those isolated and at high risk of isolation became non-significant once health status of the elderly was accounted for (Model 3). In the final model, the oldest old, females, Malays, individuals with a greater number of ADLs and chronic diseases, and current smokers had the highest mortality risk. Education was protective: older adults with secondary levels of education or higher were half as likely to die compared to older adults with no formal education. The  $p$ -values of the tests, globally as well as for each dimension of loneliness, and the plots (not shown) for each dimension based on Schoenfeld residuals indicated no deviations from the proportional hazard assumption.

Results of the sensitivity analysis (not shown), which utilized continuous scale scores for loneliness and social networks outside the household, were comparable to the primary analysis described above. In the model that included loneliness, living arrangements, social networks outside the household, socio-demographics, and health status indicators (corresponding to Model 3 above) of the first three variables, only individual-level loneliness was associated with all-cause mortality, the hazard ratio being 1.07 (1.02-1.12).

## **4. Discussion**

In our analysis we found that loneliness was associated with an increased risk of mortality, but living arrangements and social networks outside the household were not, once health status indicators were accounted for. Our results are comparable to other studies that found a significant effect of loneliness on mortality risk and no association

between social relationships and living arrangements and mortality (Holt-Lunstad et al. 2010; Luo et al. 2012).

We acknowledge that the hazard ratio might also be an underestimate of the effect of loneliness on mortality, because while we have information on social networks outside of the household and living arrangements we do not have any information on the quality of these relationships (Holt-Lunstad et al. 2010).

The findings of our study confirmed that while loneliness is related to a greater risk of mortality, social networks and living arrangements are not. Thus loneliness and social isolation are distinct concepts which require targeted programmatic and policy interventions. The Singapore government has consistently supported multi-generational housing through incentive schemes (InfoWEB 2014). Our suggestion is that while this is necessary it may not be sufficient. We found living arrangements were not associated with a greater risk of mortality, suggesting that even if older people live with their families, they may still have feelings of loneliness. Our findings highlight the need for a multidisciplinary approach to policy and programming for older adults who report feelings of loneliness in the community. From a social perspective, programs that encourage intergenerational bonding, particularly programs that are supportive of increased interaction among family members within households (either by facilitating space, time, or support, e.g., work-life balance programs, caregiver support programs) may decrease feelings of loneliness among older family members. From a psychological perspective, innovative programs (e.g., support for second careers, additional education) that target renewing older persons' sense of purpose may reduce feelings of loneliness (Schindler, Staudinger, and Nesselrode 2006; Staudinger and Kunzmann 2005).

This analysis and recent work on other societies show that loneliness is an emerging public health concern across Western and non-Western cultures. With increases in life expectancy, family care is being extended over time and is no longer confined to the physical and financial domains. Emotional support is an essential component of care across the life course, particularly for older adults who do not have supporting social structures (e.g., schools, work place) to identify loneliness. Providing avenues to access such support is where government policy and programming can play a critical role.

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