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Lee, J. H. ORCID: <https://orcid.org/0000-0003-2968-7582>  
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# Housing quality determinants of depression and suicide ideation by age and gender

Ji Hei Lee 

Real Estate & Planning, Henley Business School, University of Reading Malaysia, Iskandar Puteri, Malaysia

## ABSTRACT

The Covid-19 pandemic and subsequently increased time spent at home signified the importance of understanding on the link between housing and mental health. This paper examines how housing qualities affect depression and suicide ideation for each age group (i.e. young adults, middle-aged and older adults) and gender. With South Korea population-based panel data, fixed-effect models and a partial least squares structural equation model were used. A functional problem was a major risk factor for depression in women, whereas a structural problem was a key risk factor for men's depression. For older adults, living in basement and vulnerability to natural disaster were detrimental to mental health. Functional problems increased the likelihood of suicide ideation in the middle-aged. The mechanisms of the housing qualities-mental health nexus were varied by age and gender. This paper proposed policy suggestions including a tailored housing policy and provision, a housing rating system for health and a support system for noise control.

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Housing;  
depression;  
suicide ideation;  
mental health;  
housing quality

## Introduction

It is evidenced that the Covid-19 pandemic has influenced mental health for people around the globe – health practitioners the foremost affected, patients, their families and most of us who became homebound by the pandemic (Amerio *et al.*, 2020; Choi, 2020; Sediri *et al.*, 2020). According to a recent survey of US adult population, depressive symptoms have tripled during the lockdown period (Ettman *et al.*, 2020). Under this circumstance with significantly increased time spent at home, housing environment has become more important than ever to our mental wellbeing. The present trend of work-from-home or remote-working has been accelerated by the pandemic and is expected to continue even after the pandemic ends (Felstead & Henseke, 2017).

Housing and mental health nexus has been one of the continuing pursuits in planning, public health and social work for a few decades. In studies examining the relationship between housing and mental health, the constructs of mental health are observed in varied forms such as depression, self-esteem and stress. Depression

**CONTACT** Ji Hei Lee  [j.h.lee@henley.edu.my](mailto:j.h.lee@henley.edu.my)  Real Estate & Planning, Henley Business School, University of Reading Malaysia, Malaysia campus, Educity, Iskandar Puteri, Johor 79200, Malaysia

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has been the most studied construct on the topic. On the other hand, an extreme side of mental distress, i.e. suicide ideation, has been rarely studied in its relation to housing qualities. In previous literature, the dimension of housing concerning its effect on mental health mainly focussed on housing tenure, financial instability and public housing (Ellaway & Macintyre, 1998; Gibson *et al.*, 2011; Han & Jeon, 2018; Kim *et al.*, 2013; Law *et al.*, 2016; Lee *et al.*, 2016; Lorant *et al.*, 2005; Park & Lee, 2016). There is a lack of empirical evidence on what aspects of housing quality are related to or may cause depression and suicide ideation. Furthermore, who are the most vulnerable to the housing-mental health nexus is yet unknown.

Home environment and housing quality generate everyday sensory experiences. It should be noted that men and women are different in their sensory processing pattern (i.e. how they take, interpret and respond to sensory stimuli of environment) (Nam & Lee, 2010; Olofsson & Nordin, 2004). Women have higher sensitivity than men and young adults are more sensory sensitive than older adults; however, gender difference does not appear among older adults (Machingura *et al.*, 2019). In understanding the relationship between housing quality and mental health, gender and age have been neglected and rarely studied.

The significant rise of one-person households has been observed in many countries due to increasing ageing population, delayed marriage and increasing geographic mobility (Ronald, 2017; Snell, 2017; Yeung & Cheung, 2015). In South Korea, one-person households have continually increased and currently take up 31.7% of total households as of 2021; of the total one-person households, people aged 60 and above accounted for 36%, middle-aged 31% and young adults 32% (Statistics Korea, 2021). It is foreseeable that this trend would generate new needs and demands for a tailored housing policy and provision for one-person households in both public and private sectors. For evidence-based housing policy, it is essential to understand the housing-mental health nexus by taking age and gender into consideration.

To fill these gaps and needs, this study examined how housing qualities affect depression and suicide ideation for each age group (i.e. young adults, middle-aged and older adults) and gender.

## Literature review

### *Housing and depression*

Among various theories on the causes of depression, the Seligman's Learned Helplessness theory so far seems to best explain the effect of living environment on depression. When being exposed to repeated, uncontrollable environment causing discomfort and suffering without a way to escape, people begin to feel, think and act as if they are helpless, which eventually leads to depression (Seligman, 1972). Since housing is an expensive commodity based on households' economic condition, it is usually perceived and considered as a given condition that a person should live with rather than a condition that can be easily changed or escaped. In this regard, poor housing conditions set a precondition for learned helplessness.

Empirical studies also provide evidence for the relationship between housing and depression. In existing literature, housing correlates of depression are housing tenure,

housing-related financial burden, spatial context of housing and quality of housing. Particularly, housing tenure and housing-related financial burden were consistently found to be associated with depression (Han & Jeon, 2018; Kim *et al.*, 2013). People with homeownership showed better health outcomes than those having no homeownership; homeownership with high percentages of house-related mortgage interests predicted higher levels of depressive symptoms (Ellaway & Macintyre, 1998; Gibson *et al.*, 2011; Lee *et al.*, 2016). It is notable that these effects may vary by age groups. A study (Howden-Chapman *et al.*, 2011) showed that the effect of housing tenure (i.e. owned vs rental) on mental health diminished as people aged. However, heavy housing financial burden still predicted high depressive symptoms among the elderly (Park & Lee, 2016).

The spatial context of housing has been known as a risk factor of depression. Neighbourhood socioeconomic status is associated with depression (Kim, 2008); however, the evidence for causality is inconsistent when reviewing the longitudinal studies (Richardson *et al.*, 2015). The neighbourhood social environment such as crime and safety has been identified to correlate with depression, whereas the neighbourhood physical environment such as access to amenities and walkability has shown no association with depression (Barnett *et al.*, 2018; Beck *et al.* 2017; Domènech-Abella *et al.*, 2020; Ivey *et al.*, 2015). Overall, characteristics of neighbourhood environment look less explanatory of one's depression than individual sociodemographic factors (Beck *et al.*, 2017).

Third, housing quality is closely associated with depression and mental distress (Choi & Park, 2012; Kim *et al.*, 2013; Mora *et al.*, 2016). Particularly, functional and structural problems of housing have been evidenced to induce psychological distress and depression. Such factors include uncontrollable noise (Evans *et al.*, 2001), insufficient exposure to daylight, chronic exposure to air pollution (Evans, 1994), overcrowding (Evans *et al.*, 2003; Kim *et al.*, 2013; Mora *et al.*, 2016) and structural defects (Kim *et al.*, 2013). Despite a strong association between housing quality and mental distress, the effect size seems relatively small; a study (Choi & Park, 2012) showed that only 4.3% of depression was explained by housing factors.

Most studies on the effect of housing quality on depression were conducted predominantly in the context of high-rise flats or public housing (Garnham & Rolfe, 2019; Platt *et al.*, 2017). Evidence from a study setting which includes all types of housing and neighbourhoods would contribute to more accurate, comprehensive understanding. In addition, the data used in previous studies are mostly cross-sectional, which limits the interpretation of causal linkage between housing quality and depression. There is a need to conduct research with longitudinal data.

### **Housing and suicide**

The most known risk factors for suicidal behaviours are depression, health condition, chronic disease, relative deprivation and unemployment (Kang, 2005; Lin, 2006; Pak & Choung, 2020). However, environmental factors of suicidal behaviours are relatively understudied. Recently, residential environments have been recognized as a potential risk factor for suicidal behaviours.

Neighbourhood socioeconomic status and social ties are consistently found to have association with suicide. A review study on suicidal behaviours in Europe showed that neighbourhood disadvantages were linked to suicidal behaviours (Cairns *et al.*, 2017). Similarly, a study conducted in South Korea also revealed that a suicide mortality rate was correlated with neighbourhood socio-economic status, the number of social assistance recipients and social ties with neighbours (Huh & Choi, 2013; Yoon *et al.*, 2015). It is also supported by another evidence from the US (Marco *et al.*, 2018) that the locations of suicide-related emergency calls were associated with the residents' education level, the population density, the percentage of one-person households and the number of older adults.

In addition, housing tenure and housing instability seem to predict suicidal behaviours. Suicide ideation and suicide rate were observed more frequent and higher in tenants than homeowners (Law *et al.*, 2016; Lorant *et al.*, 2005). Fear before eviction and the loss of a home also explained suicidal behaviours (Stack & Wasserman, 2007). However, a study with the large sample of 142 US metropolitan areas showed a different result that housing-mortgage stress and suicide rates were not related (Jones & Pridemore, 2016).

Housing qualities have been rarely studied in relation to suicidal behaviours. Even among a paucity of research on this topic, most of the studies mainly focussed on suicidal behaviours in the context of public rental housing. What has been known so far is that housing attributes correlated with suicidal behaviour are noise, ventilation, air pollution and overcrowding (Choi, 2007). Hence, it is needed to conduct a population-based, longitudinal study to examine the causal link between housing qualities and suicidal behaviour and the underlying mechanism in order to address our current limited knowledge in the housing quality-suicide nexus.

### ***The mechanism of housing quality-mental health***

The mechanism on how housing condition affects depression and suicide has been little known. Phillips *et al.* (2005) evidenced with the sample of older adults that housing condition did not have any direct effect on mental wellbeing and proposed that residential satisfaction could play as a mediator in explaining the relationship between housing and mental wellbeing. For a mediation effect to exist among three constructs A, B and C (i.e.  $A \rightarrow B \rightarrow C$ ), the effect of A on B and the effect of B on C should be statistically significant (i.e.  $A \rightarrow B$  and  $B \rightarrow C$ ) (Zhao *et al.*, 2010). For residential satisfaction to mediate the housing quality-mental health nexus, housing quality should affect residential satisfaction and residential satisfaction should affect mental health.

There is established evidence that housing quality influences residential satisfaction (Ren & Folmer, 2017). Particularly, the objective attributes of housing are key determinants of residential satisfaction (Amérgo & Aragonés, 1997; Kroesen *et al.*, 2010). However, the relationship between residential satisfaction and depression has been rarely investigated. A recent study (Liu *et al.*, 2018) found in the context of senior care homes that residential satisfaction and depression were negatively associated; residential satisfaction mediated the relationship between residential environment and depression. Moving forward, empirical studies with other age groups in

non-facility settings would help to validate the relationship. To further elucidate the underlying relationships among housing quality, residential satisfaction and mental health, these constructs need to be analyzed together in the integrated conceptual framework.

### ***Gender difference in the housing-mental health nexus***

Despite a growing recognition on the potential housing-mental health link, few studies have investigated whether the effect of housing on mental health would be same for men and women. However, there are a few important pieces of literature paying attention to gender in the housing-health nexus. Regoeczi (2008) revealed that overcrowding increased the level of depression in women, while increasing the level of aggression in men. The potential reason for this difference could be explained by recent empirical findings. Perreault *et al.* (2020) evidenced that overcrowding diminished the sense of home for women. Meth & Charlton (2017) showed that improved housing quality and homeownership enhanced men's sense of masculinity, self-worth and sociability, which consequently improved the relationship with family members. In studies on mental health, it is widely accepted that the occurrence of depression is higher in women (Maji, 2018). Psychology studies acknowledge that gender differences exist in human senses (e.g. smell, noise and visual system) and the perception of sensory pain (Keogh & Herdenfeldt, 2002; Sorokowski *et al.*, 2019). It means that how men and women perceive and respond to the sensory stimuli of environment could be different. Housing qualities are closely related to senses; they generate sensory experiences. The accumulation of this evidence on gendered perceptions and responses to sensory environment tells us that the impact of housing quality on mental health may differ by gender.

### ***Research questions and hypotheses***

To fill these gaps in existing literature, this paper aims to examine how housing quality influences depression and suicide ideation for each gender and age group, i.e. young adults (aged 19–39), middle-aged (aged 40–59) and older adults (aged 60 and above). Does housing quality have any effect on depression and suicide ideation? Who would be the most vulnerable to poor housing quality? What is the mechanism of explaining the housing quality and mental health relation? The research hypotheses are constructed as follows (Figure 1):

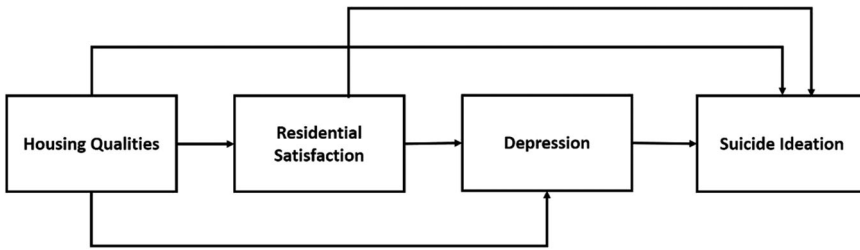
**Hypothesis 1.** Housing qualities affect depression, of which effect may vary by age and gender.

**Hypothesis 2.** Housing qualities affect suicide ideation, of which effect may vary by age and gender.

**Hypothesis 3.** Housing qualities have indirect effect on depression through residential satisfaction, which may vary by age and gender.

**Hypothesis 4.** Housing qualities have indirect effect on suicide ideation through residential satisfaction or/and depression, which may vary by age and gender.





**Figure 1.** Research conceptual framework.

## Method

### Data and sample

This study used the panel data of the Korean Welfare Panel Study (KOWEPS) which are twelve-wave, population-based surveys from 2005 to 2016. With the main purpose of investigating the quality of life among low-income households, the KOWEPS allocated about 50% of the samples to low-income households (i.e. below 60% of the Korean national median income) and surveyed across the nation which covered 209 out of the total 228 municipalities nationwide (Kim *et al.*, 2016). Table 1 describes the sample size for each panel wave and the percentage of the original sample maintained.

### Variables and measures

Table 2 summarizes variables, survey questions, scales and coding schemes. This study has two outcome variables: depression and suicide ideation. Depression is a construct commonly used in measuring mental health. On the other hand, suicide ideation (i.e. suicidal thought) measures the extreme side of mental distress.

In measuring depression, the KOWEPS used the 11-item version of the Center for Epidemiologic Studies Depression Scale (CES-D) (Kohout *et al.*, 1993). Its original version consists of 20 items which measure depression symptoms, capturing

**Table 1.** Description of panel data.

Wave	Year	Household sample size	Percentage of the original household sample maintained*
1	2005	14,613	100%
2	2006	13,671	92.07%
3	2007	13,082	86.65%
4	2008	12,821	83.92%
5	2009	12,401	80.25%
6	2010	11,749	75.45%
7	2011	15,130	74.53%
8	2012	14,705	72.17%
9	2013	14,108	69.23%
10	2014	13,801	67.31%
11	2015	13,319	64.48%
12	2016	12,938	62.19%

\* Source of data (Kim *et al.*, 2016, p. 8).

**Table 2.** Variables, survey items and coding scheme.

Variable	Survey items	Coding scheme
<b>Mental health</b>		
Depression	(CES-D 11) How often have you felt this way during the past week? 1) I did not feel like eating. 2) I was happy. 3) I felt very depressed. 4) I felt everything I did was an effort. 5) My sleep was restless. 6) I felt lonely. 7) I enjoyed life. 8) People were unfriendly. 9) I felt sad. 10) I felt that people dislike me. 11) I could not get going.	Rarely or none of the time = 0, Sometimes (1-2 days per week) = 1, Often (3-4 days per week) = 2, Most of the time (5-7 days per week) = 3. Scores range from 0 to 33.
Suicide ideation	In the past year, have you ever seriously considered a suicide?	Yes = 1, No = 0
<b>Housing</b>		
<b>Housing quality</b>		
a. Functional problem	The house is equipped with proper noise proof, ventilation, lighting, and heating system.	Yes = 0, No = 1
b. Structural problem	As a permanent building, the quality of the materials of the main structure is proof from heat, fire, and moisture.	Yes = 0, No = 1
c. Disaster vulnerability	The house is safe from natural disasters such as flooding, storm, and landslide.	Yes = 0, No = 1
d. Bathroom	Independent bathroom (with hot water) = 0; shared bathroom with other households/ no hot water for bathroom/ or no bathroom at all = 1	
e. Living in basement	Living in a basement or half-basement = 1; ground and above level = 0	
f. Overcrowding	Living under the minimum housing size per person (floor area 12m <sup>2</sup> and below) = 1, above 12m <sup>2</sup> = 0	
<b>Residential environment</b>		
Residential satisfaction	Very satisfied = 5, somewhat satisfied = 4, neither satisfied nor dissatisfied = 3, somewhat dissatisfied = 2, very dissatisfied = 1	
<b>Housing tenure</b>		
Owned home vs rental	Owned = 1, Rented = 0	
<b>Housing-related financial burden</b>		
Housing debt	The amount of housing-related debt (unit: KRW10,000,000)	
Overdue housing debt	None = 0, once = 1, two or three times = 2, four times and more = 3	
<b>Location</b>		
City vs rural	City = 1, rural = 0	
<b>Income</b>		
Household income per person	Annual disposable household income/ the number of household members (unit: KRW10,000,000)	
Satisfaction with household income	Very satisfied = 5; somewhat satisfied = 4; neither satisfied nor dissatisfied = 3; somewhat dissatisfied = 2; very dissatisfied = 1	
<b>Job</b>		
Jobless	Unemployed (actively have been seeking for employment in the past four weeks) = 1, wage worker, self-employed or employer, unpaid family employee, unemployed (with no work capability due to disability, injury, disease and ageing), unemployed due to study or housework and unemployed with no motivation to work = 0	
Satisfaction with job	Very satisfied = 5; somewhat satisfied = 4; neither satisfied nor dissatisfied = 3; somewhat dissatisfied = 2; very dissatisfied = 1	

(Continued)

**Table 2.** (Continued)

Variable	Survey items	Coding scheme
<b>Relationship</b>		
Single household	Single household = 1, other types of households = 0	
Family conflict	1. Conflicts of opinion are frequent. 2. Family members sometimes throw stuff in anger. 3. Family members always discuss any issues in a calm manner. 4. Family members often criticise each other. 5. Family members sometimes hit physically.	Strongly agree = 5, Somewhat agree = 4, Neither agree nor disagree = 3, Somewhat disagree = 2, Strongly disagree = 1 Reverse coding was applied to item 3). Aggregated score was divided by 5, and final scores range from 1 to 5.
Satisfaction with social relationship (other than family relationship)	Very satisfied = 5; somewhat satisfied = 4; neither satisfied nor dissatisfied = 3; somewhat dissatisfied = 2; very dissatisfied = 1	
<b>Wellbeing &amp; lifestyle</b>		
Health	Very healthy = 5; healthy = 4; average = 3; not healthy = 2; very bad = 1	
Self-esteem (se)	Rosenberg Self-Esteem Scale (Rosenberg, 1965): As of today, how do you feel about yourself? 1. I feel that I am a person of worth, at least on an equal plane with others. 2. I feel that I have a number of good qualities. 3. All in all, I am inclined to feel that I am a failure. 4. I am able to do things as well as most other people. 5. I feel I do not have much to be proud of. 6. I take a positive attitude towards myself. 7. On the whole, I am satisfied with myself. 8. I wish I could have more respect for myself. 9. I certainly feel useless at times. 10. At times I think I am no good at all.	Strongly agree = 4, Somewhat agree = 3, Neither agree nor disagree = 2, Disagree = 1 Reverse coding was applied to items 3), 5), 8), & 9). Scores range from 10 to 40.
Alcoholism	How often did you drink alcohol in the past one year?	None = 0, Once a month or below = 1, 2-4 times a month = 2, 2-3 times a week = 3, 4+ times a week = 4

the four aspects of depressive symptoms (i.e. depressed affect, positive affect, somatic problems and interpersonal problems) (Radloff, 1977). The abbreviated 11-item version is particularly useful when survey participants include the elderly or the frail who cannot spend much time on a survey (Yin *et al.*, 2013). Both versions are known to have good internal consistency. The internal consistency value Cronbach's  $\alpha$  of the 20-item CES-D was 0.90 in the US adult sample (Cosco *et al.*, 2017). The Cronbach's  $\alpha$  of the 11-item version was 0.84 among the Taiwanese sample (Cosco *et al.*, 2017; Yin *et al.*, 2013) and 0.87 among the Korean sample of this study.

Suicidal behaviours take a form of suicide ideation, suicide attempt and actual suicide. The panel data contains information on suicidal behaviours; however, in the panel

dataset, people who indicated that they had attempted suicide was few and the data on actual suicide was not available. For this reason, this study only used suicide ideation. For a measure of suicide ideation, a single item was selected from a set of survey questions on suicidal behaviours from the KOWEPS (i.e. ‘In the past year, have you ever seriously considered a suicide?’) with the answer choices of yes (=1) and no (=0).

The following six attributes of housing are the key independent variables of this study:

- functional problems (i.e. noise, ventilation, lighting or heating problems)
- structural problems (i.e. non-permanent building or poor construction material)
- vulnerability to natural disasters (e.g. unsafe from flooding or earthquake)
- having no independent bathroom (e.g. sharing a bathroom with other households)
- living in basement (including semi-basement)
- overcrowding (i.e. floor space 12 m<sup>2</sup> below per person)

Non-permanent buildings include greenhouses, container houses, garages, warehouses and other temporary dwellings. To operationalize overcrowding, the present study adopted the minimum floor size 12 m<sup>2</sup> below per person, following the Minimum Housing Standard Rule of the South Korea Housing Act (2011). The rule defines the minimum floor size of residence as follows: 14 m<sup>2</sup> per one-person households, 26 m<sup>2</sup> for two-person households (i.e. 13 m<sup>2</sup> per person), 36 m<sup>2</sup> for three-person households (i.e. 12 m<sup>2</sup> per person), 43 m<sup>2</sup> for four-person households (i.e. 10.8 m<sup>2</sup> per person) and so on. During the period 2005–2016 of this dataset, the average Korean household size was between 2.5 and 2.9 persons. Therefore, this study applied the minimum standard for three-person household (i.e. 12 m<sup>2</sup> per person).

Control variables included housing tenure (i.e. owned vs rental), housing-related financial burden (i.e. the amount of housing debt and overdue housing debt), location (city vs rural), household income, satisfaction with household income, unemployment, satisfaction with job, living alone, family conflict, satisfaction with social relationship, health, self-esteem and alcoholism. These control variables were selected from previous empirical studies on the correlates of mental distress.

### **Analytic strategy**

To examine the effect of housing quality on depression and suicide ideation (*Research Hypotheses 1 and 2*), a longitudinal data analysis was conducted. The key advantage of longitudinal study is its capability to examine a cause-and-effect relationship by measuring the same individuals over time and identifying changes over time, which is not possible by cross-sectional research. Using panel data, this study constructed two fixed effect models – a fixed effects logistic model for suicidal ideation and a fixed effects regression model for depression. A fixed effects model aims to examine the effect of the within-person variation, ignoring the between-person variation. In other words, it focuses on the effect of time-variant factors and controls for time-invariant factors, so it is powerful in minimizing the sampling variability. In

contrast, a random effects model is used when focussing on the effect of time-invariant factors (e.g. gender and ethnicity). The key independent variables of this study, housing qualities, are time-variant variables meaning that a person's housing qualities can change over time either by moving or renovating. There are some people who never move; however, it is a very rare case. According to a Korea Housing Survey (Ministry of Land, Infrastructure and Transport 2017), an average Korean household moves every 7.7 years; tenant households move every 3.6 years and household living on their owned home moves every 10.6 years. Hence, a fixed effects model was deemed intrinsically appropriate for the purpose of the study and the nature of the data. To further confirm the appropriateness of this model for the data, the Hausman test was conducted after running fixed and random effect models, respectively; in all cases, the fixed model was found more suitable to use.

To examine the mechanism on how housing quality affects depression and suicide ideation (*Research Hypotheses 3 and 4*), mediation analysis was conducted, using a partial least squares structural equation modelling (PLS-SEM) with pooled data. The key advantage of PLS-SEM is that it has no requirement for normality assumptions of data and no restriction of single-item measures (Hair *et al.*, 2014, 2019; Reinartz *et al.*, 2009). It is also known suitable for predictive and causal-predictive modelling due to its robustness and fewer restrictions of requirements than conventional covariance-based structural equation model (Hair *et al.*, 2014, 2019; Nitzl, 2016). The PLS-SEM algorithm and consistent bootstrapping procedures (500 samples) were conducted to obtain direct, indirect and total effects. The software Stata/SE 15 and SmartPLS 3 were used for analysis.

Age groups were classified into three groups - young adults (aged 19 to 39), middle-aged (aged 40 to 59) and older adults (aged 60 and above). Since age classifications vary by country, law and policy, the present study adopted the generally accepted definition of 'middle age' (commonly referring to age between 40 and 60) from the Encyclopedia Britannica (Encyclopædia Britannica, n.d.) and the Collins English Dictionary (Sinclair, 1995).

When a survey participant's age category changed during the twelve-wave period, the panel data were classified into the respective age group with the relevant panel waves. For example, a survey participant was a young adult during the period of wave 1 to 5 and entered the middle-aged in wave 6. In this case, the data of wave 1 to 5 were classified into young adults, the data of the remaining waves being counted as the middle-aged.

## Results

### *Descriptive statistics*

Table 3 summarizes the characteristics of the sample (N = 162,338). Depression increased with age and was the highest in older adults; the mean of older adults' depression was nearly twice as high as that of young adults' depression. The mean of depression was higher in women than men across all age groups.

A similar pattern was shown in suicide ideation. People who had thought of a suicide during the past one year significantly increased as ageing. The proportion

Table 3. Descriptive statistics of the sample.

	N	Age 19–39 (Young adults)		Age 40–59 (Middle-aged)		Age 60 and over (Older adults)	
		Men	Women	Men	Women	Men	Women
Full sample	162,338	21,445	23,999	25,412	26,027	26,093	39,362
Depression							
Obs	150,629	18,295	21,943	23,625	25,340	24,070	37,356
Mean (SD)	4.378 (5.182)	2.645 (3.835)	3.297 (4.452)	3.303 (4.541)	4.082 (4.979)	4.625 (5.209)	6.585 (5.209)
No	70,565 (96.6%)	7,029 (98.6%)	8,797 (98.0%)	11,373 (97.3%)	12,003 (96.3%)	12,179 (96.2%)	19,184 (95.2%)
Yes	2,500 (3.4%)	99 (1.4%)	178 (2.0%)	317 (2.7%)	455 (3.7%)	477 (3.8%)	974 (4.8%)
Functional problem	145,476 (89.6%)	18,937 (88.3%)	21,173 (88.2%)	22,593 (88.9%)	23,204 (89.2%)	23,795 (91.2%)	35,774 (90.9%)
Yes	16,851 (10.4%)	2,507 (11.7%)	2,823 (11.8%)	2,817 (11.1%)	2,819 (10.8%)	2,297 (8.8%)	3,088 (9.1%)
No	133,794 (82.4%)	18,132 (84.6%)	20,301 (84.6%)	21,208 (83.5%)	21,809 (83.8%)	21,261 (81.5%)	31,083 (79.0%)
Yes	28,538 (17.6%)	3,312 (15.4%)	3,696 (15.4%)	4,202 (16.5%)	4,217 (16.2%)	4,832 (18.5%)	8,279 (21.0%)
Disaster vulnerability	156,768 (96.6%)	20,857 (97.2%)	23,372 (97.4%)	24,638 (97.0%)	25,224 (97.0%)	25,051 (96.0%)	37,626 (95.6%)
Yes	5,554 (3.4%)	586 (2.7%)	623 (2.6%)	772 (3.0%)	801 (3.0%)	1,038 (4.0%)	1,734 (4.4%)
No	153,997 (94.9%)	20,883 (97.5%)	23,581 (98.3%)	24,506 (96.5%)	25,303 (97.3%)	24,113 (92.4%)	35,611 (90.5%)
Yes	82,62 (5.1%)	547 (2.5%)	402 (1.7%)	893 (3.5%)	713 (2.7%)	1,971 (7.6%)	3,736 (9.5%)
Living in basement	156,895 (96.9%)	20,700 (96.9%)	23,088 (96.6%)	24,483 (96.6%)	25,098 (96.7%)	25,439 (97.7%)	38,087 (97.0%)
Yes	4,967 (3.1%)	668 (3.1%)	809 (3.4%)	850 (3.4%)	861 (3.3%)	595 (2.3%)	1,184 (3.0%)
No	152,948 (94.2%)	20,015 (93.3%)	21,916 (91.3%)	23,345 (91.9%)	24,134 (92.7%)	25,335 (97.1%)	38,203 (97.1%)
Yes	9,390 (5.8%)	1,430 (6.7%)	2,083 (8.7%)	2,067 (8.1%)	1,893 (7.3%)	758 (2.9%)	1,159 (2.9%)
Residential satisfaction	151,001	18,354	21,991	23,669	25,400	24,120	37,467
Obs	3,490 (0.843)	3,472 (0.833)	3,442 (0.878)	3,434 (0.864)	3,440 (0.886)	3,585 (0.788)	3,535 (0.810)
Mean (SD)	63,495 (39%)	10,025 (46.8%)	11,902 (49.6%)	10,024 (39.4%)	10,272 (39.5%)	6,934 (26.6%)	14,338 (36.4%)
No	98,832 (61%)	11,418 (53.3%)	12,095 (50.4%)	15,388 (60.6%)	15,755 (60.5%)	19,157 (73.4%)	25,019 (63.6%)
Yes	124,220	16,225	18,295	20,177	20,717	20,360	28,446
Mean (SD)	1,444 (15.671)	1,838 (14.112)	2,301 (21.307)	1,931 (14.748)	1,726 (14.457)	0,719 (15.803)	0,635 (13.410)
Obs	128,523	16,957	19,166	20,971	21,537	20,829	29,063
Mean (SD)	0,020 (0.218)	0,023 (0.233)	0,026 (0.244)	0,028 (0.254)	0,027 (0.255)	0,011 (0.165)	0,010 (0.159)
Rural	35,519 (21.9%)	2,945 (13.7%)	2,941 (12.3%)	4,286 (16.9%)	4,384 (16.8%)	8,005 (30.7%)	12,958 (32.9%)
City	126,819 (78.1%)	18,500 (86.3%)	21,058 (87.8%)	21,126 (83.1%)	21,643 (83.2%)	18,088 (69.3%)	26,404 (67.1%)
Obs	162,332	21,444	23,998	25,411	26,026	26,092	39,361
Mean (SD)	2,072 (2.241)	2,577 (2.422)	2,544 (2.305)	2,489 (2.409)	2,439 (2.378)	1,577 (1.982)	1,326 (1.728)
Obs	150,996	18,351	21,992	23,669	25,401	24,121	37,462
Mean (SD)	2,733 (0.936)	2,931 (0.916)	2,959 (0.923)	2,697 (0.965)	2,679 (0.959)	2,657 (0.914)	2,613 (0.894)
No	91,542 (58.24%)	14,635 (72.5%)	11,747 (51.3%)	21,967 (87.6%)	16,612 (64.3%)	13,203 (53.1%)	13,378 (34.9%)
Yes	65,650 (41.76%)	5,554 (27.5%)	11,160 (48.7%)	3,113 (12.4%)	9,220 (35.7%)	11,674 (46.9%)	24,929 (65.1%)

(Continued)

Table 3. (Continued)

	Full sample	Age 19–39 (Young adults)		Age 40–59 (Middle-aged)		Age 60 and over (Older adults)	
		Men	Women	Men	Women	Men	Women
Satisfaction with job	150,955	18,346	21,980	23,667	25,391	24,113	37,458
Mean (SD)	3.253 (0.894)	3.367 (0.924)	3.438 (0.865)	3.238 (0.982)	3.271 (0.906)	3.161 (0.880)	3.145 (0.810)
Single household	141,463 (87.14%)	20,171 (94.1%)	23,021 (95.9%)	24,092 (94.8%)	24,646 (94.7%)	23,477 (90.0%)	26,056 (66.2%)
Yes	20,875 (12.9%)	1,274 (5.9%)	978 (4.1%)	1,320 (5.2%)	1,381 (5.3%)	2,616 (10%)	13,306 (33.8%)
Obs	157,621	21,105	23,748	24,888	25,618	25,424	36,838
Mean (SD)	1.866 (0.915)	1.879 (0.928)	1.884 (0.927)	1.941 (0.943)	1.920 (0.943)	1.839 (0.904)	1.775 (0.861)
Satisfaction with social relationship	150,981	18,351	21,990	23,663	25,398	24,114	37,465
Mean (SD)	3.712 (0.699)	3.809 (0.657)	3.806 (0.645)	3.720 (0.720)	3.740 (0.680)	3.641 (0.739)	3.629 (0.710)
Health	162,291	21,440	23,990	25,404	26,019	26,084	39,354
Mean (SD)	3.420 (1.051)	4.137 (0.723)	4.091 (0.706)	3.735 (0.907)	3.577 (0.919)	2.898 (0.996)	2.657 (0.908)
Self-esteem	150,680	18,301	21,945	23,626	25,348	24,078	37,382
Mean (SD)	30.151 (4.238)	31.862 (3.741)	31.519 (3.824)	30.672 (4.155)	30.687 (3.980)	29.240 (4.215)	28.403 (4.166)
Alcoholism	157,148	20,179	22,898	25,077	25,828	24,876	38,290
Mean (SD)	1.518 (1.494)	1.860 (1.159)	1.432 (1.339)	2.098 (1.323)	1.315 (1.465)	1.782 (1.620)	0.975 (1.560)

Note: SD = standard deviation.

of women with suicide ideation was consistently higher than that of men across all age groups.

Poor housing qualities were more frequently observed in older adults, particularly among older women. Ten percent of the sample were suffering from noise, ventilation, lighting or heating problems; and 17% of the sample were living in a non-permanent building or a building made of poor construction material (hereinafter referred to as non-permanent building). One out of five older adults were living under a non-permanent building. Five percent of the sample did not have an independent bathroom at home. The proportion of older adults living without an independent bathroom (i.e. sharing a bathroom with other households) was significantly high, when compared to other age groups. Three percent of the sample were living in a place which was unsafe from natural disasters.

### **Results from longitudinal analysis**

**Hypothesis 1.** Housing qualities affect depression, of which effect may vary by age and gender [*supported*]

**Table 4** summarizes the effects of housing qualities on depression. Functional problems of housing (i.e. noise, ventilation, lighting or heating problems) had a significant effect on depression across all ages and gender. Particularly, young and older women were the most vulnerable to this condition; when moving from a residence with noise, ventilation, lighting or heating problems to a place without such issues, their depression level decreased by 0.5 unit ( $p < 0.001$ ).

Structural problems of housing (i.e. non-permanent building or poor construction materials) also affected depression for all men and middle-aged women. Particularly, older men were the most vulnerable to this housing condition; when moving from a non-permanent building to a permanent building, older men' depression level decreased by 0.355 unit ( $p < 0.001$ ).

The effect of basement and vulnerability to natural disasters on depression was only observed among older adults. Living in basement had a significant influence on depression in both older men and women; when moving from a basement to ground or upper-level floors, older adults' depression level decreased by 0.746 and 0.789 unit, respectively. Unsafety from natural disasters influences older women's depression; when an older adult woman moves from a place vulnerable to natural disasters to a safe place, her depression level decreased by 0.355 unit ( $p < 0.001$ ).

Several housing-related confounding variables in the model showed statistically significant effects on depression. Satisfaction with residential environment predicted depression across all ages and gender except for older men. Housing tenure (i.e. owned vs rented) had no influence on depression. The amount of housing debt had a significant effect on older women's depression. Overdue housing debt affected depression among women aged 40 and above. Location of living (i.e. city vs rural) predicted older adults' depression; when moving from cities to rural areas, older men and women' depression level decreased by 0.917 and 0.815 unit, respectively ( $p < 0.01$ ).



**Table 4.** Panel fixed effects model: the effect of housing on depression by age & gender.

	Young men		Young women		Middle-aged men		Middle-aged women		Older men		Older women	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Functional problem	0.148	0.116	0.500***	0.114	0.397***	0.100	0.150	0.105	0.405**	0.127	0.487***	0.119
Structural problem	0.345**	0.105	0.178	0.103	0.186*	0.088	0.212*	0.091	0.353***	0.094	0.161	0.087
Disaster vulnerability	-0.086	0.225	0.078	0.223	-0.162	0.182	0.062	0.189	-0.081	0.189	0.355*	0.168
Bathroom	0.240	0.318	-0.131	0.381	-0.126	0.251	0.230	0.282	0.238	0.182	0.278	0.157
Living in basement	-0.499	0.255	0.252	0.241	-0.134	0.243	0.240	0.240	0.746*	0.330	0.789**	0.272
Overcrowding	-0.305	0.181	-0.184	0.152	0.173	0.141	0.153	0.147	0.146	0.262	-0.022	0.234
Residential satisfaction	-0.216***	0.044	-0.111**	0.042	-0.235***	0.038	-0.199***	0.039	-0.010	0.048	-0.131**	0.044
Owned home (vs rental)	-0.014	0.111	0.006	0.103	0.119	0.112	0.071	0.123	-0.061	0.214	-0.085	0.195
Housing -related debt	0.007	0.003	-0.001	0.002	2.34e-04	0.002	-0.003	0.003	-0.022	0.018	0.043*	0.019
Overdue housing debt	0.284	0.172	0.044	0.163	0.495***	0.129	0.686***	0.128	0.182	0.253	0.623**	0.228
City (vs rural)	-0.292	0.231	-0.244	0.220	-0.460	0.288	0.061	0.303	0.917**	0.276	0.815**	0.275
Household income per person	-0.016	0.012	-0.003	0.013	-0.014	0.011	-0.022	0.012	0.004	0.017	-0.013	0.020
Satisfaction with household income	0.043	0.041	-0.171***	0.041	-0.228***	0.036	-0.360***	0.037	-0.365***	0.042	-0.487***	0.040
Jobless	0.307**	0.096	0.102	0.076	0.419***	0.118	-0.026	0.087	-0.157	0.096	-0.144	0.093
Satisfaction with job	-0.282***	0.041	-0.384***	0.041	-0.355***	0.036	-0.390***	0.037	-0.492***	0.042	-0.572***	0.042
Single household	0.456*	0.204	0.216	0.234	0.172	0.296	-0.216	0.243	0.385	0.236	-0.089	0.144
Family conflict	0.280***	0.037	0.455***	0.037	0.256***	0.032	0.362***	0.033	0.214***	0.038	0.378***	0.038
Satisfaction with social relationship	-0.366***	0.054	-0.398***	0.054	-0.190***	0.045	-0.133**	0.048	-0.240***	0.050	-0.206***	0.049
Health	-0.061	0.048	-0.013	0.048	-0.241***	0.038	-0.309***	0.038	-0.487***	0.040	-0.647***	0.039
Self-esteem	-0.324***	0.010	-0.398***	0.010	-0.304***	0.009	-0.296***	0.009	-0.325***	0.009	-0.373***	0.009
Alcoholism	0.066*	0.032	0.157***	0.027	0.051	0.027	0.123***	0.024	-0.046	0.025	0.118***	0.025
Constant	15.525***	0.455	18.500***	0.458	16.157***	0.419	16.494***	0.445	17.742***	0.439	21.579***	0.420
R-within	0.154	0.182	0.182	0.149	0.149	0.130	0.130	0.130	0.140	0.140	0.155	0.155
R-between	0.302	0.374	0.374	0.462	0.462	0.496	0.496	0.496	0.482	0.482	0.463	0.463
R-overall	0.238	0.282	0.282	0.319	0.319	0.327	0.327	0.327	0.319	0.319	0.312	0.312
N of obs.	13,614	16,573	16,573	18,426	18,426	19,979	19,979	19,979	18,502	18,502	26,171	26,171
N of groups	3,390	3,562	3,562	3,546	3,546	3,702	3,702	3,702	3,154	3,154	4,441	4,441

Note: \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

The analysis of other control variables also provides further information on the determinants of depression. Household income itself did not affect depression; however, satisfaction with household income influenced depression, except young men. Unemployment was a strong predictor of depression among young and middle-aged men. Satisfaction with job had a significant effect on depression across all ages and gender. Being a single-person household affected depression among men aged 19–39; in other age and gender groups, it had no influence on depression. Family conflict and satisfaction with social relationship had significant influence on depression in all age groups and gender. Alcoholism was an important determinant of depression for young men and women of all ages.

**Hypothesis 2.** Housing qualities affect suicide ideation, of which effect may vary by age and gender [*supported*]

As shown in [Table 5](#), a functional problem of housing (i.e. noise, ventilation, lighting or heating problems) was found as the only determinant of suicide ideation among all housing quality variables; it only affected young and middle-aged men. For middle-aged men living with functional problems of housing, the odds ratio of suicide ideation was 2.21 times as great as the odds for those living without them. For young men, living under such a condition rather had less likelihood of suicide ideation.

Other housing-related determinants of suicide ideation were residential satisfaction and housing tenure. Residential satisfaction had a significant effect on suicide ideation among young and middle-aged men. The effect of housing tenure on suicide ideation was only observed in young men; men aged 19–39 with homeownership were less likely to think of suicide than those without homeownership.

The effect of satisfaction with household income on suicide ideation was only observed in middle-aged women. For middle aged women, living alone (i.e. being a single-person household) decreased the likelihood of having a suicidal thought; on the contrary, for older women being a single-person household, the odds of suicide ideation increased by 85.1% (OR = 1.851, SE = 0.522,  $p < 0.05$ ). Family conflict affected suicide ideation for middle-aged women and older men and women. Satisfaction with social relationship influenced suicide ideation among middle-aged men and older women. Alcoholism predicted suicide ideation for young and middle-aged men. Expectedly, depression and self-esteem were found as key determinants of suicide ideation in all age groups and gender.

### **Results from PLS-SEM mediation analysis**

The PLS-SEM results have two components to be examined – the measurement model and the structural model. The measurement model is usually evaluated for the internal consistency, convergent validity, discriminant validity and multicollinearity. Since the variables of this study are single-item variables, the measures of internal consistency (i.e. factor loadings, Cronbach's  $\alpha$  and composite reliability) were scored 1, satisfying the criterion (Chin 1998). The measure of convergent validity, average variance extracted (AVE), was 1, which met the criteria (Bagozzi & Yi 1988). The discriminant validity

Table 5. Panel fixed effects logistic model: the effect of housing on suicide ideation by age &amp; gender.

	Young men		Young women		Middle-aged men		Middle-aged women		Older men		Older women	
	OR	SE	OR	SE	OR	SE	OR	SE	OR	SE	OR	SE
Functional problem	0.042*	0.056	0.578	0.280	2.212*	0.765	0.930	0.283	1.232	0.418	1.098	0.235
Structural problem	2.224	1.551	0.933	0.359	0.978	0.308	1.324	0.323	0.697	0.154	1.147	0.177
Disaster vulnerability	25.930	49.056	1.650	1.590	0.399	0.254	0.429	0.213	1.217	0.567	1.100	0.328
Bathroom	5.90e-07	0.001	1.297	1.712	0.462	0.350	5.649	5.464	2.009	0.856	0.660	0.204
Living in basement	65.802	155.762	2.174	2.280	0.612	0.445	1.130	0.656	0.421	0.320	2.357	1.172
Overcrowding	0.748	0.687	0.402	0.312	1.521	0.666	0.979	0.410	1.288	0.767	1.106	0.515
Residential satisfaction	0.450*	0.159	0.793	0.156	0.732*	0.096	0.963	0.101	0.950	0.115	0.966	0.076
Owned home (vs rental)	0.080*	0.090	1.639	1.228	0.933	0.428	1.017	0.424	2.682	2.166	2.001	0.827
Housing-related debt	1.352*	0.165	0.965	0.057	0.998	0.040	0.997	0.044	0.976	0.059	1.005	0.038
Overdue housing debt	201.267	6.23e+05	3.50e-05	0.035	0.567	0.354	0.771	0.258	6.46e-05	0.025	1.810	0.866
City (vs rural)	2.78e+07	8.35e+10	0.758	0.708	0.419	0.483	0.964	1.195	0.396	0.345	0.450	0.288
Household income per person	1.233	0.529	1.067	0.188	0.991	0.105	0.789*	0.094	1.002	0.137	0.875	0.086
Satisfaction with household income	0.988	0.346	0.763	0.164	1.058	0.155	0.705**	0.085	0.877	0.103	0.915	0.071
Jobless	2.234	1.684	2.000	0.776	1.764	0.636	0.716	0.181	1.183	0.283	1.385	0.264
Satisfaction with job	1.036	0.332	0.897	0.160	1.072	0.143	1.072	0.119	0.994	0.112	0.957	0.079
Single household	9.84e-09	1.30e-05	1.048	0.814	2.557	1.906	0.269*	0.170	1.053	0.532	1.851*	0.522
Family conflict	1.374	0.358	1.347	0.212	1.145	0.136	1.530***	0.140	1.684***	0.166	1.290***	0.084
Satisfaction with social relationship	1.187	0.400	1.297	0.291	1.452*	0.230	1.256	0.160	1.207	0.146	1.269**	0.114
Health	1.051	0.330	0.720	0.155	0.849	0.115	1.092	0.130	0.886	0.097	0.928	0.075
Self-esteem	0.756**	0.063	0.894*	0.039	0.902**	0.028	0.945*	0.025	0.889***	0.022	0.957*	0.016
Alcoholism	0.891	0.239	1.073	0.167	1.335*	0.161	1.203	0.132	1.268**	0.111	1.078	0.110
Depression	1.107*	0.044	1.150***	0.033	1.184***	0.028	1.174***	0.022	1.137***	0.018	1.152***	0.013
Log-likelihood	-48.8		-121.9		-223.7		-329.9		-337.8		-731.9	
LR Chi-Square	86.1		130.3		161.0		210.7		225.6		380.3	
N of obs.	270		532		872		1,236		1,280		2,639	
N of groups	65		123		190		260		265		526	

Note: \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

was assessed with the Heterotrait-Monotrait Ratio of Correlations (HTMT) (as shown in Table 8), of which value was lower than 0.90 and therefore met the criteria (Henseler *et al.*, 2015). A multicollinearity measure, the variance inflation factor (VIF) coefficient was 1, which indicates that there is no collinearity issue (Hair *et al.*, 2014). The structural model was evaluated by path coefficients, their significance and variance explained. The 24%–35% of variance in depression and 7%–14% of variance in suicide ideation were explained by the variables in the model (see Tables 6 and 7).

**Hypothesis 3.** Housing qualities have indirect effect on depression through residential satisfaction, which may vary by age and gender [*partially supported*]

The indirect effect of housing qualities on depression through residential satisfaction was found in men aged 19–59 and women aged 40–59 (see Table 6). For young men, basement, bathroom, non-permanent building and overcrowding had indirect effect on depression through residential satisfaction. For the middle-aged men and women, all housing qualities, except for unsafety from disaster, had indirect effects on depression through residential satisfaction. For young women and the elderly, residential satisfaction had no effect on depression, which means that there was no indirect effect.

**Hypothesis 4.** Housing qualities have indirect effect on suicide ideation through residential satisfaction or/and depression, which may vary by age and gender [*partially supported*]

As seen in Table 7, many housing qualities showed statistically significant indirect effects on suicide ideation in all ages and gender. However, the size of indirect effects was very small in most cases. The mechanism of indirect effects of housing qualities on suicide ideation varied by age and gender.

For young men, living in basement, having no independent bathroom, living in non-permanent building and overcrowding indirectly affected suicide ideation through residential satisfaction and depression. The effect of residential satisfaction on suicide ideation was the largest in young men. For this reason, housing qualities influenced suicide ideation mainly through residential satisfaction; only a very small indirect effect was mediated through depression. On the other hand, residential satisfaction had no effect on young women's suicide ideation. For them, functional issues such as noise indirectly influenced suicide ideation only through depression.

For middle-aged men and women, all housing qualities except for vulnerability to disaster indirectly affected suicide ideation through both residential satisfaction and depression. The role of residential satisfaction as a mediator was far less important than that of depression in this age group. Functional issues and non-permanent buildings had the largest indirect effects on suicide ideation through depression for middle-aged men and women, respectively.

In older age, residential satisfaction had no influence on suicide ideation. For both men and women, functional issues indirectly influenced suicide ideation through depression. For older men, overcrowding indirectly affected suicide ideation through depression. For older women, living in non-permanent building had indirect influence on suicide ideation through depression.

**Table 6.** PLS-SEM: the effect of housing quality on depression through the mediation of residential satisfaction.

	Young men		Young women		Middle-aged men		Middle-aged women		Older men		Older women	
	b	SD	b	SD	b	SD	b	SD	b	SD	b	SD
<b>Total effect</b>												
Basement -> D	-0.017	0.011	0.015	0.013	0.002	0.009	0.008	0.010	0.017	0.010	0.006	0.008
Bath -> D	0.027	0.014	-0.011	0.011	-0.009	0.010	0.024*	0.010	0.012	0.010	0.004	0.007
Disaster -> D	0.006	0.011	-0.018	0.012	0.012	0.009	0.010	0.008	-0.004	0.009	0.003	0.007
Func -> D	0.017	0.013	0.041**	0.013	0.023*	0.010	0.010	0.009	0.026**	0.009	0.017*	0.007
Nperm -> D	0.015	0.014	0.012	0.011	0.006	0.010	0.026*	0.010	0.004	0.009	0.020*	0.008
Overcrowding -> D	-0.013	0.011	0.012	0.009	0.006	0.008	-0.005	0.009	0.026*	0.011	-0.008	0.007
<b>Indirect Effect</b>												
Basement -> R -> D	0.006**	0.002	0.001	0.001	0.003**	0.001	0.003*	0.001	0.000	0.001	0.000	0.001
Bath -> R -> D	0.002*	0.001	0.000	0.000	0.003**	0.001	0.001*	0.001	0.000	0.001	0.000	0.001
Disaster -> R -> D	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Func -> R -> D	0.001	0.001	0.001	0.001	0.002**	0.001	0.002*	0.001	0.000	0.001	0.000	0.001
Nperm -> R -> D	0.008**	0.003	0.003	0.002	0.007**	0.002	0.006**	0.002	0.001	0.002	-0.001	0.002
Overcrowding -> R -> D	0.006**	0.002	0.002	0.002	0.006**	0.002	0.005**	0.002	0.000	0.001	0.000	0.001
<b>Direct effect</b>												
Basement -> D	-0.024*	0.011	0.013	0.012	-0.001	0.009	0.005	0.010	0.017	0.010	0.007	0.008
Bath -> D	0.025	0.014	-0.011	0.011	-0.011	0.010	0.023*	0.010	0.011	0.010	0.005	0.007
Disaster -> D	0.004	0.011	-0.019	0.012	0.012	0.009	0.010	0.008	-0.004	0.008	0.003	0.007
Func -> D	0.017	0.013	0.040**	0.013	0.021*	0.010	0.008	0.009	0.026**	0.009	0.017*	0.007
Nperm -> D	0.007	0.014	0.010	0.011	-0.001	0.010	0.019	0.010	0.003	0.009	0.021*	0.008
Size -> D	-0.020	0.011	0.010	0.009	0.000	0.008	-0.010	0.009	0.025*	0.011	-0.008	0.007
R -> D	-0.044**	0.014	-0.014	0.011	0.036**	0.010	-0.029**	0.011	-0.004	0.010	0.003	0.009
Basement -> R	-0.142***	0.014	-0.105***	0.011	-0.095***	0.010	-0.107***	0.012	-0.105***	0.011	-0.118***	0.009
Bath -> R	-0.052**	0.017	-0.033**	0.012	-0.073***	0.012	-0.050***	0.012	-0.121***	0.011	-0.132***	0.011
Disaster -> R	-0.029*	0.013	-0.035**	0.012	-0.014	0.011	-0.007	0.011	-0.030*	0.012	-0.010	0.009
Func -> R	-0.015	0.015	-0.045**	0.015	-0.048***	0.011	-0.055***	0.012	-0.060***	0.011	-0.075***	0.010
Nperm -> R	-0.187***	0.014	-0.192***	0.015	-0.203***	0.011	-0.211***	0.010	-0.196***	0.011	-0.192***	0.010
Overcrowding-> R	-0.146***	0.015	-0.170***	0.012	-0.164***	0.011	-0.169***	0.011	-0.096***	0.012	-0.077***	0.010
R-square	0.240		0.285		0.337		0.331		0.345		0.341	
Adjusted R-square	0.238		0.284		0.336		0.329		0.344		0.340	

Note: R=residential satisfaction; \* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001.

Table 7. PLS-SEM: the effect of housing quality on suicide ideation through the mediation of residential satisfaction and/or depression.

	Young men		Young women		Middle-aged men		Middle-aged women		Older men		Older women	
	b	SD	b	SD	b	SD	b	SD	b	SD	b	SD
<b>Total effect</b>												
Basement → S	0.014	0.020	0.029	0.021	0.008	0.014	0.023	0.014	0.014	0.014	0.001	0.012
Bath → S	-0.025***	0.004	-0.007	0.012	0.002	0.013	0.025	0.015	0.013	0.013	-0.015	0.008
Disaster → S	0.016	0.019	-0.005	0.015	-0.011	0.013	0.003	0.013	-0.002	0.012	0.002	0.011
Functional → S	-0.027*	0.010	0.006	0.016	0.026*	0.013	0.001	0.012	0.003	0.012	0.013	0.011
Structural → S	0.018	0.016	0.013	0.015	-0.009	0.011	0.027*	0.013	-0.010	0.013	0.008	0.011
Overcrowding → S	0.032	0.020	-0.011	0.012	0.017	0.014	-0.008	0.013	0.009	0.015	-0.014	0.008
R → S	-0.044**	0.015	-0.005	0.015	-0.023	0.015	-0.014	0.014	0.010	0.012	-0.009	0.011
<b>Indirect effect</b>												
Basement → D → S	-0.004	0.002	0.004	0.004	0.000	0.003	0.002	0.003	0.004	0.002	0.002	0.002
Basement → R → S	0.005*	0.002	0.000	0.002	0.001	0.001	0.001	0.001	-0.001	0.001	0.001	0.001
Basement → R → D → S	0.001**	0.000	0.000	0.000	0.001**	0.000	0.001**	0.000	0.000	0.000	0.000	0.000
Bath → D → S	0.005	0.002	-0.003	0.003	-0.003	0.003	0.007*	0.003	0.000	0.002	0.001	0.002
Bath → R → S	0.002	0.001	0.000	0.001	0.001	0.001	0.000	0.001	-0.001	0.001	0.001	0.001
Bath → R → D → S	0.000*	0.000	0.000	0.000	0.001**	0.000	0.000*	0.000	0.000	0.000	0.000	0.000
Disaster → D → S	0.001	0.002	-0.005	0.003	0.003	0.003	0.003	0.002	-0.001	0.002	0.001	0.002
Disaster → R → S	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Disaster → R → D → S	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Functional → D → S	0.003	0.003	0.011**	0.004	0.006*	0.003	0.002	0.003	0.007**	0.002	0.005*	0.002
Functional → R → S	0.001	0.001	0.000	0.001	0.000	0.001	0.000	0.001	-0.001	0.001	0.001	0.001
Functional → R → D → S	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Structural → D → S	0.001	0.003	0.003	0.004	0.000	0.003	0.006*	0.003	0.001	0.002	0.006**	0.002
Structural → R → S	0.007*	0.003	0.000	0.003	0.003	0.003	0.001	0.003	0.000	0.000	0.000	0.000
Structural → R → D → S	0.002**	0.001	0.001	0.001	0.002**	0.001	0.002**	0.001	-0.002	0.002	0.006**	0.002
Overcrowding → D → S	-0.004	0.002	0.003	0.003	0.000	0.003	-0.003	0.003	0.006*	0.003	-0.002	0.002
Overcrowding → R → S	0.005*	0.002	0.000	0.003	0.002	0.002	0.001	0.002	-0.001	0.001	0.001	0.001
Overcrowding → R → D → S	0.001**	0.000	0.001	0.001	0.002**	0.001	0.001**	0.001	0.000	0.000	0.000	0.000
R → D → S	-0.008*	0.003	-0.004	0.003	-0.010**	0.003	-0.009*	0.003	-0.001	0.002	0.001	0.002
<b>Direct effect</b>												
Basement → S	0.013	0.020	0.024	0.019	0.006	0.013	0.020	0.013	0.011	0.013	-0.002	0.012
Bath → S	-0.032***	0.006	-0.004	0.012	0.004	0.014	0.017	0.015	0.011	0.013	-0.018*	0.008
Disaster → S	0.014	0.018	0.000	0.014	-0.015	0.011	0.002	0.012	-0.001	0.012	0.001	0.011
Functional → S	-0.031**	0.010	-0.005	0.016	0.019	0.012	-0.002	0.011	-0.003	0.011	0.008	0.010
Structural → S	0.009	0.015	0.010	0.015	-0.014	0.011	0.018	0.013	-0.009	0.012	0.000	0.010
Overcrowding → S	0.029	0.019	-0.014	0.012	0.013	0.013	-0.008	0.013	0.003	0.015	-0.012	0.009
R → S	-0.036*	0.014	-0.001	0.015	-0.013	0.014	-0.005	0.013	0.011	0.012	-0.010	0.010
D → S	0.183***	0.028	0.281***	0.028	0.277***	0.020	0.304***	0.016	0.248***	0.015	0.280***	0.013
R-square	0.073		0.109		0.117		0.139		0.111		0.108	
Adjusted R-square	0.070		0.106		0.115		0.137		0.109		0.107	

Note: R=residential satisfaction, D=depression, S=suicide ideation; \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

**Table 8.** Heterotrait-Monotrait Ratio (HTMT) of correlations.

	Alc	Bas	Bat	City	Dep	Dis	FC	Fun	Hea	Deb	Own	Inc	Job	Stru	Ove	RS	SE	JS	IS	ReIS	Sin	Ove	
Alcohol	0.029																						
Basement	0.001	0.006																					
Bath	0.017	0.094	0.084																				
City	0.048	0.075	0.086	0.000																			
Depression	0.014	0.082	0.121	0.027	0.056																		
Disaster	0.014	0.047	0.037	0.025	0.171	0.047																	
FC	0.011	0.153	0.091	0.038	0.080	0.218	0.063																
Functional	0.085	0.043	0.074	0.038	0.349	0.048	0.040	0.040															
Health	0.003	0.015	0.042	0.068	0.028	0.015	0.011	0.026	0.050														
Housing debt	0.010	0.231	0.027	0.255	0.154	0.020	0.078	0.086	0.087	0.059													
Home-owned	0.029	0.038	0.074	0.048	0.127	0.025	0.031	0.021	0.130	0.120	0.059												
Income	0.081	0.050	0.014	0.246	0.111	0.009	0.005	0.006	0.131	0.027	0.113	0.030											
Jobless	0.025	0.147	0.204	0.052	0.111	0.201	0.122	0.304	0.072	0.059	0.061	0.058	0.030										
Structural	0.010	0.010	0.000	0.004	0.031	0.006	0.034	0.008	0.013	0.049	0.018	0.006	0.004	0.008									
Overdue	0.004	0.165	0.187	0.027	0.202	0.093	0.117	0.171	0.160	0.052	0.199	0.089	0.019	0.267	0.023								
SE	0.061	0.089	0.100	0.009	0.519	0.065	0.194	0.079	0.337	0.038	0.191	0.153	0.175	0.112	0.019	0.255							
JS	0.032	0.051	0.073	0.017	0.306	0.046	0.121	0.065	0.218	0.023	0.116	0.124	0.067	0.092	0.027	0.298	0.321						
IS	0.031	0.077	0.095	0.010	0.290	0.043	0.149	0.060	0.248	0.034	0.156	0.201	0.027	0.103	0.029	0.315	0.316	0.413					
ReIS	0.067	0.050	0.058	0.064	0.292	0.013	0.160	0.047	0.201	0.004	0.162	0.083	0.099	0.046	0.027	0.285	0.392	0.370	0.256				
Single	0.028	0.053	0.106	0.029	0.159	0.030	0.099	0.026	0.111	0.082	0.165	0.172	0.101	0.057	0.002	0.029	0.123	0.032	0.016	0.001			
Overcrowding	0.005	0.080	0.102	0.038	0.031	0.032	0.049	0.064	0.027	0.014	0.118	0.004	0.007	0.071	0.014	0.119	0.059	0.033	0.053	0.050	0.053		
SI	0.001	0.039	0.014	0.026	0.314	0.024	0.122	0.041	0.114	0.012	0.099	0.042	0.039	0.047	0.016	0.086	0.197	0.114	0.120	0.088	0.049	0.007	

Note: RS = residential satisfaction; IS = income satisfaction; JS = job satisfaction; FC = job satisfaction; ReIS = satisfaction with social relationship; SI = suicide ideation; FC = family conflict.

## Discussion

Gender has been paid little attention among scholars examining the housing-health nexus. This study reveals that the effect of housing qualities on mental health and the underlying mechanism are not the same by gender. For women, functional issues of housing such as noise problems were key risk factors for depression. For men, structural issues such as non-permanent building were more important. These results could be supported by the evidence on sex-linked sensory difference showing that women have higher sensitivity of sound and olfaction and lower tolerance of noise than men (Velle, 1987). On the other hand, men's mental health was more influenced by the physical presence and symbolic status of housing (i.e. what non-permanent building is and perhaps what it symbolizes). Based on these findings, the analysis suggests that housing policy makers and public housing providers should prioritize the improvement of these two housing qualities (i.e. structural and functional issues).

A few distinct differences between older age and other age groups were observed regarding the relationship between housing quality and depression. First, living in basement and vulnerability to disaster were detrimental to older adults' depression, whereas other age groups were not affected by them. Particularly, living in basement had a detrimental effect on depression among older adults. Secondly, the study revealed that older people were more vulnerable to poor housing conditions than other age groups in most variables. The effect of housing quality on depression became stronger in older age; particularly, older women's depression was influenced by more housing-quality factors. Thirdly, the present study with longitudinal analysis provides stronger evidence and confirmation to the finding of a prior study (Howden-Chapman *et al.*, 2011) that the relationship between housing quality and general health becomes stronger as people age. Lastly, it should be noted that although housing quality affects depression substantially, it does not have any influence on suicide ideation in older age. The present study suggests that policies and programmes for age-friendly and healthy communities should pay special attention to urban older adults living in basement.

The link between housing qualities and suicide ideation is an untapped area of research. Prior to this study, there was a study with cross-sectional data which found an association between actual suicide and housing condition (i.e. moist, noise, ventilation and air quality) (Choi, 2007). Using longitudinal analysis, the present study further investigated whether the relationship could be causal. This study found that functional problems (i.e. noise, ventilation, lighting or heating problems) increased the likelihood of suicide ideation; however, this was only observed among middle-aged men. Other housing-quality factors had little influence on suicide ideation.

Another key contribution of this study was the investigation of the underlying mechanism on how housing qualities affect suicide ideation for each age group and gender. Particularly, little was known about the mechanism of housing quality and suicide ideation. The present study investigated the role of residential satisfaction and depression in mediating the relationship between housing quality and suicide ideation. Except for young men, the effect of housing quality on suicide ideation was mostly mediated through depression. For young women and older adults, residential satisfaction had no influence on suicide ideation; therefore, all the indirect effects were



mediated through depression only. In contrast, for young men, the effect of housing qualities on suicide ideation was mostly mediated by residential satisfaction. This finding highlights the importance of residential satisfaction for young men's mental health. In this study, key determinants of residential satisfaction among young men were living in basement, having no independent bathroom, structural problems and overcrowding. The improvement of these specific qualities should be given a key consideration in making housing policies and provisions targeting young adults.

Functional issues such as noise problems were identified as major risk factors for women's depression and even trigger suicidal thought among men. During the forced lockdown period of the Covid-19 pandemic, it was evidenced in many countries that housing-related noise complaints and conflicts with neighbours in apartments significantly increased (Baek, 2020; Şentop Dümen & Şaher, 2020; Sun, 2021; Tong *et al.*, 2021). In South Korea, the number of housing-related noise complaints reported to Ministry of Environment had soared from 19,495 in year 2016 to 42,250 in 2020 (Sun, 2021). This issue could be possibly addressed by establishing higher acoustic standards for building permits and completion approval and providing a support system for residents to collect the noise, file noise complaints, resolve conflicts over noise issues and obtain technical assistance to reduce or block out noise.

The findings of the present study also reveal that men who have lived in non-permanent buildings for a long period of time are at high risk of depression. From 2005 to 2015, the number of general households in South Korea had increased by 20%. For the very same period, the number of households living in non-permanent building increased by 590% from 57,066 to 393,792 (Choi & Jeong, 2018). It is largely due to the soaring housing price and the shortage of affordable housing provision. This calls for the urgency to provide more affordable housing options and stabilize housing price. Otherwise, the population health would be also at risk.

Moving forward, this study proposes a housing rating system for healthy living which includes the detailed information of each housing unit in terms of key functional and structural aspects and resilience to disaster. It would not only benefit housing consumers in making informed decisions on renting or buying a house, but also encourage socially responsible construction and real estate practices. The UK and the United States are currently in use of the Housing and Safety Rating System and the Healthy Home Rating System, respectively.

A few study limitations of the study should be noted. First, a history of depression, suicide among family members, previous suicidal attempts, past experiences of poor housing and landscape or greenery from the window which might affect mental health were not controlled in this study. It is due to the use of secondary dataset which did not contain such information. Second, when running the PLS-SEM mediation model with pooled data to test hypotheses 3 and 4, this study did not control for individuals' unique sensory processing pattern (e.g. sensory sensitivity and sensory avoiding) which has association with depression (Serafini *et al.*, 2017). Nevertheless, the fixed effect model for hypotheses 1 and 2 was not affected by it because the fixed effect model only uses the within-person variation. Third, longitudinal analysis and PLS-SEM mediation analysis showed similar results overall, concerning the effects of housing qualities on depression and suicide ideation. However, it should be noted that there were slight, minor differences in the results.

This was inevitable since the former used panel approach focussing on the causal relationship whereas the latter used pooled cross-sectional data focussing on the mechanism of housing-mental health nexus.

## Conclusion

Understanding the impact of housing qualities on mental health is essential at the present time, as we face the Covid-19 pandemic and the accelerated working-from-home trend. This study identified specific housing qualities leading to depression and suicide ideation for each age group and gender. Also, the underlying mechanism of housing quality-mental health nexus were different by age and gender. A few policy recommendations were proposed for more tailored housing policy and provision, considering human life cycle and demographic characteristics. The study asserts that improving certain housing qualities can prevent or reduce depression and suicide ideation and should be viewed as an important strategy for public health intervention.

## Conflicts of interest

There is no conflict of interest to declare.

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## Notes on contributor

*Dr Ji Hei Lee* is a lecturer in Real Estate & Planning. Her interest of research is built environment, mental health, ageing population and place-making.

## ORCID

Ji Hei Lee  <http://orcid.org/0000-0003-2968-7582>

## Data availability statement

The data that support the findings of this study are openly available in Korea Welfare Panel Study at <https://www.koweps.re.kr:442/eng/main.do>.

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