HEALTH INEQUALITIES IN HOUSING:
HOUSING COST BURDEN, HOUSING ASSETS, AND MORTALITY

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Lay Abstract

This thesis aims to investigate housing inequalities in health and the roles of protective social and housing policies in reducing health inequalities. The second chapter, as a scoping review, synthesizes prior literature that estimates the association between housing cost burden and health, and explores potential mechanisms linking housing cost burden to health. Chapter three relies on one of the nationally representative linkage datasets in Canada in order to estimate the association between housing asset, income, and mortality in Canadian older adults. It reveals that the value of housing assets and income predicts mortality risks, but housing assets do not significantly change the link between income and mortality. The fourth chapter examines whether and how housing cost burden is associated with avoidable mortality in OECD countries. Also, the roles of preventive measures including social spending and housing policies are revisited. The thesis strengthens the rationale for identifying housing as one of the important social determinants of health.

Abstract

Despite a growing body of studies on the relationship between housing and health, it is unclear whether and how (a) the housing cost burden deteriorates health and whose health it deteriorates, (b) housing assets interact with income in influencing one's health, and (c) protective policy measures alleviate mortality risks predicted by housing cost burden. This thesis aims to reduce these knowledge gaps. First, in Chapter two, I synthesize prior literature that focused on the association between housing cost burden and health and discussed methodological issues. Also, the chapter proposes future research directions. Chapter three, co-authored with Dr. Michel Grignon, Dr. Marisa Young, and Dr. James R. Dunn, assesses the potential moderating effect of housing asset level on the link between income and mortality. Although housing assets and income are independently related to mortality risks, the value of housing assets did not significantly moderate the link between income and mortality. Income-related inequalities in mortality are observed among each group of housing asset level. Our findings offer insight into the importance of redistribution of resources that can reduce risks of premature mortality and achieve healthy aging. Chapter four documents that housing cost burden was significantly associated with preventable mortality, treatable mortality, and suicide during post-Global Financial crisis (2009-2017). Also, in countries with an increased level of social spending, higher levels of social housing stock, and rent control, the observed association was substantially attenuated. Taken together, the findings of the three chapters contribute to

understandings about the link between housing and health by (a) synthesizing the prior literature and mechanisms, (b) estimating housing inequalities in health, and (c) highlighting the protective roles of social and housing policies that reduce health inequalities.

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CHAPTER 1: INTRODUCTION

Overview

The first chapter develops the background and rationale for the thesis. Firstly, I review the knowledge base concerning the influence of housing on health outcomes, focusing mainly on studies conducted in wealthy countries. Secondly, I describe research and knowledge gaps found in existing studies and suggest several limitations to existing assessments of the health effects of housing. Finally, proposing three research questions, I explain the purpose and rationale for three papers that primarily assess the association between housing and health.

Background

Conceptual frameworks for housing and health: tenure, costs and conditions

Housing is a residential place where people spend considerable amounts of their daily lives, either with family members and friends or alone. This means that people are exposed to their home environments for long periods and may thus be responsive to the health effects of particular housing characteristics.

Scholarship has developed two main frameworks for conceptualizing the association between housing and health (Rolfe et al., 2020; Shaw, 2004; Swope & Hernández, 2019). First, attention was primarily focused on the most direct and *hard*

pathways by which housing impacts health: *physical dwelling conditions*. As reported in the literature, substandard dwelling conditions that lack, for example, proper heating and ventilation systems, significantly impact the health of residents by, for instance, directly increasing the spread of infectious diseases and weakening one's ability to perform daily tasks (e.g., cooking and cleaning) (Bonnefoy, 2007; Evans, 2000). A wide range of environmental exposures can originate both from within the home and from the neighbourhood environment (Swope & Hernández, 2019). Exposures are unevenly concentrated in low socioeconomic neighbourhoods which, in turn, causes a higher prevalence of illnesses and diseases (Sampson & Winter, 2016). Otherwise stated, housing can encompass both residential and neighbourhood environmental conditions. Second, studies investigated the socioeconomic dimensions of housing - the *softer* ways in which housing affects health (Shaw, 2004). Dunn et al. (2004) argued that housing has a *meaningful* dimension in addition to the material dimension as housing can confer psychological comfort, safety, and privacy. An important component of housing that can provide such benefits is *homeownership*. It is widely reported that homeownership can improve health for two main reasons: (a) Homeowners can better enjoy health-promoting opportunities (e.g., access to amenities and community activities) compared to renters. This is because homeownership is often a marker of income whereby one has the means to improve their material conditions; owner-occupied housing is less likely to be exposed to substandard dwelling conditions, such as dampness and noise (Macintyre et al., 2003). (b) Homeownership can encourage a feeling of comfort, achievement, and belongingness,

thereby increasing long-term psychosocial wellbeing (Park et al., 2021).

Another pillar of housing that influences health is the *housing cost burden*. Although underlying mechanisms linking the housing cost burden and health are understudied, research has documented that the housing cost burden is associated with health outcomes (Nobari et al., 2019; Seo & Park, 2021). Consensus indicates that the housing cost burden can be pronounced among lower-income households as lower-income households have insufficient income to meet higher housing costs that would facilitate improved living standards, whereas higher-income households are often well positioned to spend more on household budgets (Stone, 2006; Swope & Hernández, 2019). The housing cost burden can also cause *residential instability* since those who cannot afford housing costs may fall behind on rent or mortgage payments, which increases the likelihood of eviction or involuntary house move (Vijayaraghavan et al., 2013).

As these housing characteristics can be at play simultaneously, they can have combined and additive effects on individual and household health and wellbeing. This is because (a) renters often pay higher housing costs than homeowners, thereby increasing their housing cost burden and susceptibility to residential instability (Swope & Hernández, 2019) and (b) income insufficiency can increase one's housing cost burden and the likelihood of living in substandard housing conditions (e.g., doubling up and overcrowding). Such combined effects on health can be manifest for sub-populations (e.g., low-income households) (Dunn, 2000). In summary, housing characteristics have multifaceted physical and psychological impacts that can interact with the socioeconomic

status of individuals and households, thus impacting their health and wellbeing in multiple ways.

Housing, income inequality and welfare

Homeownership-oriented policies

A growing number of countries have been implementing a wide range of policies that aim to increase homeownership, starting in the 1930s. The rationale behind homeownership-oriented policies relies on the assumption that ownership of housing assets enables individuals or households to have a stake in society since homeownership can not only bring a sense of comfort and achievement (Park & Seo, 2021) but also act as a welfare resource (Izuhara, 2016). Relatedly, the strong tendency of governments to promote homeownership also refers to '*asset-based welfare*' in which housing assets become important for one's welfare needs, particularly at later stages in life, since housing assets can provide a buffer against income loss (Prabhakar, 2019). For example, homeownership can sometimes help households to offset income insecurity since homeowners can refinance against housing assets (e.g., reverse mortgage and equity release) (Doling & Ronald, 2010; Kemeny, 1981). These policies have driven a rapid rise in homeownership in many countries where people tend to characterize homeownership as their dream and an important life goal (Beracha & Johnson, 2012).

Unintended consequences of homeownership-oriented policies

Despite the rationale for homeownership-oriented policies, it is not necessarily the case

that all households enjoy the benefits of homeownership. While some households, such as those with higher incomes, have better access to homeownership as they are better positioned to obtain preferential mortgage terms, lower-income households lack such access to homeownership (Hajer, 2009). Additionally, when living in rented housing, there is a higher possibility of experiencing financial difficulty, such as the housing cost burden, which, in turn, contributes to rent arrears in the long term (Mason et al., 2013). A lack of post-shelter income can shrink one's ability to purchase necessities such as healthcare (Dunn, 2020). Relatedly, housing costs seem to be a driving factor for increased levels of income inequality by, for example, disproportionately decreasing the post-shelter income of renters and lower-income households while increasing income for owner-occupiers and higher-income households (Heylen & Haffner, 2012; Saunders, 2017).

Some studies have further demonstrated the potential consequences of homeownership-oriented policies. First, there might be a trade-off between homeownership rates and public welfare provisions (Kemeny, 2005). This could in part be because people in home-owning societies tend to have an aversion to taxation since higher housing expenses reduce one's disposable income. This can reduce the use of essential goods and services for health and wellbeing. Additionally, the government strengthens individual responsibility and autonomy for welfare needs by diminishing welfare provision as a way of welfare restructuring (Doling & Ronald, 2010; Ronald et al., 2017). If a trade-off relationship between homeownership and public social expenditure

exists, housing policies might work beneficially only for homeowners, whereas non-homeowners may experience financial difficulty due to an absence of homeownership that can generate income. Rather, the reduction in welfare provision caused by an asset-based welfare system has a disproportionately negative impact on some groups (e.g., lower income, lower educated, and unemployed) who seek support through public assistance. This can affect one's health by posing a risk to his or her economic security in the long term.

Housing asset and income needs of older adults

More importantly, it has been suggested that homeownership may not adequately help people to improve their living standards (Fahey et al., 2004; Osberg, 2001) since there is a growing number of older adults who are living poor to die rich (asset rich, cash poor) across several countries. Older homeowners may be reluctant to liquidate housing assets since they feel an 'alienable right' to them, resorting to frugal lifestyles as a last resort (Rowlingson, 2006). Rather than liquidating housing assets, some older adults tend to bequest housing assets to offspring in return for financial support as they age (Ronald, 2007). This is particularly manifest in countries where a lack of income support reduces the wellbeing of older adults (Doling & Ronald, 2012). Although such willingness to bequest housing assets may help promote the economic security of offspring, intergenerational support may not adequately help older adults to meet their welfare needs due to rising living expenses and demographic changes (e.g., decreases in the extended family) (Ronald & Doling, 2014). Additionally, higher property taxes can put a great

financial burden on older homeowners, preventing them from moving or liquidating their property (Shan, 2010). Although older adults are encouraged to achieve homeownership, homeownership is not always completely advantageous for the wellbeing of older adults.

Thus, each measure of these socioeconomic factors influences health through various mechanisms throughout an individual's lifespan (Braveman et al., 2005). Although wealth, including assets and net worth, is not widely used as an indicator of socioeconomic status, a growing body of recent studies has documented a well-established link between assets (or wealth) and health (Pollack et al., 2007). For example, the total value of all assets is associated with the psychological health (Carter et al., 2009) and self-rated health (Robert & House, 1996) of the general population. Studies have primarily focused on middle-aged and older adults who tend to rely on housing for various reasons. Housing assets predicted increased levels of self-rated health (Costa-Font, 2008) and decreased levels of mortality in middle-aged and older adults (Connolly et al., 2010). This was motivated by the notion that (a) people have dedicated themselves to accumulating assets throughout their life course (Connolly et al., 2010; Costa-Font, 2008) and (b) wealth, including housing assets, can be a useful resource that can be quickly converted into cash to support living standards (Pollack et al., 2007).

An important issue is the combined effects of housing and income on health. First, while housing assets are strongly related to income, housing assets can have independent, rather than complementary, effects on health and wellbeing. This is because the presence of housing assets can be a source of intergenerational support (instrumental and

emotional) and inheritance for offspring (Lennartz et al., 2016; Park et al., 2021). Second, older adults tend to associate housing assets/homeownership with their identity and view them as a source of comfort since housing can represent achievement (i.e., the dream of homeownership). They may wish to own their final asset for the rest of their life at the expense of a higher income. Such conditions become noticeable in societies that have strongly encouraged people to purchase a house. This raises concerns over (a) whether and how housing assets have independent effects on health and (b) whether housing assets complement income in influencing health.

Rationales and Approaches for the Three Studies

Research gaps

In light of the importance of housing as a social determinant of health, current issues on housing insecurity raise concerns regarding whether and how housing, including the housing cost burden and housing assets, is linked to health. Although housing policies help households to maintain living standards through homeownership, unintended consequences (e.g., inequitable access to homeownership; housing cost burden; asset-rich, cash-poor individuals) of homeownership-oriented policies suggest that both housing and non-housing factors are inextricably linked in a relationship that impacts people's lives. For a better understanding of how they affect health and wellbeing, this section addresses what is not covered in the extant literature.

The housing cost burden and housing asset poverty

Measuring the extent to which differences in health are explained by housing problems is complex as housing entails multifaceted characteristics such as physical conditions, housing tenure, the housing cost burden, and the value of housing assets. Not only are data scarce for capturing the multidimensional characteristics of housing but existing methods have not been used effectively. Such limitations are manifest in studies of the housing cost burden and value of housing assets. Although many wealthy countries rely on the normative approach that defines the housing cost burden as when more than 30% of one's income is spent on housing, this does not fully consider one's willingness to spend a higher proportion of income on housing for improved wellbeing (Stone, 2006). Additionally, subjective experiences of financial difficulties associated with housing costs can increase the possibility of bias (Lacombe-Duncan et al., 2020; Martin et al., 2019). In response to these challenges, revisiting existing methods can better illustrate health disparities driven by housing problems.

Similar issues can occur regarding asset poverty. While income poverty indicators are widely used to estimate the socioeconomic conditions of individuals and provide benefits (e.g., subsidies) for households, they do not include complete information on how and whether (a) people can protect themselves from income insecurity (or income shocks) for a certain period or (b) individuals can maintain their living standards under income insecurity (Azpitarte, 2012). By considering income and assets together (asset rich and income rich; asset rich and income poor; asset poor and

income rich; asset poor and income poor) it is possible to understand how people depend on varied economic resources that determine living standards and wellbeing. An analysis of the dynamics of income and (housing) assets can contribute to an in-depth understanding of older adults who are more likely to rely on income and assets after retirement. However, the evidence is still limited (Haveman & Wolff, 2005; Rothwell & Haveman, 2013).

Underlying mechanisms linking housing and health: for whom and how

While there is a growing body of literature on the link between housing cost burden and health, evidence gaps still limit our understanding. First, while studies have uncovered nuanced evidence that examines the association between housing cost burden and health, they have not illustrated the underlying mechanisms of this association. As 'health' can refer to a variety of health outcomes, including psychological health, physical health, and healthcare utilization, the housing cost burden can impact health in many ways that are not mutually exclusive. Identifying these mechanisms is important since it can help to build interventions that promptly mitigate the health consequences of the housing cost burden. It can also help scholars investigate (hidden or under-investigated) health outcomes that are not completely covered in extant literature.

Second, there are some potential factors differentiating the association between housing and health: country/regional contexts and socioeconomic status. For example, as noted earlier, an individual's socioeconomic status may affect their housing options; higher-income households are more likely to voluntarily spend a higher proportion of their

income on housing expenses. Additionally, people in countries with supportive housing policies (e.g., housing subsidies) may be less likely to have a housing cost burden, whereas others (e.g., private renters) in countries with lower social housing stock tend to reside in high-priced rented housing. Such conditions can impact the health outcomes of a particular group by predisposing them to prolonged and cumulative stressors. The majority of the extant literature, however, has not elucidated these contributing factors.

Uncovering housing policy measures aimed at reducing health disparities

A key challenge in assessing the association between housing policies and health is that the health effects of housing policy measures on populations are not well-researched compared to other types of policies. Unfortunately, while many studies have examined the impact of social spending on health (e.g., social spending on old-age pensions (Loopstra et al., 2016) and labour market policies (Reeves et al., 2015), few have examined the relationships between housing policies and health. This is due to the limitation of data sources that include housing policy characteristics across countries. Indeed, housing policies do not well match other policies (Schwartz & Seabrooke, 2009) since they include *unmeasured* and *indirect* policies (Norris & Winston, 2012). For example, although rent control helps households gain access to affordable housing by limiting an increase in (initial) rent, public spending on housing does not include this measure since it is an indirect measure. Additionally, rent control provides neither cash benefits nor in-kind benefits. Similarly, a simple comparison of homeownership rate as a proxy of housing policies may suffer from omitted variables (e.g., social housing stock).

Approaches for the three studies

The three chapters of this dissertation are conceptually linked and build on the extant literature. The objectives of this dissertation are as follows:

1) Synthesise existing evidence for the link between housing cost burden and health outcomes and revisit the potential mechanisms linking housing cost burden to health (Chapter 2);

2) Estimate whether and how mortality risks are influenced by levels of housing assets and income among older adults aged 65 and over in Canada using a nationally representative cohort study (Chapter 3);

3) Assess whether the housing cost burden is related to mortality rates and how social and housing policy measures can mitigate mortality risks in wealthy countries (Chapter 4).

Chapter 2: A scoping review of housing cost burden and health

The second chapter of the dissertation synthesizes the literature assessing the relationship between housing cost burden and health. Relying on a scoping review, this study uncovers potential mechanisms concerning how housing cost burden can be related to health outcomes regarding, for example, psychological health, physical health, health behaviours, and healthcare utilization. The results of the review help to develop an understanding of how and under what circumstances housing cost burden can affect health. Additionally, this study highlights a need for further studies regarding the health

consequences of the housing cost burden. This chapter is motivated by earlier research that (a) did not synthesize the link between housing cost burden and health and (b) presented a limited understanding of the mechanisms underlying this association.

Chapter 3: Housing assets, income and mortality in Canadian older adults

The third chapter of the dissertation presents a quantitative analysis of the 2011 Canadian Census Health and Environment Cohort (*CanCHEC*). This chapter is motivated by earlier research that reports some disparities in mortality among older adults regarding the *dynamics of income and housing assets*. Despite a higher life expectancy, many older adults in Canada face more mortality risks due to a lack of income and assets. The use of a population-based dataset that links individual socioeconomic conditions to health outcomes such as mortality can analyse the expected duration time until death occurs among older adults who have fewer economic resources (e.g., asset poor, cash poor). This can be informative when identifying health inequalities in ageing populations. This paper can provide evidence of the combined effects of housing assets and income on mortality among older adults where such evidence is currently scarce.

Chapter 4: Housing cost burden, mortality, and protective policy measures

The fourth chapter of the dissertation assesses whether housing affordability deteriorates population health (e.g., avoidable mortality and deaths of despair). The chapter also examines the extent to which protective policy measures can moderate the observed association. The use of publicly available datasets from the OECD (Organization for

Economic Co-operation and Development) databases allows for a cross-national study of the periods before and after the Global Financial Crisis from 2007 to 2008. This study makes notable contributions to the evidence base on the ecological-level relationship between housing cost burden and health. Additionally, to my knowledge, this study is the first to examine the effects of an increasing housing cost burden on population health in wealthy countries.

Thus, Chapter 2 provides insights to inform the assessment of the housing cost burden and its effects on health. Chapter 3 illustrates the dynamics of income and assets regarding their influence on the mortality risks of older adults. Chapter 4 suggests types of policies that may reduce mortality inequalities due to the housing cost burden. Chapter 5 summarizes the key findings of the dissertation, suggests its contributions to the literature, and concludes the study with policy implications.

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CHAPTER 2: A SCOPING REVIEW OF HOUSING COST BURDEN AND HEALTH: REVISITING METHODOLOGICAL AND MECHANISM ISSUES

Abstract

***Objectives*:** This scoping review aims to synthesize existing evidence in order to build an understanding of what health problems can result from housing cost burden, how, and for whom. The study focused on empirical studies relating housing cost burden to a wide range of health outcomes.

***Methods*:** A scoping review of published articles was conducted following PRISMA guidelines by extracting the articles from five databases (PubMed, PsycINFO, Sociological Abstract, MEDLINE, and Applied Social Science Index & Abstract). Eligible studies were then included if (a) papers empirically and quantitatively assess the link between housing cost burden and health outcomes (b) they are peer-reviewed research published in English. After excluding duplicates and ineligible studies, 51 studies met the inclusion criteria.

***Results*:** Prior literature relied on a comprehensive set of indicators for housing cost burden, including the ratio approach and self-reports of housing cost burden. Overall, housing cost burden is directly and indirectly related to health, particularly psychological and physical health, and healthcare utilization. This is primarily explained by stress from lower post-shelter income and discounting of health promotion consumption. The

association between housing cost burden and health is manifest among disadvantaged groups, such as lower-income households and renters. While the majority of cross-sectional study design showed a significant association between housing cost burden and health, the longitudinal study design revealed mixed findings.

***Conclusions*:** Housing cost burden can pose a threat to health in many ways. A lack of evidence for housing tenure and age-specific groups limits our understanding. Future studies should seek to fill the knowledge gaps.

Keywords: Housing cost burden; psychological health; physical health; health behaviors; healthcare utilization; scoping review

Highlights

- A scoping review shows that housing cost burden is associated with health, primarily psychological and physical health, and healthcare utilization.
- The association between housing cost burden and health can be explained by plausible mechanisms, such as discounting of health promoting consumption and stress from post-shelter income.
- The observed association is manifest among disadvantaged groups, such as lower-income households and renters.
- Some studies did not show a significant association between housing cost burden and health due to study designs.

Introduction

Background

An increasing number of households in many countries experience housing cost burden. This is in part because wage increases may not be able to catch up with an increase in housing costs (Kemp, 2015). In addition, a lack of inclusive housing policies, such as housing subsidies and social housing, decreases one's opportunity to find out affordable housing. Given that housing costs, such as monthly rental and mortgage payments, are major components of most household budgets, such a notion bolsters the case for identifying whether and how housing cost burden influences one's well-being and life. Since studies initially paid attention to *hard* ways in which housing, such as poor dwelling conditions, has impact on health, subsequent studies offer compelling evidence for *softer* ways in which housing characteristics such as housing tenure and housing cost burden are related to health (Dunn et al., 2004; Shaw, 2004).

A growing body of evidence has documented the link between housing and health. First, not only do substandard material conditions (e.g., poor ventilation) increase immediate exposure to risk factors such as the spread of respiratory diseases (Bonnefoy, 2007; Evans, 2000; Webb et al., 2013), but they also lead to residents' fatigue and annoyance since people may not be able to perform daily life (Evans, 2003). Second, homeownership is associated with psychological well-being, such as life satisfaction and a decrease in depressive symptoms (Manturuk, 2012; Stotz, 2019). This is motivated by

the facts that (a) the compositional characteristics of owner-occupied housing (e.g., increased access to high-quality community service) increase one's opportunities to spend time with family and neighbors (Elsinga & Hoekstra, 2005), and (b) people can increase economic benefits of homeownership by borrowing against their home equity (Di et al., 2007). Such explanations bolster the case for identifying housing issues, such as poor dwelling conditions and housing tenure, as social determinants of health.

Housing cost burden refers to (a) a high proportion of household income on housing expenses (e.g., more than 30% or 50% of income) and (b) difficulty affording necessities, such as food and healthcare, due to housing costs. Housing costs account for the largest share of household expenses, and expenditure on housing is inelastic (consumption is not easily expanded or contracted). Such characteristics of housing costs have effects on well-being and health of households. For example, higher housing cost burden *per se* can contribute to psychological distress in parts because people feel frustrated and overwhelmed by threatening financial circumstances (*direct effects*). Also, people who should pay higher housing costs relative to income are forced to reduce consumption of necessities (e.g., healthcare and education), thereby discounting physical health problems, such as nutrient deficiency (*indirect effects*) (Cheer et al., 2002). A combination of these direct and indirect mechanisms suggests that housing cost burden can have a large effect on health and well-being (Dunn, 2020).

Prior literature has investigated the association between housing cost burden and health outcomes such as psychological health, physical health, and (un)healthy behaviors.

While some studies showed that housing cost burden poses a threat to health, others did not provide promising results. This discrepancy can be explained by several factors. First, studies relied on different measurements of housing cost burden (e.g., percentage of income on housing and self-perception of housing cost burden) based on availability of information from data. While housing cost to income ratio is widely used, scholarship argues that this approach may not be able to fully capture the heterogeneity of housing cost burden by income level (Stone, 2006). Another reason can be characteristics of study design that may not be able to fully take into account confounders. Second, although the association between housing cost burden and health can be pronounced among particular groups (e.g., younger adults, lower income households, and private renters), many studies primarily focused on the general population. In addition, beside assessing the effects of housing cost burden on various types of health outcomes, we also need to understand the mechanisms linking housing cost burden to health. Addressing these issues is important since it can offer insight into an intervention that alleviates housing cost burden and health.

Research aim

For in-depth understanding about the link between housing cost burden and health, we need to (a) compare various measurements of housing cost burden (b) revisit a comprehensive set of potential mechanisms linking housing cost burden and health, and (c) identify for whom the association between housing cost burden and health is pronounced. This paper aims to articulate these knowledge gaps by synthesizing prior

literature that empirically assesses the association between housing cost burden and health. Given that housing cost burden can be linked to health in many ways, the scope of the study includes all health outcomes: psychological health, physical health, health behaviors, and healthcare utilization. The findings of this study can help guide future research.

Literature review

This section describes three potential conceptual pathways between housing cost burden and health: a) 'discounting' of health-promoting consumption due to insufficient post-shelter income; b) the health impacts of stress arising from low post-shelter income, which may also include housing insecurity; c) stress-related health behaviors (e.g., smoking, poor diet, etc.).

Plausible Mechanism 1: Discounting of health promoting consumption

The first important potential mechanism linking housing cost burden to health is connected to health promoting consumption. This is important since housing costs, such as monthly rental and mortgage payment, are major components of most household budgets. When housing costs increase relative to income, this can directly affect one's ability to maintain living standards. One of the notable examples is that the amount a household can pay for housing directly causes a constraint in income, which reduces consumption in necessities, such as healthcare (e.g., out-of-pocket services and prescriptions) and food (Dunn, 2020). As noted earlier, this can be related to the fact that

expenditure on housing is *inelastic*. As housing cost burden leads households to cut back on healthcare consumption, they tend to suffer from avoidable/or preventable diseases and morbidity. In some cases, this may lead to avoidable health care use, for example, admission to the emergency department since people may not have received timely appropriate preventive healthcare due to housing cost burden (Kushel et al., 2006; Pollack et al., 2010; Stahre et al., 2015).

Those who are constrained due to housing may be forced to reduce a wide range of well-being improving behaviours, such as taking essential medicine, socializing, leisure, and exercising due to a lack of income after housing costs (Downing, 2016). Therefore, housing cost burden can pose a threat to one's health by not only discounting options for necessities of life but also preventing investment that further enriches the quality of life. Households facing high housing cost burden may delay the need for health discounting by taking on debt (e.g., payday loans, consumer debt, borrowing from friends and families), but this may be an added source of stress, especially for lower-income households, even if it forestalls health discounting (Hojman et al., 2016; Zurlo et al., 2014).

Plausible Mechanism 2: Stress from lower post-shelter income

Adverse responses to the chronic stresses of living on a low income are known to be associated with decreased levels of psychological and physical health (Baum et al., 1999). Housing may have some unique characteristics as a psychological stressor. First, given that housing is a place of comfort and a site for the continuity of life, in the face of high

housing cost burden, people may feel that their ontological security can be threatened (Dupuis & Thorns, 1998; Hiscock et al., 2001). Second, housing cost burden may result in foreclosures, evictions, and forced moves, which are an added stressor unique to housing as a part of a household's consumption (Desmond & Kimbro, 2015). As a result, people might start considering housing related problems as demanding and threatening stressors. The effects can operate not only in psychological and mental health, but also in physiological health. Responding to the notion of biological stress responses, stressors, including housing cost burden, are reported to dysregulate body and hormonal systems, by triggering stress hormones (e.g., cortisol) and elevating blood pressure (Afari et al., 2014; McEwen, 2008).

Plausible Mechanism 3: Stress-invoked health behaviors

In order to cope with stress caused by housing cost burden, people may engage in unhealthy behaviours. This is motivated by earlier work, suggesting that unhealthy behaviors, such as smoking and alcohol drinking, serve as a coping mechanism for many people (Perski et al., 2022). Similarly, some individuals under housing cost burden may engage in self-destructive behaviors (e.g., substance abuse). This corresponds to the idea of *frustration-aggression hypothesis* (Downing, 2016). According to this hypothesis, being exposed to disrespect and humiliation can lead to anger and frustration (Dollard et al., 1939). Relatedly, a number of well-executed studies indicated that such conditions are salient during economic crises (or job loss) when some display antisocial behaviors whereas others cope with stress by relying on alcohol (Case & Deaton, 2020; Catalano et

al., 2011). While the majority of previous studies primarily focus on job loss as the main stressors, it is possible that housing cost burden belongs to risk factors that cause unhealthy behaviors.

Methods

Literature search and data extraction

We searched five databases, PubMed, PsycINFO, Sociological Abstract, MEDLINE, and Applied Social Science Index & Abstract (ASSIA), with no restriction on the publication date or country of origin of the research up until May 2021 (time of the search). In our search, we used the following keywords: housing (un)affordability, housing cost burden, (un)affordable housing, rent burden, mortgage burden, housing insecurity, housing strain, housing stress, and housing induced poverty. After identifying studies through the database search engine, they were extracted into Mendeley for the screening process.

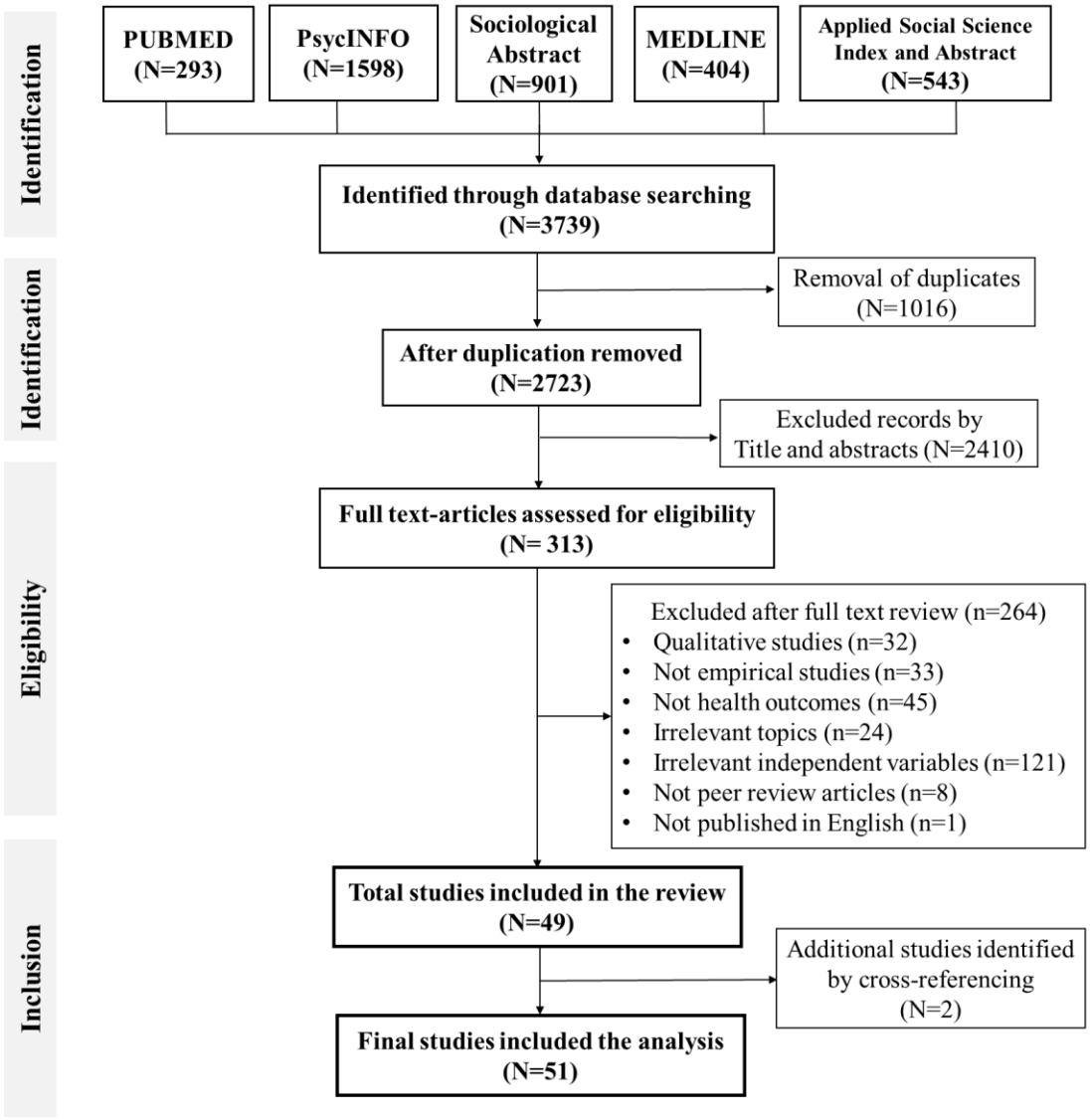
Inclusion and exclusion criteria

After the titles and abstracts were screened as an initial process of exclusion, full texts were obtained for articles that met the inclusion criteria. Eligible studies were then included if (a) they were peer-reviewed articles published in English, (b) they conducted empirical studies on the association between housing cost burden and any health outcome, and (c) they were quantitative research. Also, we restricted eligible studies to those who define housing cost burden on actual housing costs relative to income or perceived experience of difficulty paying housing costs. In other words, we excluded studies that

explore overall financial burden or threatening circumstances, foreclosure, or arrears, since it is unclear whether those stressors are caused by housing cost burden.

Health outcomes in the studies include physical and psychological health, self-rated health, unhealthy behaviors (e.g., smoking and binge drinking), and healthcare utilization (e.g., inpatient, outpatient, medication, and emergency care). For assessment of eligibility, studies were then excluded from our analysis if (i) they were intervention studies (ii) clinical trial studies, and (iii) they did not specify the measurement of either independent variables or dependent variables. Additionally, we could find two related studies through hand searches from previous studies. As a result, 51 studies were included for review. Figure 2. 1 represents the flowchart for data extraction.

Figure 2. 1 PRISMA flow chart of included studies through the screening process



Analytic strategy

Synthesis of the included studies was organized according to the following categories: country/region, characteristics of the study population, unit of analysis (e.g., individual or ecological level), study design (e.g., cross-sectional or longitudinal), control variables, a measurement tool for housing cost burden, health outcomes, main results. In particular, the main focus was to investigate how the studies measured housing cost burden and explained the relationships with health outcomes. Therefore, we divided the studies into the following categories: (a) the ratio (income) approach, (b) the residual (income) approach, (c) self-perception of housing cost burden, and (d) others.

(a) *The ratio (income) approach*: classifying households as housing cost burdened if they spend more than 30% (or 50%, continuous) of their income on housing (e.g., rent and utilities)
(b) *The residual (income) approach*: classifying households as housing cost burdened if the absolute amount of income after housing costs is below a certain level (e.g., the poverty threshold)
(c) *Self-perception of housing cost burden*: classifying households as housing cost burdened if they have felt worried or stressed about having enough money to pay housing costs
(d) *Others*: housing price to income (continuous), median county-level percentage of household income spent on housing (rent/mortgage).

Results

Summary Characteristics of Selected Studies

Table 2. 1 shows summary characteristics of the included studies. All studies were from higher-income countries, and most studies have focused on North America (55%) and Oceania (24%). The majority of studies have primarily focused on the individual-level association between housing cost burden and health (82%), while 5 studies were ecological-level studies. More than half of the included studies focused on adults, with different age ranges (e.g., 18+, 20+, or 25+). There is a heterogeneity in the measurement of housing cost burden: 51.0% for the ratio approach (cut off: 29.2% and continuous: 11.8%, respectively), 39.22% for self-perception of housing cost burden, 1.96% for the residual approach, 3.92% for others.

Table 2. 1 Descriptive characteristics of included studies (N=51)

	N	(%)
Continent[+]		
Asia	6	(11.76)
North America	28	(54.90)
Oceania	13	(23.53)
Europe	5	(9.80)
Level		
Individual level	42	(82.35)
Ecological level	5	(9.80)
Multi-level	4	(7.84)
Study population[+]		
Child & adolescents	5	(9.80)
Younger adults	12	(23.50)
Older adults	1	(1.96)
All ages	34	(66.67)
Housing cost burden		
Self-report/perception of experience	20	(39.22)
Housing costs to income ratio (cut off)	20	(39.22)
Housing price	2	(3.92)
Housing costs to income ratio (continuous)	6	(11.76)
Residual income	1	(1.96)
Others	2	(3.92)
Health outcome[+]		
Psychological health	29	(40.28)
Physical health	18	(25.0)
Health behaviors	3	(4.17)
Healthcare utilization	10	(13.89)
Self-rated health	8	(11.11)
Others	4	(5.56)
Study design		
Cross sectional	27	(52.94)
Longitudinal	24	(47.06)
Study year		
2010-	24	(47.06)
2000-	19	(37.25)
1990-	7	(13.73)
Not specified	1	(1.96)

[+] some studies duplicated

For outcomes, studies have used various health outcomes, such as psychological health (29 studies, 56.8%), physical health (18 studies, 35.3%), self-rated health (8 studies, 15.7%), health behaviors (5 studies, 9.8%), healthcare utilization (10 studies, 19.6%). 53% used cross-sectional studies, and 47% used longitudinal studies.

Health Outcomes

Psychological Health

Table 2. 2 shows the summary of the included studies on psychological health and physical health. About 89.7% (26 out of 29 studies) of studies examined that housing cost burden is associated with psychological health, including depressive symptoms and anxiety (Coley et al., 2013; Lacombe-Duncan et al., 2020) and maternal stress (Bills et al., 2019). Not only does housing cost burden is linked to adults' psychological health (Bentley et al., 2011; Bentley, Pevalin, et al., 2016), but also children and adolescents who live under housing cost burden tend to have emotional problems (Kull & Coley, 2014; O'Donnell & Kingsley, 2020). A part of underlying mechanisms linking housing cost burden to psychological health is that housing cost burden leads to financial hardship, such as the inability to pay bills and food, since households cannot afford after paying housing costs (Singh et al., 2020). Such conditions influence people to feel overwhelmed and threatened by a decrease in living standards. In addition, residents may negatively perceive their community since housing cost burden can weaken one's opportunity to enjoy community and neighborhood resources (Badland et al., 2017).

While cross sectional studies (13 out of 13 studies) yielded results on the link

between housing cost burden and psychological health, longitudinal studies showed mixed findings. Four longitudinal studies did not provide supportive evidence for the association between housing cost burden and health in adults (Novoa et al., 2017; Park & Jung, 2019; Pierse et al., 2016) as well as children and adolescents (Coley et al., 2013). They explained that because the study population has more limited economic resources to meet living standards, they may suffer more from other economic or housing problems, thereby offsetting the association between housing cost burden and health (Coley et al., 2013; Novoa et al., 2017). Also, it can be possible that some households are more willing to experience housing cost burden in order to reside in adequate dwelling conditions. This notion can be particularly applicable to higher income households who would not freeze their household budget to assist other living needs (Stone, 2006).

Physical Health

Physical health includes chronic disease (e.g., hypertension, diabetes, obesity, cardiovascular disease), injury, and biomarkers. About 89% (16 out of 18 studies) of the studies showed that housing cost burden is associated with physical health. For example, housing cost burdened households are more likely to have problems in general physical health (Fedina et al., 2020; Martin et al., 2019; Schure et al., 2016). Also, they tend to have specific chronic diseases, such as arthritis (Pollack et al., 2010) and diabetes (Stupplebeen, 2019). In particular, three studies showed that the likelihood of reporting hypertension is higher when individuals experience housing cost burden (Pollack et al., 2010; Stupplebeen, 2019) or live in unaffordable neighborhood (Angrisani & Lee, 2016). Lastly, the likelihood of having obesity is higher among children and adolescents (Nobari

et al., 2019) and renters under housing cost burden (Rodgers et al., 2019). Studies offered an explanation that housing cost burden can cause food insecurity that predisposes one to chronic disease.

The findings differ by study design. All of the cross-sectional studies (10 out of 10 studies) revealed that housing cost burdened households than their counterparts (non-burdened households) tend to have physical health problems. Note that in articles by Pollack et al. (2010), housing cost burden did not significantly predict the occurrence of certain chronic diseases (i.e., obesity, diabetes, and heart disease). By contrast, while two *ecological* level longitudinal studies out of 8 longitudinal studies found that housing cost burden did not predict suicide rates (Jones & Pridemore, 2016; Reeves et al., 2015). In respect to these results, they explained that (a) particular groups may be more severely affected by housing cot burden and (b) more acute stressors, such as foreclosure, than housing cost burden, can put people at heightened risks of physical health problems. The rest of the longitudinal studies (6 out of 8 studies) are in accordance with the notion of proposed mechanisms: housing cost burden may result in postponement of necessary service and a lack of regular preventive care, which increases the risks of chronic diseases, particularly for lower income or uninsured households.

Table 2. 2 A summary of the included studies on psychological health and physical health

Health outcome	Psychological health		Physical health	
Study design	Cross-sectional	Longitudinal	Cross-sectional	Longitudinal
Child & Adolescents		(Coley et al., 2013)[+], (Kull & Coley, 2014), (O'Donnell & Kingsley, 2020)	(Nobari et al., 2019), (Sengoelge et al., 2013)	
Younger Adults (aged under 65)	(Kearns et al., 1993)	(Bentley et al., 2011) (5)[*] , (Bentley, Baker, et al., 2016) [*], (Bentley, Pevalin, et al., 2016)[*], (Mason et al., 2013), (Rodgers et al., 2019) [*]		
Older Adults				(Angrisani & Lee, 2016) (2)
All ages (younger and older adults)	(Badland et al., 2017), (Bills et al., 2019), (Chung et al., 2020), (J R Dunn, 2002), (Fedina et al., 2020)[*], (Lacombe-Duncan et al., 2020) (2), (Novoa et al., 2015), (Park & Seo, 2020), (Pollack et al., 2010), (Schure et al., 2016), (Stahre et al., 2015), (Wang et al., 2019) (2)	(Baker et al., 2020), (Bentley et al., 2012)[*], (Lee et al., 2016), (Martin et al., 2019) , (Novoa et al., 2017)[+], (Park & Jung, 2019)[+], (Pierse et al., 2016) [+], (Rourke et al., 2011), (Singh et al., 2020) (2)	(Arcaya et al., 2020), (Chung et al., 2020), (Liu et al., 2014), (Pollack et al., 2010) (5)[#], (Schure et al., 2016), (Stahre et al., 2015) (2), (Stupplebeen, 2019) (3)[*]	(Clair & Hughes, 2019) (Jones & Pridemore, 2016) [+] (Martin et al., 2019) (2) (Reeves et al., 2015) [+] (Rourke et al., 2011)

Note. [*]some groups (e.g., lower income households) pronounced, [#]some outcomes significant, [+] No association. the number of health outcomes included in the bracket

Table 2. 3 shows the summary of the included studies on healthcare behaviours, healthcare utilization, and others including self-rated health.

Health Behaviours

Health behaviours include smoking, (problematic or binge) alcohol drinking, and drug use. Five studies examined the relationship between housing cost burden and health behaviours. Four cross-sectional studies yielded heterogenous results: 3 out of 4 studies identified an association of current smoking with housing cost burden (Hermine et al., 2019; Pollack et al., 2010; Stahre et al., 2015) but 2 out of 4 studies did not find a significant association for problematic drinking (Bowen & Mitchell, 2016; Stahre et al., 2015). One cross-sectional study that focused on single-room occupancy building residents found that rent burdened residents are less likely to engage in risky behaviors such as drug use (Bowen & Mitchell, 2016). One longitudinal study found similar results, showing that housing cost burden did not significantly predict drinking and smoking (Bentley et al., 2021). Rather, housing cost burden decreased the likelihood of (self-reported status of) alcohol use in the study. A part of the reasons for this result is that housing cost burden can decrease one's ability to meet the need for both health improving necessities and health deteriorating non-necessities (e.g., illicit drug use).

Healthcare Utilization

Healthcare utilization includes the use of preventive service, routine check-ups, postponement of healthcare service/prescriptions due to cost, etc. 7 out of 7 cross

sectional studies found that housing cost burden is associated with (a) not being able (or delaying) to see doctor (or medication) (b) hospitalization (Charkhchi et al., 2018; Fuller et al., 2019; Han et al., 2019; Kushel et al., 2006; Meltzer & Schwartz, 2016; Stahre et al., 2015). However, in these studies, the emergency department visit was not significantly predicted by housing cost burden (Kushel et al., 2006; Pollack et al., 2010). In three longitudinal studies, by contrast, housing cost burden predicted the likelihood of delaying healthcare, and decreased use of prescription (Martin et al., 2019; Rodgers et al., 2019) but rather increased consultation with doctors about mental disorders (Wei et al., 2021).

Self-rated health and Others

Housing cost burden was associated with a decrease in marital satisfaction (Nelson et al., 2013) and a lower sense of community belonging (Leviten-Reid et al., 2020). In addition, children living in unaffordable housing was associated with externalizing symptoms (e.g., aggressive and rule-breaking behaviors) (Kull & Coley, 2014). With the exception of one study (Park & Jung, 2019), seven studies revealed that housing cost burden predicted a decrease in self-rated health.

Table 2. 3 A summary of the included studies on health behaviours, healthcare utilization, self-rated health, and others

Health outcome	Health behaviours		Healthcare utilization		Others /self-rated health	
Study design	Cross-sectional	Longitudinal	Cross-sectional	Longitudinal	Cross-sectional	Longitudinal
Child & Adolescents						(Coley et al., 2013), (Kull & Coley, 2014)
Younger Adults (aged under 65)		(Bentley et al., 2021) (4)[#]	(Han et al., 2019), (Kushel et al., 2006) (6)	(Rodgers et al., 2019)[*], (Wei et al., 2021)		
Older Adults						
All ages (younger and older adults)	(Bowen & Mitchell, 2016) (2)[#], (Hermine et al., 2019), (Pollack et al., 2010), (Stahre et al., 2015) (2)[#]		(Charkhchi et al., 2018), (Fuller et al., 2019) (3), (Meltzer & Schwartz, 2016), (Pollack et al., 2010), (Stahre et al., 2015)	(Martin et al., 2019) (3)	(Badland et al., 2017), (Charkhchi et al., 2018), (Dunn, 2002), (Leviten-Reid et al., 2020), (Meltzer & Schwartz, 2016), (Nelson et al., 2013) (Pollack et al., 2010), (Stahre et al., 2015)	(Martin et al., 2019) (Park & Jung, 2019)[+]

Note. [*]some groups (e.g., lower income households) pronounced, [#]some outcomes significant, [+] No association. the number of health outcomes included in the bracket

The identification of subgroup according to socioeconomic status

Some studies divided the study population into sub-groups according to socioeconomic status to investigate to whom hosing cost burden can decrease health. For example, compared to owner-occupiers (including mortgagors), renters are likely to have psychological health problems associated with housing cost burden (Bentley, Pevalin, et al., 2016; Mason et al., 2013; O'Donnell & Kingsley, 2020). Physical health problems (i.e., hypertension) are salient for housing cost burdened renters than for owner-occupiers (Angrisani & Lee, 2016; Rodgers et al., 2019). Lower-income households are more likely to report psychological health problems (Bentley et al., 2011; Mason et al., 2013). In addition, Bentley et al. (2016) found that the association between housing cost burden and psychological health is more pronounced among insecurely employed people compared to securely employed people (Bentley, Baker, et al., 2016). Another study found that the association between housing cost burden and psychological health is more salient among substandard housing dwellers compared to adequate housing dwellers (Park & Seo, 2020). These findings suggest housing cost burden can be more detrimental to health of those who do not have enough financial resources (e.g., income and stable job) that helps to maintain living standards.

Quality Assessment

Using the Newcastle-Ottawa scale for cohort studies, we conducted a quality assessment of the included studies (Table 2. 4). Each study is judged on three domains that include

eight items: (i) the selection of the study population, (ii) the comparability of the study population, and (iii) ascertainment of outcome of interest. On the basis of these criteria, we considered studies scored 5 and above to be of good quality. Although a large proportion of the selected studies used a nationally or regionally representative study, they used self-reported exposure (or outcomes), which may over- or under-estimate the observed association. 20 studies were followed up for enough time for an outcome to occur, but 31 studies did not follow-up the participants long enough for outcomes to occur.

Table 2. 4 Quality assessment of the included studies

	Selection				Comparability	Outcome			Total (out of 8)
	Representativeness of the exposed cohort	*Selection of the non-exposed cohort*	*Ascertainment of exposure*	*Demonstration that outcome of interest was not present at start of study*	*Comparability of cases and controls on the basis of the design or analysis*	*Assessment outcome*	*Follow up long enough for outcomes to occur*	*Adequacy of follow up cohort*	
(Angrisani & Lee, 2016)	*	*	*		*		*	*	6
(Arcaya et al., 2020)	*		*		*	*	*		5
(Badland et al., 2017)	*		*		*				3
(Baker et al., 2020)	*	*		*	*		*	*	6
(Bentley et al., 2012)	*	*	*		*		*		5
(Bentley, Pevalin, et al., 2016)	*	*	*				*	*	5
(Bentley et al., 2021)	*	*	*		*		*		5
(Bentley et al., 2011)	*	*	*		*		*		5
(Bentley, Baker, et al., 2016)	*	*	*		*		*	*	6
(Bills et al., 2019)	*	*	*		*				4
(Bowen & Mitchell, 2016)		*	*		*				3
(Charkhchi et al., 2018)	*	*	*		*				4
(Chung et al., 2020)	*	*	*		*				4
(Clair & Hughes, 2019)	*	*	*		*	*	*		6
(Coley et al., 2013)	*	*	*		*			*	5
(Dunn, 2002)	*	*							2
(Fedina et al., 2020)	*	*	*		*				4
(Fuller et al., 2019)		*	*		*				3
(Han et al., 2019)	*	*	*						3
(Jones & Pridemore,	*	*	*		*	*	*		6

2016)									
(Mason et al., 2013)	*	*	*		*		*	*	6
(Kearns et al., 1993)	*	*	*						3
(Kull & Coley, 2014)	*	*	*					*	4
(Kushel et al., 2006)	*	*	*		*				4
(Lacombe-Duncan et al., 2020)	*	*	*		*				4
(Lee et al., 2016)	*	*	*		*				4
(Leviten-Reid et al., 2020)	*	*	*		*				4
(Liu et al., 2014)	*	*	*		*				4
(Martin et al., 2019)	*	*	*						3
(Meltzer & Schwartz, 2016)	*	*	*		*				4
(Nelson et al., 2013)	*	*			*				3
(Nobari et al., 2019)	*	*	*		*	*			5
(Novick et al., 2020)	*	*	*		*	*	*	*	7
(Novoa et al., 2017)	*	*	*	*	*				5
(Novoa et al., 2015)	*	*	*		*				4
(O'Donnell & Kingsley, 2020)	*	*	*		*		*	*	6
(Pierse et al., 2016)	*	*	*				*		4
(Hermine et al., 2019)	*	*	*		*				4
(Park & Jung, 2019)	*	*	*		*				4
(Park & Seo, 2020)	*	*	*		*		*		5
(Pollack et al., 2010)	*	*	*		*				4
(Reeves et al., 2015)	*		*			*	*		4
(Rodgers et al., 2019)	*	*	*	*	*		*		6
(Rourke et al., 2011)	*	*	*	*	*		*		6
(Schure et al., 2016)	*	*	*		*				4
(Sengoelge et al.,	*		*			*			3

2013)									
(Singh et al., 2020)	*	*	*		*		*	*	6
(Stahre et al., 2015)	*	*	*		*				4
(Stupplebeen, 2019)	*	*	*		*				4
(Wang et al., 2019)	*	*	*					*	4
(Wei et al., 2021)	*		*			*	*		4

Discussion

A Summary of Main Findings

This study sought to synthesize the results of prior literature that estimate the association between housing cost burden and a wide set of health outcomes, including psychological and physical health, health behaviours, and healthcare utilization. Also, the present study contributes to the existing literature by (a) comparing the measurement of housing cost burden (b) revisiting the proposed mechanisms linking housing cost burden to health, and (c) identifying for whom housing cost burden disproportionately affect health outcomes.

First, the prior literature provided suggestive evidence, showing that housing cost burden is associated with a variety of health outcomes. Most of the studies primarily focused on two health outcomes: psychological health (56.9%) and physical health (35.2%). Scholarship offered explanations on mechanisms. Housing cost burden can be a direct and acute exposure to one's psychological health, in parts because people can be psychologically concerned about their subsequent housing related events, such as arrears and eviction. In addition, it is possible that given that housing cost burden can cause financial hardship such as the inability to pay necessities, their emotional concerns over living standards can be provoked. This can be replicated to physical health problems, particularly chronic diseases. Since housing cost burdened households are forced to cut their expenses on food or substitute their meals with cheap and high-calorie foods, thereby contributing to insufficient nutrition and chronic diseases. Such explanations are in line with the proposed mechanisms, discounting of health promoting consumption and

stress from post-shelter income.

Second, about 30% of the studies focused on health behaviors (e.g., smoking and drinking) and healthcare utilization (e.g., postponement of preventive services, hospital admissions). Again, these works are motivated by the notion that (a) people attempt unhealthy behaviors to alleviate stressors and (b) expenditure on housing can decrease one's ability to maintain health (e.g., seeking regular check-up). While some studies found that housing cost burden predicted the likelihood of unhealthy behaviors, others did not support it. That is, it is not necessarily the case that the stress provoked behaviors occur as a response to housing cost burden. Similar to the first proposed mechanisms of discounting health promoting consumption, housing cost burden can rather decrease the likelihood unhealthy behaviors through a decrease in post-shelter income. Rather, we can suggest that mechanism operates among those who can afford to do so. Also, it helps to understand that physical health problems caused by housing cost burden may not be explained by health damaging behaviors.

Third, housing cost burden has substantial effects on health of disadvantaged groups. Lower-income households (Bentley et al., 2011), insecurely employed people (Bentley, Baker, et al., 2016), renters (Bentley, Pevalin, et al., 2016; Mason et al., 2013; Rodgers et al., 2019) are likely to have mental health problems associated with housing cost burden. We can understand that socioeconomically disadvantaged people have fewer options in order to better cope with material hardship caused by housing cost burden. For example, unemployed persons or precarious workers may have to change their housing options by moving out to another place (Bentley, Baker, et al., 2016). Also, in light of the

role of homeownership that brings a sense of security and comfort (Dupuis & Thorns, 1998), renters are often likely to have health problems associated with housing cost burden compared to homeowners (Coley et al., 2013). Likewise, housing tenure does not fully prevent renters from experiencing housing related problems, such as evictions. This highlights that socioeconomic conditions can moderate the association between housing cost burden and health.

Fourth, at the ecological level, neighborhood level unaffordable housing is associated with health outcomes. For example, neighborhood resources that enrich well-being of residents (e.g., access to parks and amenities) may be concentrated in regions with high valued housing where rich residents live in. Acknowledging the first proposed mechanisms, residents in unaffordable housing are not willing to pay taxes due to a lack of after-housing-costs-income. These communities may lead to under-investment in health-promoting resources, such as leisure and recreation facilities. As a result, such conditions can negatively affect residents to feel frustrated and perceive communities as unfair.

Last, more importantly, the results on the link between housing cost burden and health differ by study design: cross-sectional and longitudinal studies. In the included studies that focused on psychological and physical health, all of the cross-sectional studies showed a statistically significant association of housing cost burden and health. On the other hand, some of the longitudinal studies (4 studies on psychological health, 2 studies on physical health) did show *statistically non-significant* results. This is because characteristics of study design. Although cross-sectional studies control for confounders,

it may not be possible to solely isolate the association between housing cost burden and health since two characteristics concurrently shape this association: characteristics of housing cost burdened households (*compositional*, such as lower income and poor housing conditions) and the characteristics of housing cost burden per se (*causal*). This suggests that the observed association reported by cross-sectional studies can be still confounded by unmeasured and measured heterogeneity. By contrast, in longitudinal studies that estimate within-subject differences in health predicted by within-subject differences in housing cost burden, the models can take into account heterogeneity.

Methodological Issues and Direction for Future Studies

Identifying different groups according to demographic and housing tenure

Little is known about whether housing cost burden is related to health of child and adolescents. The vast majority of included studies mainly focused on working-age population. It is evidence that from the perspective of life course approach, exposures in childhood/or adolescence can influence health in later life since adverse health consequences may accumulate over time (Johnson et al., 2011). Therefore, responding to the life course approach, it would be informative to assess how housing cost burden in childhood and adolescence has prolonged effects on health by adulthood. In addition, while it is widely accepted that older adults do not undergo material hardship since they tend to be homeowners after retirement, this is not the case as our review found. In many countries, a growing number of older adults are faced with housing cost burden even in post-retirement life. Future studies should examine what factors lead to housing cost

burden for older adults.

Second, it is important to note that housing cost burden can occur differently to each type of housing tenure. For example, mortgagors than outright-owner occupiers are more likely to spend on housing costs since they should pay regular down payment towards the purchase of a house. Also, while private renters should regularly pay monthly rents, subsidized renters can get help paying rent from the government. That is, housing cost burden can vary by sub types of tenure within owner-occupiers or renters. Despite the rationale, the majority of the included studies in the present studies did not isolate mortgagors from homeowners and subsidized renters from renters. Future studies may wish to unpack different types housing tenure (e.g., outright owner-occupiers, mortgagors, private renters, and subsidized renters) to better examine whether housing tenure moderates the association between housing cost burden and health.

Clarity on causal mechanisms

Although much work to date has identified the relationship between housing cost burden and health, it is still difficult to comprehend underlying mechanisms since they have not estimated the effects of mechanisms. In social epidemiology, clarity on mechanisms helps to provide insight into causes of health outcomes more generally and strengthen causal inference (Diez Roux, 2022). Existing conceptual framework suggested mechanisms. Housing cost burden can influence one's health by (a) provoking ontological insecurity and feelings of frustration, (b) decreasing health promoting consumption (e.g., necessities and amenities), and (c) causing subsequent housing related problems (e.g., doubling up

and overcrowding) (Dunn et al., 2004; Swope & Hernández, 2019). Unpacking these mechanisms through which housing cost burden leads to health problems can lay the foundation for understanding of how and whether housing cost burden as social condition is of social, psychological, behavioral factors linked to health.

Conclusion

Our scoping review shed a light on whether and how housing cost burden is linked to health outcomes. While our findings support the notion that housing cost burden is one of the important social determinants of health, it is of great significance to use analytic and methodological approaches that help to estimate the association. In particular, this present study offers implications: (a) the development of measurement for housing cost burden (b) identification of those who are disproportionately impacted by housing cost burden (c) delicate approaches to study design that solely and accurately estimates the link between housing cost burden and health.

This study has some limitations. First, there is a possibility of publication bias in which a significant association is more likely to be published (Chan et al., 2004). This may limit a clear understanding of the association between housing cost burden and health. Second, since this scoping review thoroughly used five research databases of English publications, we cannot rule out the bias due to the exclusion of non-English papers. Despite these limitations, we believe this study has many strengths. To our knowledge, this is one of the first studies that synthesized existing evidence for the link between housing cost burden and health. Particularly, we extended the study participants

to children and adolescents, and health outcomes to psychological and physical health, health behaviors, and healthcare utilization. This helps to understand under what circumstances housing cost burden has effects on health.

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Supplemental Table

Supplemental Table 2. 1 Characteristics of the included studies (Health outcome: Psychological health)

Author (year)	Age region, year,	Level	Study design	Control variables	Exposure	Measurement tool for health	Main findings
(Badland et al., 2017)	Aged 18+, Australia (2017)	ML	CS	DE, SE, NC	RCL (regional level)	Feeling unsafe	Significant association
						Community dissatisfaction	Significant association
(Baker et al., 2020)	Aged 16+, Australia, (2002-2016)	IL	LO	DE, SE, HC, O	RCL	The Mental Component Summary (MCS)	Both prolonged and intermittent exposure was associated with lower mental health
(Bentley et al., 2012)	Aged 15+, Australia (2001-2009)	IL	LO	DE, SE, O	RCF	The Mental Component Summary (MCS)	Mental health decreased with cumulative exposure to housing cost burden for first year but not significant for consecutive years, only for females
(Bentley et al., 2011)	Aged 25 to 64, Australia (2001-2007)	IL	LO	DE, SE	RC	The Mental Component Summary (MCS)	Significant association only for lower income
						Mental health (subscale of SF-36)	Significant association for lower income
						Vitality (Subscale of SF-36)	No significant association
						Social functioning (subscale of SF-36)	Significant association only for lower income
						Role limitations due to emotional problem (subscale of SF-36)	No significant association

Author (year)	Age region, year,	Level	Study design	Control variables	Exposure	Measurement tool for health	Main findings
(Bentley, Baker, et al., 2016)	Aged 25 to 64, Australia (2001-2010)	IL	LO	DE, SE, O	RC	The Mental Component Summary (MCS)	Significant association particularly for insecurely employed
(Bentley, Pevalin, et al., 2016)	Aged 25 to 64, Australia and the UK (2001-2008)	IL	LO	DE, SE	RC	Mental health (subscale of SF-36)	Australia: significant association only for renters
						12-items General Health Questionnaire	The UK: significant association for homeowners
(Bills et al., 2019)	Mean: 32.6, US (1994)	IL	CS	DE, SE, NC, O	RC	Maternal stress	Significant association for low-income mothers
(Chung et al., 2020)	Aged 18+, Hong Kong (2014-2015)	IL	CS	DE, SE, HC, O	RI (Quartiles)	12 items Short- Form Health Survey	Significant association
(Coley et al., 2013)	Aged 2 to 21, US (1999-2002)	ML	LO	DE, SE, O	RN	Internalizing symptoms (e.g., depression and anxiety)	No significant association
(Dunn, 2002)	Aged 18+, Canada (1999)	IL	CS		RN, PE	feeling downhearted and blue	Significant association
(Fedina et al., 2020)	Mean of age: 38.0-47.4, US (2010)	IL	CS	DE, SE, O	PE	Self-rated mental health	Significant association only for white
(Kearns et al., 1993)	Mean of age: 30.1-39.0, New Zealand (1987-1989)	IL	CS		RC	Composite score (AUDIT, General Health Questionnaire-12 items)	Significant association
(Kull & Coley, 2014)	Aged 2 to 5, US (1999, 2001)	IL	LO	DE, SE	RN	Internalizing problems	Significant association mediated by neighborhood disadvantage

Author (year)	Age region, year,	Level	Study design	Control variables	Exposure	Measurement tool for health	Main findings
(Lacombe-Duncan et al., 2020)	Aged 16+, Canada (2013-2015)	IL	CS	DE, SE, O	PE	CES-D 10 scale	Significant association
						Post-traumatic stress symptoms (PTSD Checklist Civilian scale)	No significant association
(Lee et al., 2016)	Aged 19+, Korea (2011-2013)	IL	LO	DE, SE, HC, O	RC (tenure & 5%, 10%)	CES-D 11 scale	Significant association
(Martin et al., 2019)	Aged 18+, US (2011-2015)	IL	LO	DE, SE, O	PE	Self-rated mental health (# of days in the past month)	Significant association
(Mason et al., 2013)	Aged 15 to 64, Australia (2001-2010)	IL	LO	DE, SE	RCL	SF-36 Mental Component Summary (MCS) score	Significant association particularly for lower income renters
(Novoa et al., 2017)	Aged 16+, Spain (2012-2013)	IL	LO	DE, SE, HC, NC	RCL	General Health Questionnaire - 36	No significant association
(Novoa et al., 2015)	Aged 16+, Spain (2015)	IL	CS	DE, HC, O	PE	Depression or anxiety	Significant association
(O'Donnell & Kingsley, 2020)	Aged 4 to 15, Australia (2004-2014)	IL	LO	DE. SE. HC, NC, O,	RC	SDQ (Strengths and Difficulties Questionnaire) scale	Compared to mortgagors with lower cost burden, renters with housing cost burden report socio-emotional and behavioral problems
(Park & Jung, 2019)	Aged 18+, Korea (2015-2016)	IL	LO	DE, SE, O	RC	CES-D 11 scale	No significant association
(Park & Seo, 2020)	Aged 18+, Korea (2015-2016)	IL	CS	DE, SE, HC, O	RC	CES-D 11 scale	Significant association particularly for substandard adequate housing dwellers

Author (year)	Age region, year,	Level	Study design	Control variables	Exposure	Measurement tool for health	Main findings
(Pierse et al., 2016)	Aged 18 to 80, New Zealand (2002-2010)	IL	LO	SE	RC	Psychological measure (Kessler-10)	No significant association
(Pollack et al., 2010)	Aged 18+, US (2008)	IL	CS	DE, SE, NC	PE	Psychiatric conditions	Significant association
(Rodgers et al., 2019)	Aged 35 to 43, US (2000-2014)	ML	LO	DE, SE, HC, NC, O	RN (county-level)	CES-D	Significant association
(Rourke et al., 2011)	Mean of age: 43.1 Canada (year not reported)	IL	LO	DE, SE, NC, HC, O	PE	HIV-specific HRQOL (Health-Related Quality of life)	Significant association
(Schure et al., 2016)	Aged 18+, US (2011-2012)	IL	CS	DE, SE	PE	Poor mental health (≥6 days in the past 30 days)	Significant association
(Singh et al., 2020)	Aged 15+, Australia (2014-2015)	IL	LO	DE, SE, O	RCL	Mental Health Inventory (MHI) scale	Significant association
						Kessler Psychological Distress Score	Significant association
(Stahre et al., 2015)	Aged 18+, US (2011)	IL	CS	DE, SE, O	PE	mental health (≥14 days in the past 30 days)	Significant association
(Wang et al., 2019)	Mean of age: 48.11, China (2014)	IL	CS		RC	Feeling depressed, hopeless (higher score reflect better)	Significant association
						Being able to remember important things that happen to them within a week (higher score reflects better)	Significant association

IL: Individual Level, EC: Ecological Level, ML: Multi-level, LO: Longitudinal, CS: Cross-sectional, RC: Ratio Approach Cut-

Off (30%), RCL: Ratio Approach Cut-Off (30% of Income % Lower Income Distribution), RN: Ratio Approach No Cut Off (Continuous), RI: Residual Income Approach, PE: Perceived Experience Of Housing Cost Burden, HI: Housing Price To Income, DE: Demographic Characteristics, SE: Socioeconomic Conditions, HC: Housing Related Characteristics, O: Others

Supplemental Table 2. 2 Characteristics of the included studies (Health outcome: Physical health)

Author (year)	**Age (year)**	**Level**	**Study design**	**Control variables**	**Exposure**	**Measurement tool for health**	**Results**
(Angrisani & Lee, 2016)	Aged 51+, US (2004, 2006, 2008, 2010)	ML	LO	DE, SE	HI (housing price index)	Self-reported hypertension diagnosis	Significant association particularly for male and lower educated
						Hypertension (biomarker)	Significant association
(Arcaya et al., 2020)	All ages, US (2014-2018, 2020)	EC	CS	DE, SE	PE, HI	Covid 19 case rates (per 100,000)	Significant association
(Chung et al., 2020)	Aged 18+, Hong Kong (2013-2015)	IL	CS	DE, SE, HC, O	RI (Quartiles)	12- item Short- Form Health Survey version 2	Significant association
(Clair & Hughes, 2019)	Aged 21+, UK (2010-2012)	IL	LO	DE, SE, HC, O, M (housing tenure)	RCL	Biomarker C-reactive protein (CRP)	Significant association particularly for private renters
(Fedina et al., 2020)	Mean: 38.0-47.4, US (2010)	IL	CS	DE, SE, O	PE	Self-rated physical health	Significant association only for white
(Jones & Pridemore, 2016)	All ages, US (2005-2009)	EC	LO	DE, SE	O (Housing mortgage stress index)	total, sex, race specific suicide rates	No significant association
(Liu et al., 2014)	Aged 18+, US (2009)	IL	CS	DE, SE, O	PE	Frequent insufficient sleep	Significant association
(Martin et al., 2019)	Aged 18+, US	IL	LO	DE, SE, O	PE	physical health (# of days in the past month)	Significant association

Author (year)	Age (year)	Level	Study design	Control variables	Exposure	Measurement tool for health	Results
	(2011-2015)					Presence / number of chronic medical conditions	Significant association
(Nobari et al., 2019)	Aged 2 to 5, US (2001, 2014)	IL	CS	DE, SE, NC, O, M (household size)	PE	Obesity (BMI ≥95 percentile)	Significant association
(Novick et al., 2020)	Aged 30 to 64, US (2009-2017)	IL	LO	DE, SE, O	PE	Rapid kidney function decline	No significant association
						Incident reduce estimated glomerular filtration rate	No significant association
						Incident albumin-to-creatinine ratio	Significant association
(Pollack et al., 2010)	Aged 18+, US (2008)	IL	CS	DE, SE, NC	PE	Arthritis	Significant association
						Asthma	No significant association
						Diabetes	No significant association
						Heart disease	No significant association
						Hypertension	Significant association
						Obesity	No significant association
(Reeves et al., 2015)	Aged 25+, 20 EU countries (2002-2011)	EC	LO	O (year)	PE	male suicide rate (aged 25+)	No significant association
						male suicide rate (aged 25 to 64)	No significant association
						male suicide rate (aged under 65)	No significant association
(Rodgers et al., 2019)	Aged 35 to 43, US (2000-2014)	ML	LO	DE, SE, HC, NC, O	RN (County-level)	Diabetes	No significant association
						Hypertension	Significant association only for renters
						Obesity (BMI≥30kg/m2)	Significant association only for renters

Author (year)	Age (year)	Level	Study design	Control variables	Exposure	Measurement tool for health	Results
(Rourke et al., 2011)	Mean: 43.1 Canada (year not reported)	IL	LO	DE, SE, NC, HC, O	PE	HIV-specific quality of life	Significant association
(Schure et al., 2016)	Aged 18+, US (2011-2012)	IL	CS	DE, SE	PE	Poor physical health (≥14 days in the past 30 days)	Significant association
(Sengoelge et al., 2013)	Aged 1 to 14, 26 European countries (2006)	EC	CS		O (loading factor of income and housing costs)	Children injury mortality	Significant association
(Stahre et al., 2015)	Aged 18+, US (2011)	IL	CS	DE, SE, O	PE	Poor health limiting daily activity (≥14 days in the past 30 days)	Significant association
						Physical health (≥14 days in the past 30 days)	Significant association
(Stupplebeen, 2019)	Aged 18+, US (2009, 2012)	IL	CS	DE, SE, O	PE	Diabetes	Significant association only for Native Hawaiian/other Pacific Islander (not for white and asian)
						Cardiovascular disease	Significant association only for Native Hawaiian/other Pacific Islander (not for white and asian)
						Asthma	Significant association

Author (year)	Age (year)	Level	Study design	Control variables	Exposure	Measurement tool for health	Results
							only for white and asian (not native Hawaiian/other Pacific Islander)

IL: Individual Level, EC: Ecological Level, ML: Multi-level, LO: Longitudinal, CS: Cross-sectional, RC: Ratio Approach Cut-Off (30%), RCL: Ratio Approach Cut-Off (30% of Income % Lower Income Distribution), RN: Ratio Approach No Cut Off (Continuous), RI: Residual Income Approach, PE: Perceived Experience Of Housing Cost Burden, HI: Housing Price To Income, DE: Demographic Characteristics, SE: Socioeconomic Conditions, HC: Housing Related Characteristics, O: Others

Supplemental Table 2. 3 Characteristics of the included studies (Health outcome: Health behaviours)

Author (year)	**Age (year)**	**Level**	**Study design**	**Control variables**	**Exposure**	**Measurement tool for health**	**Results**
(Bentley et al., 2021)	Aged 25 to 64, Australia (2001-2018)	IL	LO	DE, SE, O	RCL	Self-reported status of drinking	The odds of alcohol use decreased with housing cost burden
						Problem drinking	No significant association
						Cigarettes smoked per week	No significant association
						Current smoking	No significant association
(Bowen & Mitchell, 2016)	Mean of age: 49.9, US (2013)	IL	CS	DE, O	RC	Problem drinking	No significant association
						Illicit drug use other than marijuana	Compared to no burden group: moderate burden (OR: 0.60, 95% CI: 0.17 to 2.14) higher burden (OR: 0.19, 95% CI: 0.04 to 0.82)
(Hermine et al., 2019)	Aged 18+, US (2015)	IL	CS	DE, SE, O	PE	Current smoking	Significant association
(Pollack et al., 2010)	Aged 18+, US (2008)	IL	CS	DE, SE, NC	PE	Current smoking	Significant association
(Stahre et al., 2015)	Aged 18+, US (2011)	IL	CS	DE, SE, O	PE	Current smoking	Significant association
						Past 30 days binge drinking	No significant association

IL: Individual Level, EC: Ecological Level, ML: Multi-level, LO: Longitudinal, CS: Cross-sectional, RC: Ratio Approach Cut-Off (30%), RCL: Ratio Approach Cut-Off (30% of Income % Lower Income Distribution), RN: Ratio Approach No Cut Off (Continuous), RI: Residual Income Approach, PE: Perceived Experience Of Housing Cost Burden, HI: Housing Price To Income, DE: Demographic Characteristics, SE: Socioeconomic Conditions, HC: Housing Related Characteristics, O: Others

Supplemental Table 2. 4 Characteristics of the included studies (Health outcome: Healthcare utilization)

Author (year)	**Age (year)**	**Level**	**Study design**	**Control variables**	**Exposure**	**Measurement tool for health**	**Results**
(Charkhchi et al., 2018)	Aged 18+, US (2015)	IL	CS	DE, SE	PE	Not being able to see a doctor in the past 12 months	Significant association
(Fuller et al., 2019)	Mean of age: 36.0, US (2017-2018)	IL	CS	DE, SE, O	PE	Any unmet healthcare in the past 12 months	Significant association
						Hospital admission in the past 12 months	Significant association
						Number of emergence department (ED) visits in the past 12 months	Significant association
(Han et al., 2019)	Mean of age: 57.8-61.6	IL	CS	DE. SE, O	PE	Postponement of needed healthcare	Significant association
(Kushel et al., 2006)	Aged 18 to 64, US (1994)	IL	CS	DE, SE	PE	No ambulatory care visits	No significant association
						Emergency Department (ED) visits	Significant association
						Hospitalization	Significant association
						Postponement of health care in the past year	Significant association
						Postponement of medication in the past year	Significant association
						No usual source of care	Significant association
(Martin et al., 2019)	Aged 18+, US (2011-2015)	IL	LO	DE, SE, O	PE	Deferred care due to cost	Significant association
						Had a routine check-up within past year	Significant association
						No usual source of care	Significant association
(Meltzer & Schwartz, 2016)	Aged 17 to 90, US (2011)	IL	CS	DE, SE, HC	RN	Postponement of any health service	Significant association

Author (year)	Age (year)	Level	Study design	Control variables	Exposure	Measurement tool for health	Results
(Pollack et al., 2010)	18+ (2008)	IL	CS	DE, SE, NC	PE	Cost-related prescription non-adherence	Significant association
						Cost-related healthcare non-adherence	Significant association
						emergency department (ED) visit in the past year	Significant association
(Rodgers et al., 2019)	Aged 35 to 43 (2000-2014)	ML	LO	DE, SE, HC, NC, O	RN (county-level)	Use of anti-hypertensives	Among participants with incident hypertension, a unit increase in housing cost burden was associated with lower odds of antihypertensive use for renters
(Stahre et al., 2015)	Aged 18+, US (2011)	IL	CS	DE, SE, O	PE	Delayed doctor visit because of costs	Significant association
(Wei et al., 2021)	Aged 20 to 54, China (2013-2017)	EC	LO	SE	HI (city level)	The rate at which people consult doctors about their mental disorders	Significant association, particularly for middle aged adults (than for younger adults)

IL: Individual Level, EC: Ecological Level, ML: Multi-level, LO: Longitudinal, CS: Cross-sectional, RC: Ratio Approach Cut-Off (30%), RCL: Ratio Approach Cut-Off (30% of Income % Lower Income Distribution), RN: Ratio Approach No Cut Off (Continuous), RI: Residual Income Approach, PE: Perceived Experience Of Housing Cost Burden, HI: Housing Price To Income, DE: Demographic Characteristics, SE: Socioeconomic Conditions, HC: Housing Related Characteristics, O: Other

Supplemental Table 2. 5 Characteristics of the included studies (Health outcome: Self-rated health and others)

Author (year)	**Age (year)**	**Level**	**Study design**	**Control variables**	**Exposure**	**Measurement tool for health**	**Results**
(Badland et al., 2017)	Aged 18+, Australia (2011)	ML	CS	DE, SE, NC	RCL (regional level)	Self-rated health	Significant association
(Charkhchi et al., 2018)	Aged 18+, US (2015)	IL	CS	DE, SE, M (Food insecurity)	PE	Self-rated health (higher =good)	Significant association
(Coley et al., 2013)	Aged 2 to 21, US (1999-2002)	ML	LO	DE, SE, O	RN	Externalizing problems	No significant association
(Dunn, 2002)	Aged 18+, Canada (1999)	IL	CS		RN, PE	Self-rated health	Significant association
(Kull & Coley, 2014)	Aged 2 to 5, US (1999, 2001)	IL	LO	DE, SE	RN	Externalizing problems	Significant association mediated by neighborhood disadvantaged
(Leviten-Reid et al., 2020)	Mean: 63.9, Canada (2016)	IL	CS	DE, SE, HC, NC, O	PE	Sense of community belonging	Significant association
(Martin et al., 2019)	Aged 18+, US (2011-2015)	IL	LO	DE, SE, O	PE	Self-rated health (# of days in the past month)	Significant association
(Meltzer & Schwartz, 2016)	Aged 17 to 90, US (2011)	IL	CS	DE, SE, HC	RN	Self-rated health (higher =good)	Significant association
(Nelson et al., 2013)	Aged 23 to 96 (1992)	IL	CS	DE, SE	RN	Marital satisfaction	Significant association
(Park &	Aged 18+, Korea	IL	LO	DE, SE, O,	RC	Self-rated health	No significant association

Author (year)	**Age (year)**	**Level**	**Study design**	**Control variables**	**Exposure**	**Measurement tool for health**	**Results**
Jung, 2019)	(2015-2016)			HC			
(Pollack et al., 2010)	Aged 18+, US (2008)	IL	CS	DE, SE, NC	PE	Self-rated health	Significant association
(Stahre et al., 2015)	Aged 18+, US (2011)	IL	CS	DE, SE, O	PE	Self-rated health	Significant association

IL: Individual Level, EC: Ecological Level, ML: Multi-level, LO: Longitudinal, CS: Cross-sectional, RC: Ratio Approach Cut-Off (30%), RCL: Ratio Approach Cut-Off (30% of Income % Lower Income Distribution), RN: Ratio Approach No Cut Off (Continuous), RI: Residual Income Approach, PE: Perceived Experience Of Housing Cost Burden, HI: Housing Price To Income, DE: Demographic Characteristics, SE: Socioeconomic Conditions, HC: Housing Related Characteristics, O: Others

CHAPTER 3: HOW DO HOUSING ASSET AND INCOME RELATE TO MORTALITY? A POPULATION-BASED COHORT STUDY OF 881220 OLDER ADULTS IN CANADA

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Abstract

***Objectives*:** A growing body of research has documented a well-established link between socioeconomic conditions and mortality among older adults. However, relatively few studies have examined the extent to which assets and income are concurrently associated with mortality risks in older adults. This study aims to understand (a) whether housing assets and income are associated with mortality and (b) if the value of housing assets affects the relationship between income and mortality; both questions are studied among older adults aged 65 or over in Canada.

***Methods*:** Using the population-based linked dataset (2011 Canadian Census Health and Environment Cohorts) of 881,220 older adults over six years of follow-up (2011-2017), this study uses survival analysis to estimate the link between housing assets, income level and mortality. We also assess the potential moderating effect of housing asset levels on the association between income and mortality by categorizing individuals along two dimensions: whether they are income-poor and whether they are housing assets-poor.

Results: The mortality rate was higher among both the lowest asset (*HR* = 1.346) and the lowest income group (*HR* = 1.203). The association is pronounced for older adults aged 65 to 74. Assets did not significantly moderate the link between income and mortality. Income-related inequalities in mortality are observed among each group of housing asset level. Compared to those who are neither income-poor nor housing assets-poor, individuals who were income poor but not housing assets-poor were more likely to die (*HR*=1.067) over seven years of follow-up, and people who were housing assets-poor

only were more likely to die (*HR*=1.210). Being housing-assets poor and income-poor yielded a higher hazard ratio (*HR*=1.291).

Conclusions: Housing assets and income are associated with mortality of older adults. It is important to identify people who are assets poor and/or income poor who are at higher risks of mortality. Social policies aimed at reducing income insecurity and housing insecurity can reduce mortality inequalities.

Keywords: Socioeconomic inequality; housing asset poverty; income poverty; mortality; older adults; Canada

Highlights

- Housing asset and income levels were concurrently associated with mortality risks among Canadian older adults.
- While the link between housing asset, income, and mortality became attenuated as people aged, they are still significant among people aged 85 and over.
- The levels of housing asset did not significantly moderate the association between income and mortality risks among older adults.
- Compared to older adults who are neither housing asset poor nor income poor, older adults who are both housing asset- and income poor are the most vulnerable to mortality risks.

Introduction

Background

Countries differ in the policy supports they provide for homeownership, and accordingly differ in the percentage of households in different forms of housing tenure (Stamsø, 2010). In many countries that favour homeownership through tax and other policies, there is a belief in the importance of homeownership for the economic security of people late in life. Homeownership, many argue, can be a means to offset long-term risks of income insecurity in later life, since homeowners can refinance against housing assets (e.g., reverse mortgage and equity release) (Doling & Ronald, 2010; Kemeny, 1981). When public spending on welfare decreases, one's willingness to rely on housing assets is more likely to increase since public spending cannot fully help people to buffer against the adverse consequences of welfare state retrenchment (Ronald et al., 2017). Similar to other countries, Canada has an "*asset-based welfare system*" in which many people are eager to purchase home and acquire assets in order to achieve a path towards individual economic security (Walks, 2016). The Canadian homeownership rate thus rose from 60% in 1971 to 69% in 2016, the rate being higher among older adults (75% among those aged 65 and older), compared to younger individuals (44% among those aged 20 to 34) (Canada, 2015).

Unfortunately, it is not necessarily the case that older adults are well-positioned to utilize housing assets for their well-being. Indeed, only a small proportion of older adults in the population can convert their residential property equity into income (Osberg, 2001). There are several reasons for this. First, an increasing number of older adults prefer to bequeath their housing assets rather than liquidating housing assets. Since younger generations are facing a rapidly growing gap between house price growth and income growth, it is increasingly difficult for them to realize homeownership. As a result, adult children are increasingly living with their parents and/or inheriting parental housing assets as inter-generational assistance (Lennartz et al., 2016; Ronald et al., 2017).

Second, although some older retirees are assumed to have paid off their mortgage before retirement, others still have housing expenses, such as principal and interest on a mortgage, and property taxes, which account for a higher proportion of income (Makdissi & Sopchokchai, 2019). This is mainly due to housing prices that tend to increase faster than incomes. Moreover, many older adults in wealthy countries are increasingly faced with income poverty partly because lower-income older adults have a lack of access to workplace pension or do not have sufficient savings on their own for retirement. Overall, this can put older adults at elevated risks of economic insecurity, which can, in turn, have impacts on their health and survival.

Research aims

Using a Canadian census-based linked mortality dataset, this paper aims to assess the relationship between housing assets, income, and mortality risks among older adults. Disentangling income and housing asset poverty helps to understand whether mortality risk is influenced by a lack of current income or/and asset accumulated over the lifetime (Azpitarte, 2012). We also want to assess whether (a) older adults in income poverty can be better protected from mortality risk due to the stock of asset resources and (b) those who do not have adequate assets rely on current income to maintain their livelihood. Our analytic approaches are twofold. First, this study assesses whether housing assets and income are independently related to mortality among older adults. Second, we examine the extent to which housing assets moderate the association between income and mortality.

Literature review

Health inequalities in old age

There has been growing attention to health inequalities in older age (Huisman et al., 2004). In some contexts, health inequalities between different socioeconomic groups are less pronounced because people in disadvantaged groups have a higher likelihood of premature mortality - a survival effect. By contrast, empirical studies have demonstrated that there are social gradient patterns of health inequalities among older adults (Benzeval

et al., 2011; McMunn et al., 2008). Regarding these results, research suggests that not only do health disparities in old age reflect current disadvantages in having access to essential healthcare, but they may also indicate cumulative effect of exposures to socioeconomic marginalization (e.g., gender, occupation, income, and education) over an extended period of time. The identification of health inequality is becoming particularly important, since it can provide a rationale for improvement of life expectancy by reducing gaps in socioeconomic status and implementing timely important interventions for health equity. Responding to this call, the social science and epidemiology literature has assessed multidimensional constructs of socioeconomic status that affect health (Braveman et al., 2005). This section thoroughly synthesizes existing studies on how housing and income are related to health (mainly focusing on mortality) among older adults.

Income and health

Income is considered to be at the core of health inequalities, since income is the most direct resource that determines quality of life and well-being (Smith et al., 1999). From the material perspectives, adequate income helps people to afford necessities, such as food, as well as to live in better living environment (Bowling, 2004). In some contexts, for example, where universal health insurance system does not fully work, income level determines greater access to better quality of healthcare. Second, income levels are

intertwined with neighbourhood level (dis)advantages. For example, increased levels of income can help households to enrich quality of life by promoting affordable and healthy choice (e.g., healthy foods, less exposure to environmental pollution, and higher levels of social support among residents) (Wight et al., 2014).

The association between income and health is not only observed among young active adults (which could signal a reverse causality effect, from poor health to low income), but remains salient among older adults. In empirical studies, income is statistically associated with health outcomes, such as functional limitation (Berkman & Gurland, 1998), and mortality (Hoffmann, 2011; Huisman et al., 2004). These results provide compelling evidence for socioeconomic differentials in health and also suggest that such differentials might be inequitable (because systematically associated with characteristics that are not entirely within the control of individuals, especially at older ages). Interestingly, the observed association remains significant when controlling for age, gender, education, and occupation. Although the majority of studies initially stemmed from European countries (Huisman et al., 2004), subsequent studies extended research subjects to older adults living in North America (McIntyre et al., 2016; Shahidi et al., 2020) and Asian countries (Kino et al., 2020). Overall, these results suggest that income has an important and independent role in improving health and well-being of older adults by, for example, facilitating one's health promoting activities and keeping living standards.

Another line of studies suggested that a lack of income predicted higher levels of disease severity (Emery et al., 2013) and decreased levels of compliance with care management (Ruberman et al., 1984). Given that lower income can increase exposures to social isolation (e.g., lower levels of social connections), lower income households find it challenging to develop their ability to obtain health care services, and healthcare knowledge for appropriate decision. As a result, this elevates disease severity or the prevalence of risk factors (e.g., co-morbidity). Interestingly, this is replicated in countries in which the healthcare system universally and equally covers access to health services for all (Dixon et al., 2007). Indeed, this raises call for action aimed at addressing inequalities in income-related healthcare utilization at older age.

Housing tenure, housing asset and health

Housing has specific meanings for older adults compared to younger generations. While the reasons for the observations are not empirically fully established, prior literature offered several plausible underlying mechanisms. First, homeownership, compared to other indicators, has an additional advantage that reflects lifetime change, and circumstances through the life course (Connolly, 2012; Connolly et al., 2010). Many older adults tend to feel comfortable and attached to living space in post-retirement life by spending more enjoyable time with family members and friends in a home they own (McCann et al., 2012; Wiles et al., 2012). Usually, owned-occupied housing tends to have

better physical features, such as housing quality and location (e.g., access to amenities and leisure) (Laaksonen et al., 2009; Macintyre et al., 1998). Those who own a home have financial resources for home adaptation, which enables them to stay at home longer. Empirical results support those mechanisms: Not only does homeownership predict better general health in European countries in international comparisons (Connolly et al., 2010; Dalstra et al., 2006) and psychological health in Asia (Park et al., 2021), but also owner-occupiers have a lower mortality risk than renters in Finland (Laaksonen et al., 2009). McCann et al. (2012) reported that homeowners are less likely to be admitted to care homes, compared to renters in Northern Ireland.

Second, (housing) assets can be converted into income that older adults can rely upon over time (Costa-Font, 2008; Doling & Ronald, 2010). Housing assets can reflect a key choice in one's life that allows older people to satisfy needs over time, particularly as income diminishes after retirement. This is driven by an asset-based welfare system that encourages people to purchase a house as a substitute for a lacking welfare system. For example, generating income by selling one's residence (and cashing in potential capital gains) allows for a more flexible budget. This can be beneficial for older adults, who do not earn regular income or did not plan a pension plan. Relatedly, one's ability to access and purchase a house can be determined by her or his income level. For example, higher income households are better positioned to purchase a good quality of priced housing they prefer to dwell in because higher income households compared to lower income

households tend to find it less challenging to pay down payment or borrow mortgage loans. As a result, higher income can maximize one's opportunity to increase value of housing assets in a later life. This suggests that the value of housing assets (or homeownership) and income can be interrelated.

Acknowledging the role of housing assets, studies documented its association with health. Housing asset has been found to be significantly associated with self-rated health (Costa-Font, 2008) and mortality (Connolly et al., 2010). The studies primarily focused on middle-aged and older adults, who tend to rely on housing for reasons, as noted earlier. One of the important issues is the combined effects of housing and income on health. First, while housing assets are strongly related to income, it is possible that housing assets can have sole and independent effects on health and well-being, rather than complementing each other. This is motivated by the fact that the presence of housing assets can be a source of intergenerational support (instrumental and emotional) in return for the inheritance for their offspring (Lennartz et al., 2016; Park et al., 2021). Second, older adults tend to associate housing assets/homeownership with their identity and a source of comfort since housing can represent achievement (i.e., the dream of homeownership) over their lifetime from work to retirement. Sometimes, they may want to own the last resort for the rest of their life at the expense of low income. Such conditions become noticeable in societies that have strongly encouraged people to purchase a house. This raises the questions over (a) whether and how housing assets have

independent effects on health or (b) whether housing assets complement income in influencing health.

Data and Methods

Data source and participants

This study uses the 2011 Canadian Census Health and Environment Cohort (hereafter 2011 CanCHEC), a population-based, person-specific linked dataset that combines the 2011 National Household Survey (hereafter 2011 NHS) and the 2011-2017 Canadian Vital Statistic Death Database (hereafter CVSD). The 2011 NHS, which consists of approximately 6.5 million cohort members, represents a 20% sample of the population living in Canada's provinces and territories. NHS participants were selected from the 2011 census of the population dwelling list, meaning that the institutionalized population was excluded. The NHS provides detailed information on demographic, socioeconomic characteristics, including the value of owned housing, capital gains, income, and household expenditures. The NHS respondents were asked to indicate relevant information (e.g., the presence and amounts of income from various sources as well as total income). The CVSD is an administrative database, which annually collects demographic information, the primary cause of death, and place/and residence of death from all vital statistics registries on all deaths in Canada.

Our analysis restricted the study population to private, non-farm, non-band, and non-reserve households (N = 881,220 older adults aged 65 and over). Other households are excluded because housing asset values for farm/or band households are not separately collected and may be less clear. Self-generated anonymous identification code help to link NHS to CVSD at the individual level. Of note, the study measured independent variables and covariates at a single point in time (2011), so we could not examine any changes in housing assets and income for a follow-up. That is, the study is about the effect on survival over six years of characteristics observed in 2011. Guided by the Statistics Canada's disclosure control guidelines, sample sizes are the sum of the rounded as a means of ensuring the protection of survey.

Measurement

Dependent variable

The main dependent variable of this study is a binary measure that takes a value of 0 if the individual is alive and 1 the year the individual dies, of whatever cause (mortality due to any cause, A00-Y89). We defined the survival period as the number of years between the baseline year (2011) and either death or seven years, at which point information about surviving older adults is censored (end of follow-up in 2017).

Independent variables

Total household income is the sum of the total income of all members of the household, such as wage and salaries, self-employment earnings, income from investment sources (e.g., dividends and interests on bonds) other regular income, and government transfers. Of note, capital gains and one-time receipts (e.g., lottery winnings) are not included in total income since they are not by their nature regular or recurring. Housing asset refers to value of private dwelling estimated by owner-occupiers (whether fully paid or still under mortgage), if their housing asset were to be sold and is 0 for tenants. We adjust the value of both income and housing assets for household size, using the square-root of the number of household members in order to take into account economies of scale in the production of household goods (OECD, n.d.). We then categorize individuals along the dimensions of income-poverty and housing asset-poverty based on definitions of poverty thresholds (Balestra, 2018; Gornick et al., 2009). The income poverty threshold is reached if household income is below 50% of the median income. In order to assess the income gradient in mortality, we further divide the population into five groups: above 200% of median income (income rich), 150-200% of median income, 100-150% of median income, 50-100% of median income, and below 50% of median income (income poor).

For the measurement of asset poverty, we again use 50% of the median income as the threshold. We convert the value of housing into annual income and calculate how many years of income at 50% of current median income could thus be generated (Balestra,

2018; Haveman & Wolff, 2005). One of the merits for this approach is that it can estimate whether and how long housing asset help households to offset income insecurity for a *certain period of time* (Haveman & Wolff, 2005; D. W. Rothwell & Haveman, 2013). This is particularly important for older adults who may experience a lack of income after retirement that can shrink regular wages. Categories are as follows: 0 (asset-poor), 1-10 years (less than 10 times of threshold), 10 to 14 years (10-14 times of the threshold) 15 to 19 years (15-19 times of the threshold), and 20 years or more (asset-rich, 20 times higher than the threshold).

Finally, we combine the two variables to identify (a) *asset and income poor* (or double poor) when households in income poverty who are also in asset poverty (renters), and therefore unable to make their ends meet; (b) *income poor only* when their current income is insufficient but they do have a stock of housing assets that provides financial buffers of households in the absence of income; (c) *asset poor only* when those whose income is above poverty threshold but they do not have adequate stock of asset; (d) *asset and income non-poor* (or double non-poor) who have adequate stock of asset and income.

Covariates

A large set of control variables is included in the analysis for this study. For demographic indicators, sex (male or female), age (age and age-squared), marital status (single, currently married, separated/divorced/widowed) were included. The household

composition was categorized as a single person or multi-person. Three educational attainment categories were used: primary or below, secondary or above, and post-secondary or above. A question on limitations in activities of daily living asks a yes or no response. We added the variables of whether the dwelling requires minor/major maintenance. Place of residence was classified categorized into two groups: urban (Census Metropolitan Area (CMA)/ and Census Agglomeration (CA) formed by one or more adjacent municipalities centered on a population centre and others if otherwise.

Statistical analysis

First, we provide descriptive statistics of the study population, using individual-level weights provided by Statistics Canada to account for non-response. We run a Cox Proportional Hazard model to assess whether asset and income poverty are independently associated with mortality. Then, we examine whether housing asset level moderates the link between income and mortality after control variables are taken into account. Finally, we assess the combined effects of asset and income on mortality. The main assumption of Cox Proportional Hazard model is that survival curves for different predictor or control variables have hazard functions that are proportional regardless of time. All Cox models tested the proportional-hazard assumption based on a log-log plot of survival and Schoenfeld residual, showing that the assumption is met. Confidence intervals (95% CI) for the HRs (Hazard Ratios) are represented for all models. STATA/SE version 15.0 (Stata

Corp, College Station, TX) was used for all analyses.

Results

The baseline characteristics of the study population are presented in Table 3. 1. Of the 881,220 persons, 25% had an asset level 20 times higher than 50% of median income, while 22% were classified as being in asset poverty, which means they did not own any housing assets. About 12% of older adults have the highest income (above 200% of median income), whereas 10% are in income poverty (below the income poverty threshold). There is a variation in mortality rate according to asset and income level. The incidence rate of death was higher among asset poor (26%) as well as income poor (25%) compared to asset-rich (16%) or income rich (15%). In log-rank tests, there was a significant difference in survival distributions by explanatory variables and covariates.

Table 3. 1 Descriptive statistics of older adults aged 65 or over in Canada

	Total		Deaths	
	N	Distribution (%)	N	Incidence Rate
Housing asset level				
Housing asset (20+ years)	220,865	(25.06)	35,310	(15.99)
Housing asset (15-19 years)	129,570	(14.70)	23,920	(18.46)
Housing asset (10-14 years)	150,030	(17.03)	28,990	(19.32)
Housing asset (<10 years)	185,965	(21.10)	41,185	(22.15)
No housing asset (Renters)	194,790	(22.10)	50,830	(26.09)
Income level				
Above 200% of median income	108,090	(12.27)	15,880	(14.69)
150-200% of median income	108,855	(12.35)	18,085	(16.61)
100-150% of median income	211,620	(24.01)	39,490	(18.66)
50-100% of median income	365,530	(41.48)	85,265	(23.33)
Below 50% of median income	87,125	(9.89)	21,510	(24.69)
Age				
65 to 74	506,395	(57.47)	56,320	(11.12)
75 to 84	290,975	(33.02)	78,350	(26.93)
85 and above	83,845	(9.51)	45,560	(54.34)
Sex				
Female	479,215	(54.38)	86,940	(18.14)
Male	402,005	(45.62)	93,295	(23.21)
Marital status				
Single	45,735	(5.19)	9,885	(21.61)
Currently married	514,940	(58.43)	88,885	(17.26)
Separated/widowed/div	320,545	(36.38)	81,460	(25.41)
Educational attainment				
Under secondary	359,830	(40.83)	89,995	(25.01)
Secondary or above	199,835	(22.68)	39,535	(19.78)
Post-secondary or above	321,555	(36.49)	50,705	(15.77)
Living arrangement				
Living alone	240,090	(27.25)	61,030	(25.42)
Living with anyone	641,130	(72.75)	119,200	(18.59)
Difficulty with activities of daily living				
Not stated	19,620	(2.23)	4,270	(21.76)
No	493,145	(55.96)	62,440	(12.66)
Yes	368,450	(41.81)	113,520	(30.81)

Dwelling requires maintenance				
No	663,325	(75.27)	133,870	(20.18)
Repair needed	217,895	(24.73)	46,365	(21.28)
City of residence				
Urban	701,495	(79.60)	141,670	(20.20)
Rural	179,725	(20.40)	38,565	(21.46)
Total	881,220			

Table 3. 2 represents the joint distribution of categories of housing assets and income levels among older adults. The majority of older adults are neither income poor nor housing asset poor (73%). In other words, about 27% are in housing asset poor or income poor. While 17% of older adults were asset poor only, about 5% were income poor only. 5% was double poor (asset poor and income poor).

Table 3. 2 Joint distribution of housing assets and income levels among older adults aged 65 or over

		Income non-poor								*Income poor*		Total	
		Above 200% of median income		150-200% of median income		100-150% of median income		50-100% of median income		Below 50% of median income			
		N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Housing asset non-poor	Housing asset (20+ years)	59,870	(6.8)	39,385	(4.5)	54,570	(6.2)	57,685	(6.6)	9,690	(1.1)	221,205	(25.1)
	Housing asset (15-19 years)	18,940	(2.2)	22,410	(2.5)	38,065	(4.3)	44,505	(5.1)	5,780	(0.7)	129,695	(14.7)
	Housing asset (10-14 years)	13,280	(1.5)	20,985	(2.4)	44,625	(5.1)	63,215	(7.2)	8,065	(0.9)	150,170	(17.0)
	Housing asset (<10 years)	8,340	(1.0)	15,090	(1.7)	44,215	(5.0)	98,795	(11.2)	19,570	(2.2)	186,015	(21.1)
Housing asset poor	No asset (Renters)	8,070	(1.0)	11,335	(1.3)	30,560	(3.5)	100,335	(11.4)	43,825	(5.0)	194,140	(22.0)
Total		108,510	(12.3)	109,205	(12.4)	212,035	(24.1)	364,530	(41.4)	86,935	(9.9)	881,220	(100)

Table 3. 3 shows the hazard ratio of all-cause mortality according to housing asset and income level during the follow-up period. As presented in Column 1, there is a clear and strong housing asset gradient in mortality among older adults in Canada. Compared to people who are asset rich, the lowest housing asset group was more likely to die in the follow-up period (*HR* = 1.346, 95% CI: 1.325, 1.367), followed by lower middle (*HR* = 1.261, 95% CI: 1.241, 1.281), middle (*HR* = 1.156, 95% CI: 1.137, 1.175), and upper-middle (*HR* = 1.117, 95% CI: 1.098, 1.136). Columns 2 – 4 show the observed relationship for different age groups. Income and housing asset inequalities in mortality were the largest among those aged 65 to 74, and these inequalities were quite attenuated among those aged 85 and over. The lowest housing asset and the lowest income groups were more likely to die compared to the corresponding reference group among those aged 65 to 74 (*HR* = 1.601, 95% CI: 1.555, 1.648 and *HR* = 1.324, 95% CI: 1.271, 1.380, respectively, Column 2). The corresponding hazard ratio was 1.319 (95% CI: 1.288, 1.351) and 1.148 (95% CI: 1.107, 1.190) among those aged 75 to 84 (Column 3). Among those aged 85 and over, the lowest housing asset group compared to the highest housing asset were more likely to die (*HR*=1.117, 95% CI: 1.084, 1.151). The lowest income group was more likely to die in the follow-up (*HR* = 1.089, 95% CI: 1.042, 1.140).

Table 3. 3 Hazard ratio of mortality according to asset and income level for different age groups

Column	(1)	(2)	(3)	(4)
Age group	Total	Aged 65 to 74	Aged 75 to 84	Aged 85 and over
	HR	*HR*	*HR*	*HR*
Housing asset (ref: Housing asset, 20+ years)	1	1	1	1
Housing asset (15-19 years)	1.117*** (1.098, 1.136)	1.147*** (1.112, 1.183)	1.122*** (1.094, 1.151)	1.070*** (1.034, 1.108)
Housing asset (10-14 years)	1.156*** (1.137, 1.175)	1.220*** (1.185, 1.257)	1.145*** (1.117, 1.173)	1.091*** (1.056, 1.128)
Housing asset (<10 years)	1.261*** (1.241, 1.281)	1.362*** (1.323, 1.401)	1.251*** (1.221, 1.281)	1.140*** (1.104, 1.177)
No housing asset (Renters)	1.346*** (1.325, 1.367)	1.601*** (1.555, 1.648)	1.319*** (1.288, 1.351)	1.117*** (1.084, 1.151)
Income (ref: above 200% of MI)	1	1	1	1
150-200% of MI	1.048*** (1.026, 1.071)	1.089*** (1.049, 1.130)	1.047** (1.013, 1.083)	0.990 (0.947, 1.035)
100-150% of MI	1.092*** (1.072, 1.113)	1.150*** (1.112, 1.189)	1.067*** (1.036, 1.099)	1.037 (0.998, 1.077)
50-100% of MI	1.165*** (1.144, 1.186)	1.267*** (1.226, 1.309)	1.119*** (1.088, 1.152)	1.081*** (1.043, 1.121)
Below 50% of MI	1.203*** (1.176, 1.232)	1.324*** (1.271, 1.380)	1.148*** (1.107, 1.190)	1.089*** (1.042, 1.140)

Note. The 95 percent confidence intervals are in brackets. Models adjusted for age and age-squared, sex, marital status, educational attainment, living arrangement, activity limitation, housing condition, and place of residence, HR = Hazard Ratio, MI: Median Income, * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 3. 4 presents the association between the income measure and all-cause mortality according to housing asset level among those aged 65 to 74. Overall, there was an income gradient in mortality risks for both asset non-poor and asset poor. Among asset-richer groups, the lowest income households were 1.215 times more likely to die than the top income group after adjusting for covariates (95% CI: 1.096, 1.348). The hazard ratio for the lower middle, middle, upper-middle-income groups who died was significantly higher than that of the highest income group (*HR* = 1.233, 95% CI: 1.165, 1.305; *HR* = 1.146, 95% CI: 1.084, 1.212; *HR*=1.120, 95% CI: 1.055, 1.189, in Column 1). Income inequalities in mortality were also significant among asset poor groups, in which the hazard of all-cause mortality for the lowest income older adults were 1.493 times than that for the highest income among asset-poor (95% CI: 1.348, 1.654), as shown in Column 5. Income inequalities became quite attenuated according to age. In Supplemental Table 3. 1, we included interaction term of housing asset and income level. The results showed that housing asset levels did not significantly change the association between income levels and mortality for three groups, aged 65 to 74, aged 75 to 84, and aged 85 and over, respectively.

Table 3. 4 Hazard ratio of mortality according to income for different asset levels among aged 65 to 74

Column	(1)	(2)	(3)	(4)	(5)
Age group	Aged 65 to 74	Aged 65 to 74	Aged 65 to 74	Aged 65 to 74	Aged 65 to 74
Asset level	Housing asset 20+ years	Housing asset 15-19 years	Housing asset 10-14 years	Housing asset <10 years	No housing asset (Renters)
	HR	*HR*	*HR*	*HR*	*HR*
Above 200% of MI	1	1	1	1	1
150-200% of MI	1.120*** (1.055, 1.189)	1.011 (0.929, 1.099)	1.109* (1.011, 1.216)	1.179** (1.056, 1.317)	1.065 (0.944, 1.202)
100-150% of MI	1.146*** (1.084, 1.212)	1.121** (1.039, 1.208)	1.116* (1.027, 1.213)	1.254*** (1.137, 1.383)	1.246*** (1.124, 1.382)
50-100% of MI	1.233*** (1.165, 1.305)	1.133** (1.049, 1.224)	1.244*** (1.145, 1.350)	1.389*** (1.263, 1.528)	1.443*** (1.309, 1.591)
Below 50% of MI	1.215*** (1.096, 1.348)	1.177* (1.029, 1.347)	1.275*** (1.129, 1.440)	1.444*** (1.295, 1.609)	1.493*** (1.348, 1.654)

Note. The 95 percent confidence intervals are in brackets. Models adjusted for age and age-squared, sex, marital status, educational attainment, living arrangement, activity limitation, housing condition, and place of residence, HR = Hazard Ratio, MI: Median Income, * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 3. 5 revealed the combined effects of asset and income on mortality. Compared to non-poor, income poor only were 1.067 times more likely to die (95% CI: 1.044, 1.091), and people who were asset poor only were 1.210 times more likely to die (95% CI: 1.195, 1.225). Also, the hazard ratio for asset-poor and income poor was significantly higher than that of non-poor (*HR*: 1.291, 95% CI: 1.263, 1.320). We found a similar pattern when we categorized older adults into three groups. Among those aged 65 to 74, the hazard ratio for asset poor and income poor was higher than that of the reference group (*HR*: 1.541, 95% CI: 1.483, 1.601, Column 2), whereas among those aged 75 to 84, asset poor and income poor were 1.239 times more likely to die compared to the reference group (Column 3). The hazard ratio of asset poor and income was still higher among those aged 85 and over (*HR*: 1.072, 95% CI: 1.028, 1.118) but the hazard ratio of income poor was not significant (*HR*: 1.033, 95% CI: 0.992, 1.076), as presented in Column 4. For sensitivity analysis, we tested whether the difference in HR between three poor groups (income poor only, asset poor only, and double poor). The results showed that while double poor has higher levels of HR than income poor only or asset poor only, asset poor only were also 1.126-1.134 times more likely to die than income poor only for all age groups (aged 65 to 74, aged 75 to 84, aged 85 and over).

Table 3. 5 The combined effects of housing asset and income on mortality for different age groups

Column	(1)	(2)	(3)	(4)
Age group	Total	Aged 65 to 74	Aged 75 to 84	Aged 85 and over
	HR	*HR*	*HR*	*HR*
Non poor	1	1	1	1
Only income poor	1.067*** (1.044, 1.091)	1.099*** (1.054, 1.145)	1.054** (1.018, 1.092)	1.033 (0.992, 1.076)
Only housing asset poor	1.210*** (1.195, 1.225)	1.387*** (1.355, 1.420)	1.187*** (1.165, 1.210)	1.051*** (1.026, 1.077)
Double poor	1.291*** (1.263, 1.320)	1.541*** (1.483, 1.601)	1.239*** (1.196, 1.284)	1.072** (1.028, 1.118)

Note. The 95 percent confidence intervals are in brackets. Models adjusted for age and age-squared, sex, marital status, educational attainment, living arrangement, activity limitation, housing condition, and place of residence, HR = Hazard Ratio, MI: Median Income, * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Discussion

A growing body of literature shows a graded relationship between housing assets, income, and health among older adults. Such notions are explained by the fact that (a) income directly helps people make their ends meet (Iceland & Bauman, 2007) (b) housing assets refers to a part of cumulative advantage throughout the life course (Connolly et al., 2010; Costa-Font, 2008). In particular, housing assets can be important for well-being of older adults, since they can benefit from stored housing wealth that can be converted into consumption later in life. Despite these rationales, little is known about (a) whether income and housing assets have independent effects on older adults' health when they are concurrently taken into account (b) whether and how the value of housing affects the relationship between income level and mortality. To address these knowledge gaps, this large population-based study examined both asset- and income-based inequalities in mortality among Canadian older adults. Also, we examined how housing assets can help to mitigate mortality risks associated with income insecurity among older adults.

First, this paper confirmed the presence of substantial socioeconomic inequalities in mortality among older adults. It innovated in showing that lower levels of housing assets and income are strongly associated with mortality risk in older adults when both are concurrently taken into account. Although the associations between housing assets, income, and mortality become attenuated with age, the observed association remains

statistically significant for all age categories. This suggests that income and housing assets have different roles in achieving healthy lives. Adequate income, as a primary source of consumption, allows older adults to meet basic goods and needs (Rothwell & Robson, 2018; Rothwell & Haveman, 2013). On the other hand, housing assets can be one of the cumulative and additional advantages over the lifetime (Connolly et al., 2010). Also, given that housing is a major platform to provide healthy and supportive service that serves to meet the needs of older adults (Costa-Font, 2008), not only can higher-priced housing have better dwelling conditions, they can be situated in neighbourhoods that enable the purchase of amenities and services, as higher income does (Laaksonen et al., 2009). In other words, the ownership of housing assets enriches well-being in ways that income does not comparably achieve. This finding confirms that each socioeconomic indicator represents an independent effect when others are concurrently taken into account.

Second, we found that housing assets did not significantly mitigate the mortality risks caused by lower levels of income. Rather, the association between income and mortality is statistically significant among housing asset rich and housing asset poor, respectively. This means that although older adults can use their housing property for equity loans, as well as refinancing, housing assets do not necessarily and fully help to protect people in income poverty from mortality risks. A possible explanation for this finding is that older adults tend to be risk averse in refinancing housing assets since (a)

increased amount of debt and higher interest rates due to cash out refinance can negatively influence the rest of their life (e.g., selling home) (Rowlingson, 2006) (b) their willingness to bequeath housing assets to their offspring encourages older adults to secure housing safe as long as possible (Ronald et al., 2017). Also, it is possible that older adults may experience financial pressure from mortgage debt even after retirement (Mehdipanah et al., 2022). This seems applicable to many countries, such as Canada, where the increase of housing price may lengthen the time to pay off the mortgage (26.8% of housing asset holders are mortgagors in this study).

Last, by employing two measures of poverty, we assessed the combined effects of housing assets and income on mortality. Our findings showed that compared to those who are neither asset poor nor income poor, both asset and income poor (double poor) are the most vulnerable to mortality risks. Not only do double poor groups have less opportunity to build assets over life course, but they also might not fully benefit from private or pension plans due to eligibility or reduction in pension coverage (OECD, 2019). Such circumstances of a lack of economic resources decrease older adults' capacity to have any financial cushion that buffers them against mortality risks. For example, a lack of economic resources can elevate the severity of diseases (Emery et al., 2013) and decreases compliance with care management (Ruberman et al., 1984). This highlights the importance of social policies aimed at promoting economic prosperity (for both housing assets and income) of older adults.

There are several strengths in our study that can contribute to the literature on the effect of housing assets and income on health. First, this study relies on a large sample size, which allowed us to study heterogeneous effects on a relatively rare event. Second, to the authors' knowledge, this study is one of the first to connect asset and income levels to mortality among older adults. We further classified the study participants according to asset and income, such as non-poor, income poor only, asset poor only, and double poor, since they may have distinctive patterns of mortality inequalities. Last but not least, Results of this study on the impact of economic resources on mortality give important implications for Canadian countries where health inequalities are still salient.

The limitations should be acknowledged. First, the study survey excluded residents in collective/or institutional dwellings who may be at greater risk for mortality. Since prior literature reported that homeownership delays entry into nursing homes by helping older adults to maintain social relationships in the community (Sarma & Simpson, 2007), the inclusion of institutionalized older adults can deepen our understanding about dynamics of housing assets and mortality in older adults. Also, mortality may be inaccurate due to the loss to follow-up of subjects through migration outside of Canada. This may result in an over- or under-estimation of observed associations. Second, while the study has information for the presence of mortgage, it did not include information on whether older adults rely on the reverse mortgage or not. The identification of the use of mortgage can help to accurately understand whether cash-out refinance improves

economic well-being of older adults. Last but not least, the study measured independent variables and covariates at a single point in time, so we could not examine the effect of any variations in asset and income since the baseline. In addition, a lack of information on chronic diseases that older adults may limit our understanding of how economic resources influence health in many ways, thereby causing mortality. Future studies may wish to examine trajectories of housing assets, income, and health conditions of older adults.

Conclusion

Our results have important policy implications. First, income supports are still critical and therefore, we cannot ignore the importance of income on the belief that housing assets will offset income insufficiency in older adults. The government should (a) strengthen social policies aimed at enhancing income adequacy of older adults (b) identify what factors can drive income poverty in older adults. For example, the government can lift older adults out of poverty by, for example, increasing the benefits of existing income support programs (e.g., the Old Age Security and the Guaranteed Income Supplement) and expanding the availability of programs that provide assistance with living costs.

Second, given that asset rich but income poor groups are more likely to die, housing policies should be in balance with income support policies (Rowlingson, 2006). We can suggest policy measures for capitalization of housing assets (e.g., reverse

mortgage), which can reduce financial insecurity of older adults. Relatedly, one of the established drivers of higher house prices in Canada is the tax exemption on capital gains for the primary residence. A primary defense of this policy is that people are depending on their home equity to support their retirement. While it confers some mortality advantage, it is important to weigh its importance against the revenue that a tax on capital gains or imputed rents could generate for the government to spend on housing and/or income support programs.

Last but not least, in light of mortality inequalities among older adults, policymakers should make efforts to identify those who are at higher risks of mortality, such as housing asset poor and income poor. In healthcare settings, diagnostic risk screening can be provided to reduce mortality through early detection and treatment.

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Ethics approval

The Statistics Canada Policy Committee approved this linkage data.

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Supplemental Table

Supplemental Table 3. 1 The interactive effects of housing asset and income on mortality for different age groups

Column	(1)	(2)	(3)
Age group	Aged 65 to 74	Aged 75 to 84	Aged 85 and over
	HR	*HR*	*HR*
Income (ref: above 200% of MI)			
150-200% of MI	1.164*** (1.073, 1.263)	1.017 (0.948, 1.090)	0.983 (0.899, 1.076)
100-150% of MI	1.178*** (1.093, 1.271)	1.074* (1.009, 1.143)	0.996 (0.920, 1.078)
50-100% of MI	1.315*** (1.215, 1.423)	1.114** (1.048, 1.184)	1.127** (1.043, 1.218)
Below 50% of MI	1.198** (1.047, 1.371)	1.076 (0.961, 1.204)	1.034 (0.907, 1.177)
Housing asset (ref: Housing asset, 20+ years)			
Housing asset (15-19 years)	1.070 (0.665, 1.720)	1.276 (0.906, 1.796)	1.106 (0.722, 1.692)
Housing asset (10-14 years)	1.013 (0.666, 1.539)	0.869 (0.631, 1.197)	0.896 (0.602, 1.334)
Housing asset (<10 years)	0.994 (0.673, 1.468)	0.958 (0.718, 1.278)	0.929 (0.637, 1.355)
No housing asset (Renters)	1.314 (0.907, 1.904)	1.074 (0.814, 1.417)	0.960 (0.683, 1.348)
Income X Housing asset			
150-200% of MI X Housing asset (15-19 years)	0.937 (0.813, 1.079)	0.990 (0.877, 1.117)	1.079 (0.918, 1.268)
150-200% of MI X Housing asset (10-14 years)	0.909 (0.782, 1.057)	1.006 (0.883, 1.145)	1.005 (0.853, 1.185)
150-200% of MI X Housing asset (<10 years)	0.990 (0.830, 1.181)	1.043 (0.900, 1.209)	0.992 (0.825, 1.193)
150-200% of MI X No housing asset	0.999 (0.828, 1.206)	1.052 (0.898, 1.233)	1.024 (0.857, 1.223)

100-150% of MI X Housing asset (15-19 years)	1.057 (0.929, 1.203)	0.911 (0.817, 1.017)	1.144 (0.990, 1.322)
100-150% of MI X Housing asset (10-14 years)	0.986 (0.858, 1.132)	1.003 (0.895, 1.125)	1.067 (0.923, 1.234)
100-150% of MI X Housing asset (<10 years)	1.062 (0.907, 1.244)	1.027 (0.901, 1.171)	1.021 (0.869, 1.200)
100-150% of MI X No housing asset	1.134 (0.969, 1.327)	1.014 (0.884, 1.162)	1.014 (0.870, 1.181)
50-100% of MI X Housing asset (15-19 years)	0.982 (0.859, 1.123)	0.943 (0.846, 1.051)	0.983 (0.850, 1.135)
50-100% of MI X Housing asset (10-14 years)	0.960 (0.835, 1.103)	1.022 (0.913, 1.143)	0.989 (0.861, 1.135)
50-100% of MI X Housing asset (<10 years)	1.056 (0.902, 1.235)	1.058 (0.932, 1.200)	0.950 (0.814, 1.109)
50-100% of MI X No housing asset	1.189* (1.021, 1.385)	1.029 (0.904, 1.171)	0.907 (0.785, 1.047)
Below 50% of MI X Housing asset (15-19 years)	1.070 (0.843, 1.357)	0.934 (0.768, 1.136)	1.093 (0.870, 1.374)
Below 50% of MI X Housing asset (10-14 years)	1.034 (0.831, 1.288)	1.027 (0.855, 1.233)	1.109 (0.902, 1.365)
Below 50% of MI X Housing asset (<10 years)	1.211 (0.984, 1.491)	1.064 (0.896, 1.264)	1.081 (0.884, 1.322)
Below 50% of MI X No housing asset	1.334** (1.100, 1.617)	1.101 (0.932, 1.300)	1.031 (0.858, 1.240)

Note. The 95 percent confidence intervals are in brackets. Models adjusted for age and age-squared, sex, marital status, educational attainment, living arrangement, activity limitation, housing condition, and place of residence, HR = Hazard Ratio, MI: Median Income, * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

CHAPTER 4: THE ASSOCIATION BETWEEN HOUSING COST BURDEN AND AVOIDABLE MORTALITY IN WEALTHY COUNTRIES: CROSS-NATIONAL ANALYSIS OF SOCIAL AND HOUSING POLICIES, 2000-2017

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Abstract

Objectives: It has been shown that high cost of housing can be detrimental to individual health. However, it is unknown (a) whether high housing costs pose a threat to population health and (b) whether and how social policies moderate the link between housing cost burden and mortality. This study aims to reduce these knowledge gaps.

Methods: Country-level panel data from OECD countries are used. Housing cost to income ratio and age-standardized mortality were obtained from the OECD database. Fixed effects models were conducted to estimate the extent to which the housing cost to income ratio is associated with preventable mortality, treatable mortality, and suicides. In order to assess the moderating effects of social and housing policies, different types of social spending per capita as well as housing policies are taken into account.

Results: Housing cost to income ratio was significantly associated with preventable mortality, treatable mortality, and suicide during post-Global Financial crisis (2009-2017) but not during pre-Global Financial Crisis (2000-2008). Social spending on pension and unemployment decreases the levels of mortality rate associated with housing cost burden. In countries with social housing stock, the link between housing cost burden and mortality was attenuated. Similar patterns were examined for countries with rent control.

Conclusions: Our findings suggest that housing cost burden can be related to population

health. Future studies wish to examine the role of protective measures that alleviate health problems caused by housing cost burden.

Keywords: Housing cost burden; avoidable mortality; deaths of despair; social spending; housing policy

Highlights

- An increased level of housing cost to income was associated with preventable mortality, treatable mortality, and suicide rate in developed countries during post-Global Financial Crisis (2009-2017).
- Social spending on pension and unemployment moderated the link between housing cost to income and mortality rate.
- Housing policy measures, such social housing stocks and rent control, helped to prevent people from experiencing mortality risks caused by housing cost burden.

Introduction

Background

Housing cost burden is a growing concern in many countries. Wage increases have not been able to completely catch up an increase in housing costs (Kemp, 2015). This negatively influences households' ability to make ends meet as a result of a decrease in post-shelter income. Also, unpredictable and depreciated housing market have not helped homeowners to cash out against their housing property in a timely manner (Wetzstein, 2017). Rather, an increasing number of households give up becoming homeowners because threatening housing market and strict mortgage practice may lead to economic insecurity of households (Izuhara, 2016). This in turn substantially increases demand for rental housing than expected (Hochstenbach & Ronald, 2020). Indeed, this trend is pronounced in aftermath of Global Financial Crisis (hereafter GFC) where many households are forced to quit jobs and face material hardship (Pittini, 2012; Harvard Univeristy, 2020). Although wealthy countries have promoted the ownership of housing through measures, such as tax relief and interest-free down-payment assistance loans, they have not paid attention to affordable housing policies aimed at providing benefits for renters (e.g., social and public housing) (Dewilde, 2018; Hochstenbach & Ronald, 2020). As such, these circumstances may endanger the living standards of socioeconomic

disadvantaged households, such as lower income households, who are at higher risks of housing insecurity (Kemp, 2015)

Housing cost burden may be related to health through three major pathways that are not necessarily mutually exclusive. First, when housing cost burdened households may experience decline in physical health, such as nutrient deficiency and (diet-related) chronic conditions (Stupplebeen, 2019) since housing cost burden discounts consumption of essential goods, such as healthcare and food. By delaying necessary healthcare services due to a lack of post-shelter income, households may be forced to be hospitalized in the long run (Kushel et al., 2006; Stahre et al., 2015). Second, housing cost burden can provoke psychological concerns. Given that housing cost burden may cause threatening situations (e.g., eviction and arrears), people may feel not being able to independently control over their life. Prior studies documented a well-established link between housing cost burden and mental health, such as depression and anxiety (Burgard et al., 2012; Lee et al., 2016). Third, such stressors may influence households to attempt unhealthy behaviors, such as smoking and problematic drinking (Stahre et al., 2015). These can manifest in those who tend to rely on maladaptive coping strategies for stress-relief.

These potential mechanisms can be explicable to population level. People are likely to become frustrated and threatened by rapid increase in living expenses, and also, they might even perceive housing cost burden to be unfair. As a result, this leads to

hypertension and stress-related disorders (Ellen et al., 2001), and violent behaviors (Downing, 2016). More importantly, this phenomenon revisits the notion of *disease (or deaths) of despair*, which displays the association between hopelessness, depression and despair related illness/or death (e.g., depression, suicide/suicidal thoughts, and alcohol related diseases) (Case & Deaton, 2020). Scholarship argues that disease of despair has remarkably soared during economic transition, such as income inequality, unemployment, and poverty, since negative circumstances cause cognitive (e.g., thought connected to defeat), emotional (e.g., feelings of sadness), behavioral despair (e.g., self-destructive acts). Given that housing cost burden signals cost of living crisis, disease of despair can be caused by housing cost burden (Venkataramani & Tsai, 2020). Consistent with this explanation, the global financial crisis (hereafter GFC) lead to economic recession, which resulted in job loss, material hardship, and housing cost burden (Pittini, 2012; Harvard Univeristy, 2020) and also, this has brought eviction and foreclosure-related suicides (Fowler et al., 2015).

The relationship between housing cost burden and health can vary according to social and housing policies. First, social policies ensure all households get equal access to services that are essential to health maintenance. For example, healthcare policies, such as preventive care (e.g., immunization, health promotion program, and regular health check-ups), help to universally promote health, since they *directly* provide necessary services and encourage people to manage their health, regardless of their socioeconomic status

(Stuckler et al., 2009). Second, social policies, such as pension and housing, can *indirectly* affect health outcomes in a way that addresses causes of the causes of health. They can mitigate unequal exposure to/and uncertainty of socioeconomic and environmental risk factors by, for example, supplementing income and preventing material hardship (Kalousová & Evangelist, 2019). Particularly, disadvantaged people, such as lower-income households and unemployed, tend to largely benefit from these policies, since such social programs can protect them from financial strain. This in turn alleviates their risks of disease and mortality. Empirical studies are congruent with these explanations, showing that social spending decreased mortality risks (Stuckler et al., 2010), suicide rates (Nelson & Fritzell, 2014), and food insecurity (Loopstra et al., 2016).

Research aims

Using a series of dataset for the Organization for Economic Co-operation and Development (hereafter OECD) countries, this study examines the association between housing cost relative to income and mortality rates in wealthy countries. This study estimates fixed-effects models to gauge within-country changes in mortality rate explained by housing cost-to-income ratio. This study also investigates whether the housing-mortality association varies by social spending as well as housing policies. In doing so, we assess the role of protective policies that can mitigate mortality rate in countries with housing cost burden.

Data and Methods

Data were collected for OECD member countries between 2000 and 2019 to test the hypothesis that rising trends of unaffordable housing – housing cost relative to disposable income at the national level are associated with mortality rates in wealthy countries. Our study subjects include 27 countries: Australia, Austria, Belgium, Canada, Czech Republic, Estonia, France, Finland, Germany, Greece, Hungary, Japan, Latvia, Luxembourg, Lithuania, the Netherlands, Norway, New Zealand, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, the UK and the US, from 2000 to 2017 (or the latest available year). We assumed that mortality rates tend to increase as the crisis goes on, rather than at the beginning of the recession (Laliotis et al., 2016). Thus, we also examined whether housing cost burden is associated with mortality during pre-GFC (2000-2008) and post-GFC (2009-2017). We then evaluate whether and how different types of social spending and housing policies moderate the impact of housing on mortality rates. All data are online and freely available from the OECD.

Dependent variables: Avoidable mortality and deaths of despair

This study uses two mortality outcomes: avoidable mortality and suicide. First, avoidable mortality rates can be divided into preventable mortality and treatable (or amenable) mortality: (1) preventable mortality can be mainly avoided through public health policy,

such as prevention, from the viewpoint of social determinants of health (e.g., intentional self-harm) and (2) treatable mortality can be timely prevented through healthcare intervention, including secondary treatment (e.g., diabetes and appendicitis). Second, we also test whether suicides are related to housing cost burden. Case and Deaton (2020) argued that behavior-related mortality (e.g., mainly drug overdose and suicide) are on the rise in the US (among the less educated whites, aged 50 to 65) since many people experience despair and hopelessness caused by economic downturn (Case & Deaton, 2020). Here, we use suicide rates as a proxy for deaths of despair. Note that suicides belong to the category of avoidable mortality. Mortality rate is age-standardized, number of deaths per 100,000 people an OECD standard population.

Independent variable of interest: Housing cost-to-income ratio

To obtain country-level data on housing cost burden, we used housing cost to income ratio available from the OECD database (OECD, 2020). Housing spending in households, which includes actual rentals (for tenants), imputed rentals (for owner-occupiers), maintenance, and others, is presented as a percentage of household disposable income. The data is taken from the OECD Annual National Accounts Database on Financial consumption expenditure of households. We assume that this indicator enables us to assess the degree to which households can afford housing relative to their income as socioeconomic position.

Moderating variables: Social spending and housing policy measures

First, data on social spending per capita was collected from the OECD Social Expenditure Database (SOCX), which includes a range of programs, including pension and unemployment benefits, health, and housing (OECD, 2022b). Second, this paper examines the effect of two housing policy measures on mortality outcomes: the size of a country's social housing stock and the presence of rent control. We define higher social housing stock if social housing accounts for more than 10% of total housing stock (5 out of 27 countries). Rent control includes (a) controls on initial rent levels or/and (b) regulated and/or negotiated rents applied across rental sectors (13 out of 27 countries). These measures capture whether a country supports socioeconomically disadvantaged people to afford rental housing. Data on housing policy measures are available from the OECD Affordable Housing Database (OECD, 2022a).

Statistical models

For analysis, we used fixed effects linear regression, which can control for unobservable time-invariant country-level confounding factors, such as social, cultural, and other conditions that are constant. That is, we can solely estimate within-country changes in mortality predicted by within-country changes in housing cost burden. Our first fixed-effects, or within-country, regression model is as follows:

$$Mortality_{it} = \beta_1 Housing\ cost\ burden_{it} + \beta_2 Control_{it} + Year_t + \mu_i + \varepsilon_{it}$$

Here, *i* is country and *t* is year. *Mortality* is mortality rate; *Housing cost burden* is the aforementioned measure of house cost to income; β_2 is a vector of time-varying control variables. Control variables are composed of GDP (adjusted for purchasing power parity). They are related to both independent and dependent variables in our study (Reeves et al., 2015), and also capture the direct effects of the recession on mortality rates. *Year* is a set of variables that control for year-specific effects on mortality. μ controls for country-specific, time-invariant error terms. ε is the error term that varies with country and time.

Next, moving to the second step of the analysis, we (a) tested whether (time varying) social spending moderate the relationship between housing cost burden and mortality rate using a series of interaction terms with indicators of social spending (b) conducted stratified analysis to estimate the association between housing cost burden and mortality according to (time invariant) housing policies (social housing stock and rent control). For all analyses, we used the "*xtreg*" command in Stata/SE 15.0 and 95% confidential intervals (hereafter 95% CI) are calculated based on robust standard errors.

Results

Housing cost burden and mortality

Table 4. 1 shows the association between housing cost burden and mortality, taking into account control variables. In Panel A, we saw no association between housing cost burden and mortality rates during the pre-GFC period, for preventable and treatable mortality rates (β = -0.311, 95% CI: -6.235, 5.611 and β = 0.815, 95% CI: -3.172, 4.801). However, in Panel B, we saw a statistically significant association between housing cost burden and preventable mortality rate (β = 2.808, 95% CI: 0.086, 5.530) and treatable mortality rate (β = 1.554, 95% CI: 0.424, 2.683) during the post-GFC period between 2009-2017. An increase in housing cost burden is also associated with 0.552 increase in suicide rates during post-GFC period (95% CI: 0.015, 1.090).

Table 4. 1 An association between housing cost burden, avoidable mortality, and suicide rates across OECD member countries

Panel A. ***Pre-Global Financial Crisis***	*B* (95 % CI)	*B* (95 % CI)	*B* (95 % CI)
Per 1% increase in housing costs to income	-0.311 (-6.235 to 5.611)	0.815 (-3.172 to 4.801)	0.621 (-0.213 to 1.456)
Per $100 rise in GDP per capita	-0.019 (-0.091 to 0.052)	0.014 (-0.023 to 0.051)	0.007 (-0.007 to 0.020)
Country-years	227	227	227
Countries	27	27	27
Panel B. ***Post-Global Financial crisis***	*B* (95 % CI)	*B* (95 % CI)	*B* (95 % CI)
Per 1% increase in housing costs to income	2.808* (0.086 to 5.530)	1.554** (0.424 to 2.683)	0.552* (0.015 to 1.090)
Per $100 rise in GDP per capita	-0.006 (-0.071 to 0.059)	0.006 (-0.025 to 0.037)	0.002 (-0.011 to 0.015)
Country-years	233	233	233
Countries	27	27	27

Note. Confidence intervals are based on robust standard errors clustered by country. All models control for year, and country-specific time trends. Column 1 shows the results for preventable mortality rates. Column 2 shows the results for treatable mortality rates. Column 3 shows the results for suicide rates. $^{***}p<0.001$, $^{**}p<0.01$, $^{*}p<0.05$

Moderating roles of social spending

Error! Reference source not found. presents the protective role of social spending in the l ink between housing cost burden and treatable mortality rate. We found that the positive interaction term between social spending on pension and unemployment and housing cost burden was statistically significant for preventable mortality as an outcome (β = -0.174, 95% CI: -0.344, -0.004 and β = -0.902, 95% CI: -1.700, -0.104). In contrast, when social spending on healthcare as well housing is above $100 per capita, the association between housing cost burden and preventable mortality rate was not mitigated. Social spending on pension has significant modifying effects on the link between housing cost burden and treatable mortality (β = -0.075, 95% CI: -0.143, -0.007), suggesting that the association between housing cost burden and preventable mortality is attenuated when social spending on pension is higher. We repeated this analysis for social spending on unemployment, healthcare, and housing but they did not significantly change the levels of treatable mortality rates associated with housing cost burden.

Table 4. 2 An association between housing cost burden and preventable and treatable mortality rate, by social spending during post economic crisis (2009-2017)

	B (95 % CI)	*B* (95 % CI)	*B* (95 % CI)	*B* (95 % CI)	*B* (95 % CI)	*B* (95 % CI)	*B* (95 % CI)	*B* (95 % CI)
Per 1% increase in housing costs to income	7.183* (0.777 to 13.588)	4.372* (0.367 to 8.378)	1.281 (-4.045 to 6.607)	3.974* (0.182 to 7.765)	3.158* (0.782 to 5.534)	1.538 (-0.269 to 3.345)	0.379 (-1.184 to 2.141)	1.945* (0.432 to 3.463)
Per $100 increase in social spending on pension per capita	2.090 (-2.474 to 6.654)				0.933 (-0.731 to 2.598)			
Housing cost to income X pension per capita	-0.174* (-0.344 to -0.004)				-0.075* (-0.143 to -0.007)			
Per $100 increase in social spending on unemployment per capita		17.089* (1.244 to 32.934)				5.540 (-2.145 to 13.225)		
Housing cost to income X unemployment per capita		-0.902* (-1.700 to -0.104)				-0.266 (-0.647 to 0.115)		
Per $100 increase in social spending on healthcare per capita			-3.265 (-8.969 to 2.438)				-2.127* (-4.093 to -0.131)	
Housing cost to income X health per capita			-0.002 (-0.216 to 0.210)				0.023 (-0.060 to 0.106)	
Per $100 increase in social spending on				26.854 (-35.789 to				4.231 (-19.950,

housing per capita				89.498)				28.411)
Housing cost to income X housing per capita				-1.777 (-4.132 to 0.578)				-0.552 (-1.501 to 0.398)
Country-years	233	233	233	233	233	233	233	233
Countries	27	27	27	27	27	27	27	27

Note. Confidence intervals are based on robust standard errors clustered by country. All models control for GDP per capita, year, and country-specific time trends. Column 1-Column 4 show the results for preventable mortality rate. Column 5-Column 8 show the results for treatable mortality rate. $^{***}p<0.001$, $^{**}p<0.01$, $^{*}p<0.05$

Table 4. 3 illustrates the moderating role of different types of social spending per capita on the relationship between housing cost burden and suicide rates. While social spending on pension, healthcare, and housing was not found to be a significant moderator that mitigates risks of suicide, an additional $100 spent on unemployment per capita reduces the link between housing cost burden and suicide rate (β = -0.129, 95% CI: -0.256, -0.001).

Figure 4. 1 and **Error! Reference source not found.** show the relationship between housing cost burden and mortality according to social spending on pension and unemployment benefits. As social spending on pension or unemployment benefits increases, the predicted value of mortality rates relative to housing cost to income ratio remains constant or decreases.

Table 4. 3 An association between housing cost burden and suicide rate, by social spending during post economic crisis (2009-2017)

	B (95 % CI)	*B* (95 % CI)	*B* (95 % CI)	*B* (95 % CI)
Per 1% increase in housing cost to income	1.376* (0.090, 2.662)	0.882* (0.093, 1.167)	0.894 (-0.426, 2.215)	0.683 (-0.014, 1.380)
Per $100 increase in social spending on pension per capita	0.337 (-0.486, 1.161)			
Housing cost to income X pension per capita	-0.028 (-0.056, 0.001)			
Per $100 increase in social spending on unemployment per capita		2.204 (-0.525, 4.933)		
Housing cost to income X unemployment per capita		-0.129* (-0.256, -0.001)		
Per $100 increase in social spending on healthcare per capita			0.044 (-1.037, 1.125)	
Housing cost to income X health per capita			-0.026 (-0.073, 0.019)	
Per $100 increase in social spending on housing per capita				1.554 (-7.427, 10.535)
Housing cost to income X housing per capita				-0.150 (-0.525, 0.225)
Country-years	233	233	233	233
Countries	27	27	27	27

Note. Confidence intervals are based on robust standard errors clustered by country. All models control for GDP per capita, year, and country-specific time trends. $^{***}p<0.001$, $^{**}p<0.01$, $^{*}p<0.05$

Figure 4. 1 The association between housing cost burden and mortality, by social spending on pension

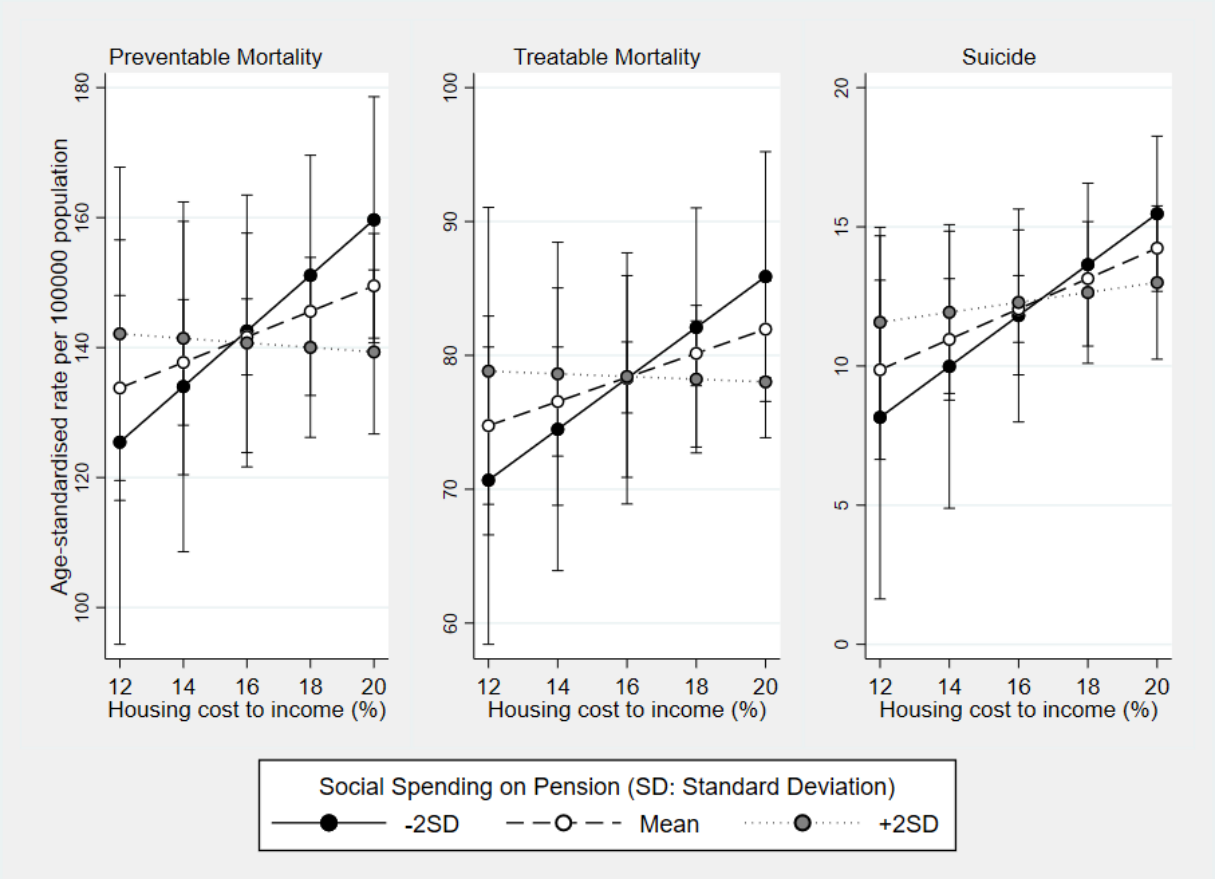
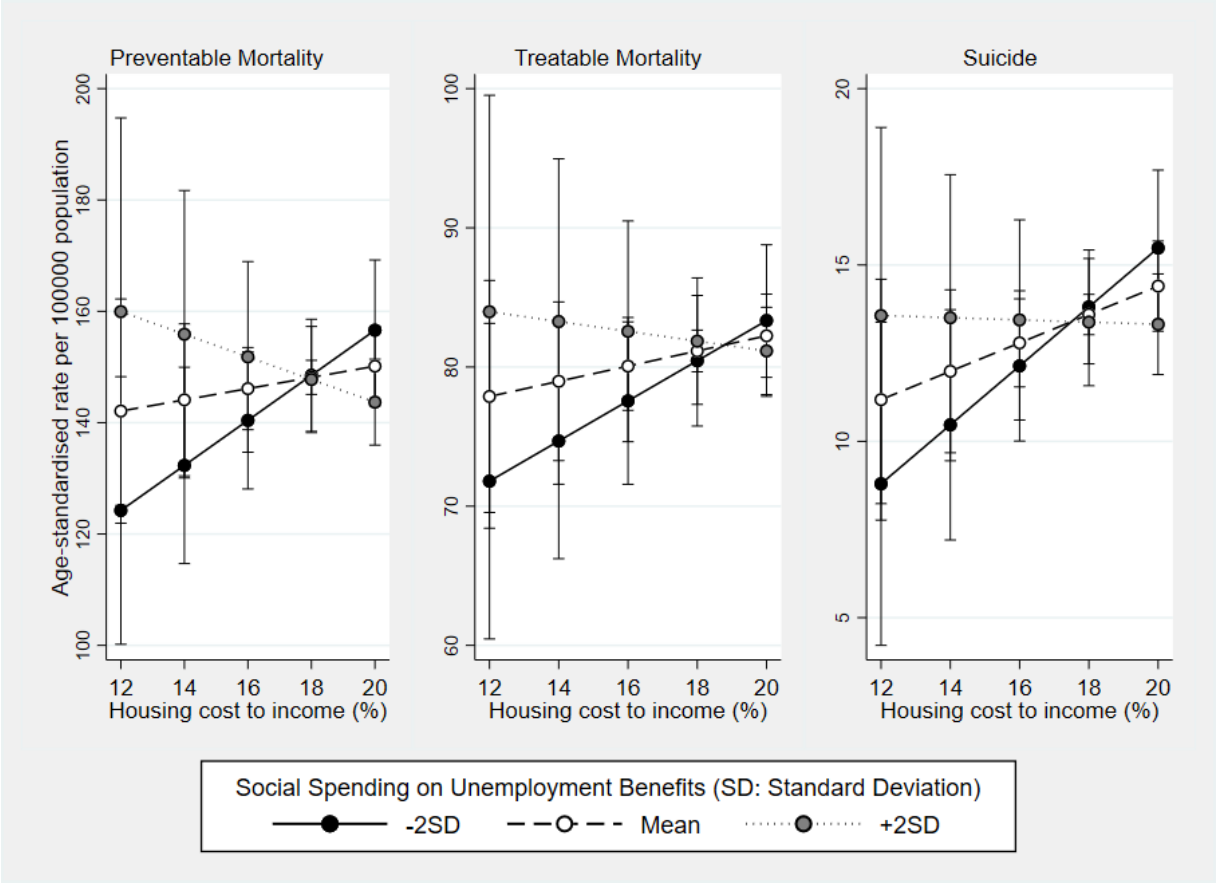


Figure 4. 2 The association between housing cost burden and mortality, by social spending on unemployment benefits



Moderating roles of housing policy measures

We further tested whether housing policy measures changes the levels of mortality rate associated with housing cost burden (Table 4. 4). Panel A-1 and Panel A-2 indicates results for the association between housing cost burden and mortality rate by social housing stock. As shown in Panel A-1, in countries with lower stocks of social housing, housing cost burden was significantly associated with preventable mortality (β = 3.014, 95% CI: 0.133, 5.894), treatable mortality (β = 1.484, 95% CI: 0.197, 2.772), and suicide rate (β = 0.647, 95% CI: 0.100, 1.194). However, Panel A-2 shows that the observed association was attenuated in countries with larger social housing stocks for preventable mortality (β = -4.891, 95% CI: -7.344, -2.437), treatable mortality (β = 0.066, 95% CI: -1.642, 1.775), and suicide rates (β = -0.963, 95% CI: -2.633, 0.707).

We found a similar pattern for rent control (Panel B-1 and Panel B-2). Countries that do not have rent control still had a significant association between housing cost burden and preventable mortality (β = 4.119, 95% CI: 0.014, 8.225) and suicide (β = 0.877, 95% CI: 0.050, 1.704), whereas countries that do control rent levels did not show any significant association between housing cost burden and mortality, including preventable mortality (β = 0.236, 95% CI: -4.103, 4.575), treatable mortality (β = 0.692, 95% CI: -1.336, 2.720), and suicide (β = 0.165, 95% CI: -0.546, 0.875), respectively.

Table 4. 4 An association between housing cost burden and mortality rate, by housing policy measures during post economic crisis (2009-2017)

Panel A-1. Low social housing stock	*B* (95 % CI)	*B* (95 % CI)	*B* (95 % CI)
Per 1% increase in housing cost to income	3.014* (0.133, 5.894)	1.484* (0.197, 2.772)	0.647* (0.100, 1.194)
Country-years	191	191	191
Countries	22	22	22
Panel A-2. Higher social housing stock	*B* (95 % CI)	*B* (95 % CI)	*B* (95 % CI)
Per 1% increase in housing cost to income	-4.891** (-7.344, -2.437)	0.066 (-1.642, 1.775)	-0.963 (-2.633, 0.707)
Country-years	42	42	42
Countries	5	5	5
Panel B-1. No rent control	*B* (95 % CI)	*B* (95 % CI)	*B* (95 % CI)
Per 1% increase in housing cost to income	4.119* (0.014, 8.225)	2.052 (-0.035, 4.137)	0.877* (0.050, 1.704)
Country-years	120	120	120
Countries	14	14	14
Panel B-2. Rent control	*B* (95 % CI)	*B* (95 % CI)	*B* (95 % CI)
Per 1% increase in housing cost to income	0.236 (-4.103, 4.575)	0.692 (-1.336, 2.720)	0.165 (-0.546, 0.875)
Country-years	113	113	113
Countries	13	13	13

Note. Confidence intervals are based on robust standard errors clustered by country. All models control for GDP per capita, year, and country-specific time trends. Column 1 shows the results for preventable mortality rate. Column 2 shows the results for treatable mortality rate. Column 3 shows the results for suicide rate. $^{***}p<0.001$, $^{**}p<0.01$, $^{*}p<0.05$

Figure 4. 3 and Figure 4. 4 plot results of the relationship between housing cost burden and mortality according to housing measures. As shown in Figure 4. 3, the predicted value of mortality is higher when housing cost burden increases in countries with lower social housing stock, whereas the predicted value decreases or remains constant in countries with higher social housing stock. Similar patterns were found for rent control (Figure 4. 4). The association between housing cost burden and mortality is more pronounced in countries without rent control, whereas the link between housing cost burden and mortality is attenuated in countries with rent control.

Figure 4. 3 The association between housing cost burden and mortality, by social housing stock

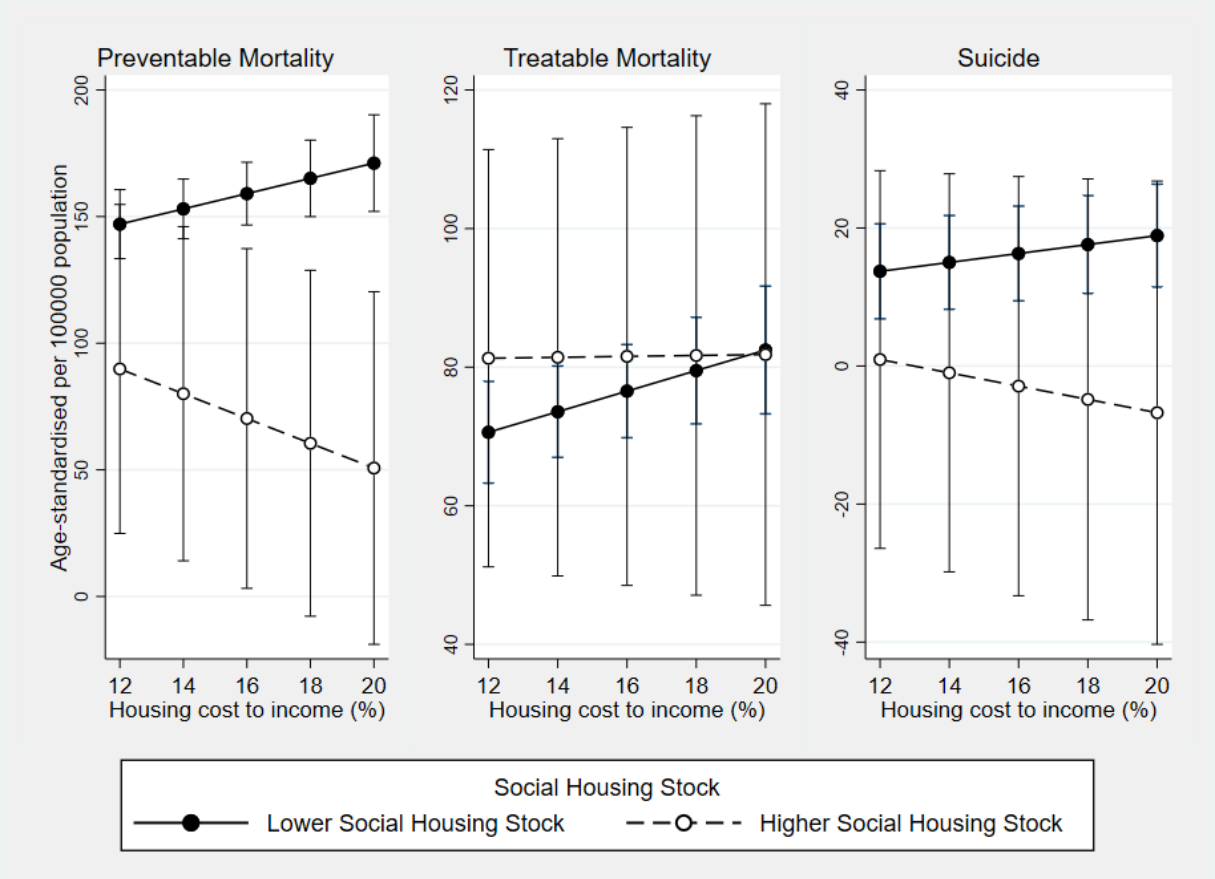
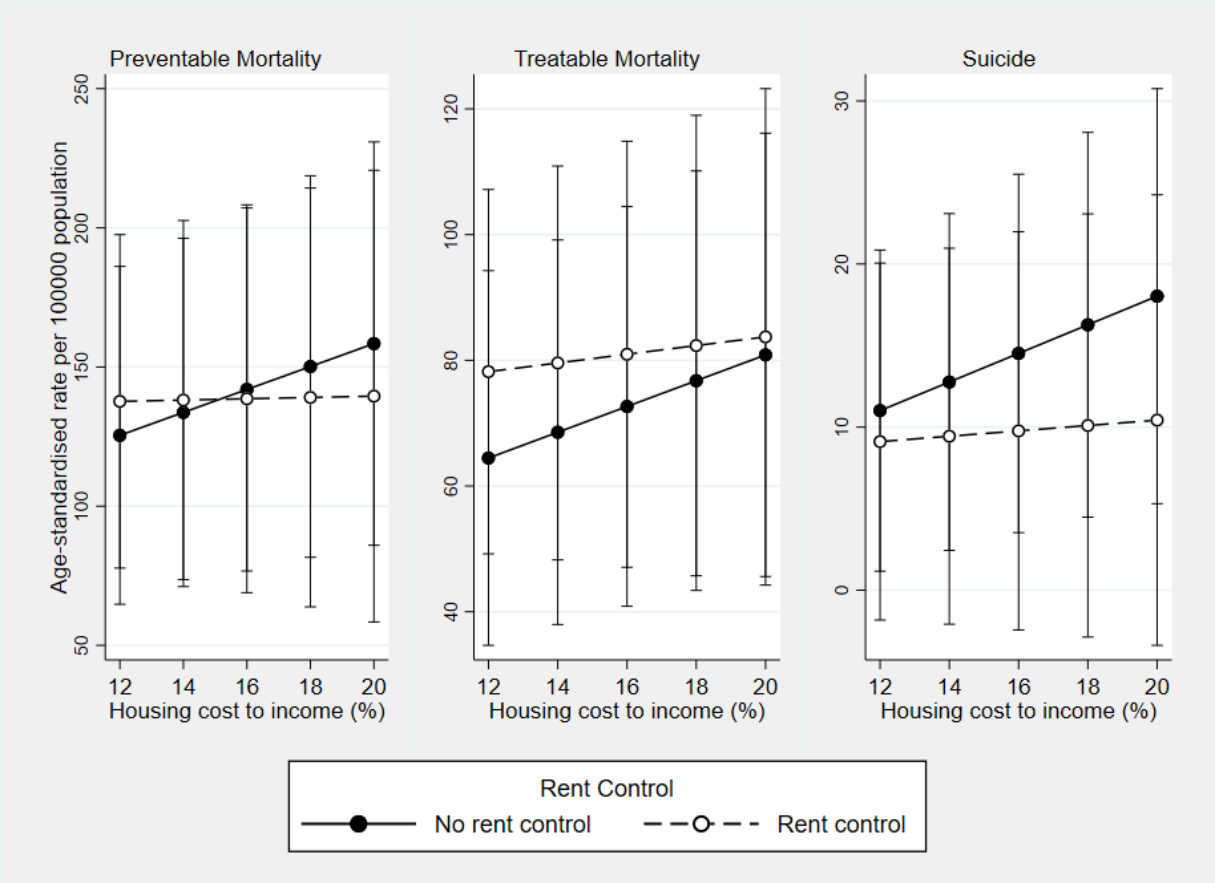


Figure 4. 4 The association between housing cost burden and mortality, by rent control



Discussion

Despite a well-documented link between housing cost burden and health at the individual level, how housing cost burden relates to population health at the societal level is understudied. Also, few studies examined the distinctive roles of social policies and housing policies in mitigating the link between housing cost burden and population health. The present study aims to examine whether unaffordable housing at the societal level is associated with greater risk of avoidable mortality and deaths of despair (particularly suicide). We further assessed the moderating effects of social spending and housing policy measures on the link between housing cost burden and mortality rate. There are several important findings in the foregoing analysis.

First, analyses showed that housing cost burden predicted a higher level of avoidable mortality and suicide rates in wealthy countries during the post-Global Financial crisis (2009-2017). Given that not only does housing cost burden provoke concerning feelings (e.g., despair and hopelessness), but this also increases risks of illness and disease (Case & Deaton, 2020; Laliotis et al., 2016), the GFC can deteriorate such risks. For example, people are more likely to be concerned about housing insecurity (e.g., eviction, foreclosure, and rent arrears) in responses to housing cost burden as they are at higher risks of unemployment and wage loss in the aftermath of the GFC. It suggests that the GFC includes short and long term socioeconomic difficulties that pose mortality risks

(Reeves et al., 2015).

Second, we also demonstrated that social spending on old-age and unemployment benefits was significantly associated with lower mortality rates. This finding aligns with existing studies that social spending buffers households against economic hardship (R Loopstra et al., 2016; Stuckler et al., 2009). Social spending may have an important role in reducing economic hardship by helping households to earn additional income for their survival (Kalousová & Evangelist, 2019; Stuckler et al., 2009). While plausible, it should be interpreted with caution since social spending on health care and housing did not significantly moderate the link between housing cost burden and mortality rates. Usually, spending on healthcare can be positively associated with economic stress in parts because healthcare is reactive measures, such as characterized by an increasing demand due to life expectancy, rather than preventive one.

More importantly, results of this study estimated the influence of housing policy measures. First, social housing for broad segments of the population appears to be associated with lower mortality risks. Social housing sectors potentially promote housing security of households because they can find out alternative options rather than being overwhelmed by priced rented housing. Second, rent controls intend to keep living cost affordable particularly for lower income residents by limiting the amount that landlords can demand for leasing a home. Overall, these protective measures protect households

against suffering from housing cost induced stressors (e.g., reduced post-shelter income or feeling of despair and hopelessness) by reducing the likelihood of negative events (e.g., eviction) or alleviating psychological stress (Boelhouwer, 2020; Elsinga & Hoekstra, 2005). This result can highlight that premature death, such as suicide, could be avoided through effective social spending as well as housing policy measures.

There are several limitations to this study. First, the data does not provide information for housing cost burden or mortality rates by socioeconomic groups. While this study has investigated true 'population-level' attributes of countries and their impact on mortality consistent with concepts such as "social facts" and population health (Rose, 1985), future studies would ideally have individual-level and country-level data so that nested analysis of individuals nested in macro contexts could be conducted. Second, although we identified the moderating effects of social spending, we did not separate different programs within each category. For example, there are policy changes, such as expansion/or reduction of social housing stock, in some countries, while others may introduce new housing programs. More work is needed to understand how changes in particular programs moderate the association between housing cost burden and health.

Despite its limitations, the study has several strengths. First, this is one of the first studies to assess the association between housing cost burden and mortality rates. We were able to assess within-country variations in avoidable mortality rates associated with

housing cost burden. Second, this study demonstrated the extent to which protective policies may mitigate risks of mortality associated with housing cost burden. In particular, the use of unmeasured housing policy measures, such as existing social housing stock and rent control, facilitate our understanding of how indirect housing policies helps to alleviate the link between housing cost burden and mortality. Our study provides compelling evidence of (a) how housing cost burden since the GFC causes mortality (b) why social policies remain important to improve population health.

Given that many countries have been experiencing increasing housing burden issues for many years, results of the study provide meaningful implications. Housing cost burden can cause economic insecurity, and as a result, increase mortality risks. Furthermore, this study highlights that social policies can protect households from experiencing mortality risks. Unfortunately, since there was a growing pressure to cut back on social spending after the economic crisis, an increasing number of households are faced with housing cost burden. Therefore, more research is needed to illustrate potential mechanisms how health inequalities associated with housing cost burden may be alleviated by social policies. Particularly, housing policies need to be considered for better understanding of protective factors for adverse health consequences caused by housing cost burden.

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Supplemental Table

Supplemental Table 4. 1 Description of variables and data sources of research

Variables	Description	Data source
Dependent variables		OECD Health data
Preventable mortality rate	Deaths that could have been avoided by public health interventions focusing on wider determinants of public health *(age-standardized rate per 100000 population)*	
Treatable mortality rate	Deaths that could have been avoided through optimal quality health care *(age-standardized rate per 100000 population)*	
Suicide rate	Deaths from suicide and intentional self-harm *(age-standardized rate per 100000 population)*	
Independent variables		
Housing cost to income (%)	Housing costs as % of household disposable income	OECD National Accounts
Moderating variables		
Public spending per capita (US $100)		OECD Social Expenditure Database
Pension	Income for retirees, early retirement pensions, and services for the elderly people (other than medical care)	
Unemployment benefits	Cash benefits and benefits in kind for people to compensate for unemployment	
Health	Healthcare goods and services, including personal care and collective services	

Housing	Housing related cash benefits and benefits in-kind (e.g., housing/rent assistance and subsidies)	
Housing policy measures		OECD Affordable Housing Database
Social housing	Social rental dwellings as share of total dwellings	
Rent control	Restriction on initial rent levels and/or rent level increases	
Control variables		
GDP per capita	Real GDP per capita in constant dollars	OECD National Accounts

Supplemental Table 4. 2 Descriptive statistics of variables

	1. Mortality rate (age standardized rate per 100000)			2. Housing cost burden (%)	3. Public spending per capita (US $100)				4. Housing policies	
	1.1 Preventable mortality	1.2 Treatable mortality	1.3 Suicide		3.1. Pension	3.2. Unemployment benefit	3.3. Health	3.4. Housing	4.1. Rent control	4.2. Higher social housing stock
AUS	109.71	61.35	11.56	17.18	20.93	2.72	24.99	1.39	N	N
AUT	138.06	68.88	14.57	15.99	54.74	4.94	30.80	0.62	Y	Y
BEL	142.82	70.88	17.92	15.96	34.49	13.71	31.87	0.71	Y	N
CAN	130.06	69.39	11.14	18.58	16.92	2.82	29.28	1.69	Y	N
CHE	104.00	51.89	14.57	19.39	36.38	4.73	16.33	1.39	Y	N
CZE	186.44	126.00	13.95	20.60	21.34	1.77	17.14	0.43	N	N
DEU	133.89	78.94	11.10	18.03	37.75	5.70	34.23	2.37	Y	N
ESP	112.61	64.00	7.16	16.85	26.54	7.82	20.79	0.54	N	N
EST	274.76	146.59	18.65	16.96	16.06	0.74	10.80	0.12	N	N
FIN	154.76	74.71	18.08	18.82	40.00	8.05	21.60	1.84	Y	Y
FRA	124.76	58.41	15.85	17.54	45.00	6.14	32.83	3.24	Y	Y
GBR	135.13	85.25	6.94	21.41	24.23	1.13	29.73	5.75	N	Y
HUN	304.06	164.44	23.12	16.47	19.72	1.31	11.97	1.12	N	N
ITA	100.80	60.13	5.92	17.68	48.61	2.80	25.46	0.09	N	N
JPN	111.56	58.78	20.26	19.89	34.10	1.11	25.54	0.33	N	N
LTU	329.61	178.50	35.11	13.64	14.32	0.56	9.81	0.05	N	N
LUX	127.67	66.33	11.59	17.99	59.75	10.12	52.09	2.29	N	N
LVA	323.83	194.72	22.34	18.98	13.85	1.12	6.76	0.21	N	N
NLD	116.11	67.94	9.52	15.64	26.65	6.18	19.25	1.79	Y	Y
NOR	119.35	65.18	11.31	14.89	41.12	2.55	31.92	0.85	N	N
NZL	130.59	81.29	12.26	15.88	15.23	1.84	23.78	2.68	Y	N

POL	204.06	122.29	14.69	18.29	20.02	0.78	9.46	0.18	Y	N
PRT	123.92	77.54	9.28	14.67	30.88	3.27	18.59	0.01	Y	N
SVK	235.83	169.17	12.05	26.16	13.52	1.00	11.92	0.09	N	N
SVN	175.44	83.44	21.51	15.79	28.33	1.70	17.92	0.04	N	N
SWE	109.56	65.22	12.12	18.29	40.12	3.07	28.19	2.12	Y	N
USA	181.44	97.22	12.29	15.96	29.99	2.09	39.16	1.55	Y	N

CHAPTER 5: CONCLUSIONS

This dissertation offers insights into the role of housing as a determinant of health. Despite a well-documented association between housing characteristics (e.g., homeownership and housing cost burden) and health, little is known about whether and how (a) different measures of housing cost burden influence health outcomes; (b) housing assets interact with income, thereby influencing the mortality risks of older adults; and (c) protective measures can alleviate mortality risks predicted by housing cost burden. To reduce knowledge gaps, I synthesized the extant literature on housing cost burden and health (Chapter 2) and conducted two empirical studies (Chapters 3 and 4). Not only does this dissertation contribute to the extant literature by articulating the health consequences of multifaceted housing problems but it also has implications for programmes and interventions to reduce health disparities associated with housing problems. The final chapter discusses the main findings of the three studies and explains their strengths and limitations. Based on the findings, future studies and policy implications are discussed.

Summary of the Findings

The first paper (Chapter 2) synthesized existing evidence that estimates the association between the housing cost burden and health outcomes. The review found that the housing

cost burden is associated with health outcomes, particularly psychological health, physical health, and healthcare utilization. The findings of prior literature can be explained by potential mechanisms, such as the discounting of health-promoting consumption and stress from a lack of post-shelter income. The review offers two key findings: (a) the link between housing cost burden and health is pronounced among disadvantaged people, including lower-income households, renters and unemployed persons and (b) the association between housing cost burden and health is statistically significant in a cross-sectional study design but not necessarily in a longitudinal study design. The first finding shows the necessity of support for interventions and programmes aimed at reducing the housing cost burden for these groups. The second finding proposes methodological directions for future research. In summary, Chapter 2 highlights the importance of the housing cost burden as a social determinant of health.

The second paper (Chapter 3) yielded important insights into health inequalities among older adults in Canada. This paper addressed two research questions: (1) How are housing assets and income associated with the mortality of older adults? (2) To what extent do housing assets alleviate mortality risks associated with income (in)security? The findings revealed that both housing assets and income are predictors of mortality among older adults. Another important finding is that levels of housing assets did not significantly moderate the observed link between income and mortality. This does not

support the concept of an asset-based welfare system which encourages the ownership of housing assets as a replacement for welfare in later life. Rather, this corresponds to the statement that emphasis on homeownership leads to greater risks for some older adults who have not been able to achieve homeownership (Doling & Ronald, 2010). A more appropriate interpretation may be that housing assets and income have independent roles that influence the health and wellbeing of older adults. Additionally, the findings support the notion that socioeconomic gaps in mortality continue even among older adults (Benzeval et al., 2011).

The third paper (Chapter 4) tested two hypotheses: (a) whether the housing cost burden increases avoidable mortality rates in wealthy countries and (b) whether protective policies such as social spending, social housing stock and rent control can mitigate the impacts of the housing cost burden on mortality. This study was motivated by the fact that the ecological-level association between housing cost burden and health is understudied. The paper found that an increasing housing cost burden relative to income has more severe consequences concerning avoidable mortality, particularly suicide. Interestingly, the observed association between housing cost burden and mortality was pronounced during the post-economic crisis period (2009-2017), in which an increasing number of households experienced threatening circumstances, such as job losses and rent arrears. Additionally, social spending on pensions and unemployment benefits and housing policy

measures (e.g., rent control and social housing stock) mitigate the impact of the housing cost burden on mortality rates. This suggests that greater protective policies enhance the resilience of individuals by buffering the negative impacts of the housing cost burden and its resulting health consequences.

In summary, the main findings of the thesis have several key implications. While wealthy countries are increasingly prioritizing homeownership for economic prosperity - not only to acquire a secure place of residence but also as a means of accumulating savings and assets -, such measures may not necessarily and equally benefit all households. For example, some households such as renters and lower-income households may experience a housing cost burden. Not only do such burdens decrease one's opportunities to purchase and own a house but they also put households at elevated risks of health problems due to a decrease in post-shelter income. Additionally, homeownership-oriented policies can be concerning for older adults if they are not able to completely rely on housing for their wellbeing. In Canada, for example, older renters still have not acquired housing assets in addition to income which, in turn, increases the risks of morbidity and mortality. Overall, the three papers of the thesis demonstrate that housing dimensions, including housing cost burden and housing assets, are associated with health. However, as the fourth chapter identified, the link between housing and health can be prevented through social and housing policies. Thus, health inequalities in

housing can be addressed by implementing protective policy measures.

Contribution to Literature and Knowledge

Comprehensive understanding of the association between housing and health

While a growing body of literature is laying the foundation for an understanding of the social determinants of health (e.g., income and employment), a lack of evidence limits our understanding of how and whether housing problems including housing cost burden determine one's health and wellbeing at the individual and ecological levels. To the best of my knowledge, few studies have synthesized the mechanisms linking housing cost burden to health. This thesis, therefore, adds to the literature by articulating which mechanisms explain the link between housing cost burden and health through empirical studies. Chapter 2 also contributes to the current understanding regarding the measurement of the housing cost burden, for example, the ratio approach, the residual income approach, and self-perception of housing cost burden. This can guide scholars to adopt diverse approaches for identifying which groups tend to experience a housing cost burden and health problems.

Health inequalities in old age

Many studies argue that health inequalities decrease in older adults since disadvantaged

people already have premature mortality before they reach advanced age. However, this is not necessarily the case, as Chapter 3 identified. The chapter highlighted socioeconomic inequalities in the mortality of older adults by articulating the roles of housing assets and income. As many countries are becoming ageing societies, such topics contribute to the development of healthy ageing policies and programmes.

Preventive and protective policies

Social policies, such as public spending on unemployment benefits and pensions, serve to decrease mortality risks. Prior studies, however, have not separated housing policies from social policies as some housing policies such as rent control may not be completely measurable. Additionally, a lack of available datasets for housing policies across countries limits comparative studies. As Chapter 4 demonstrated, housing policies have an important role in providing affordable housing options and helping households cope with adverse consequences of the housing cost burden. I overcame the limitations of previous studies since I relied on data from OECD databases, which allowed me to compare housing policies regarding, for example, social housing stock and rent control in developed countries. To my knowledge, this is one of the first studies to estimate the roles of housing policies in alleviating mortality risks at the ecological level.

Challenges

While this thesis was able to address many of the relevant issues in estimating the impacts of housing on health, limitations should be acknowledged, which can be improved upon in follow-up studies. First, since the studies primarily focused on wealthy western countries, the findings are not generalizable to other contexts. The majority of the included studies in the scoping review (Chapter 2) were limited to developed countries. The extent to which a variety of housing problems pose risks to the health of populations in developing countries remains unclear. Second, since the two empirical studies (Chapters 3 and 4) did not directly examine potential mechanisms linking housing assets or housing cost burden to mortality, it remains unclear *how* people are likely to experience health issues caused by housing problems. To better understand the association, related social, psychological, and behavioural mechanisms must be investigated.

Policy Implications and Recommendations

Advanced knowledge regarding how housing affects health has policy implications. First, the findings highlight the need to understand the factors that cause health problems. Not only can the housing cost burden deliver immediate exposure to disease and mortality but it also involves resultant issues, such as unmet healthcare needs and decreased levels of

social support. These can have persistent effects on health. Otherwise stated, housing is inextricably linked to health over the life course. This suggests that the provision of affordable housing can be an effective strategy to reduce health inequalities over time. For example, some measures, such as housing allowance, social housing, and strict rent regulation, are in place in some countries to support housing cost-burdened households (Elsinga & Hoekstra, 2005; Griggs & Kemp, 2012; Schwartz & Seabrooke, 2009). Additionally, investment in social protection programmes, such as pensions and unemployment benefits, can lead to health improvements and fosters one's need to purchase necessities when in financial difficulties. Therefore, more attention must be given to intervening in the housing market to render housing affordable.

Second, it is noted that housing assets do not always enhance the wellbeing of older adults if income is insufficiently secured. While many countries encourage homeownership and the capitalization of assets, increasing living expenses (e.g., increased housing costs) and a lack of pension coverage may weaken older adults' ability to live independently. These problems must be addressed urgently since a growing number of older adults in developed countries face many types of hardships that deteriorate health. Housing policies should be in balance with (a) policies aimed at actively promoting the capitalization of assets for asset holders who do not have sufficient incomes and (b) delicate approaches that help to maintain income security and tenancy

for asset-poor individuals (Arundel & Ronald, 2020). These strategies can contribute to healthy ageing by helping older adults readily rely on economic resources, including income and assets.

Third, as individual health and wellbeing are strongly related to housing from a public health perspective, policymakers and health professionals must consider housing issues in the development of health interventions. For example, efforts have been made to link housing support programmes with mental health programmes to provide permanent housing and improve psychological health (Kirst et al., 2020). This is mainly shaped by the idea that clients can independently maintain health and safety through the immediate provision of adequate housing. In community outreach programmes, the development of screening tools for housing problems can help service providers assess housing and health needs (Billioux et al., 2017). Community workers can have a critical role by delivering services and referring patients to healthcare or housing services. Not only can such efforts be an initial step to acknowledging health inequalities in people with housing problems but they can also help identify those who require housing-related support such as housing subsidies or social housing.

Suggestions for Future Research

Approaches and limitations to measuring the housing cost burden

The findings of the scoping review (Chapter 2) show that the housing cost burden can be measured in various ways. Previous studies widely adopted the *ratio income approach*, which defines housing cost-burdened households as those who pay more than 30% of their income towards housing costs. However, this approach has some limitations as (a) it can be somewhat arbitrary since it relies on the cut-off and (b) it may not account for the heterogeneous characteristics of households. For example, higher-income households tend to *voluntarily* pay a higher proportion of income on housing for wellbeing; this would not be applicable to lower-income households that cannot afford housing. Rather, lower-income households are forced to reduce their consumption of health-promoting resources as a result of decreases in post-shelter income (Stone, 2006). This suggests that one's ability to afford housing depends on their socioeconomic status.

Alternative approaches can reduce such limitations. The *30/40 indicator* operationalises the measurement of the housing cost burden of lower-income households by focusing on the bottom 40% of income distribution that spends more than 30% of their income on housing. The *residual approach* focuses on disposable income after housing costs. This is motivated by the assumption that household size, composition, and other necessary living expenses (e.g., healthcare, food, etc.) should be considered by subtracting them from household income (Jewkes & Delgadillo, 2010). The *subjective approach* investigates one's difficulties in affording housing expenses (Lacombe-Duncan

et al., 2020; Martin et al., 2019). This measure aims to directly investigate the absolute housing needs (or deprivation) of households beyond monetary measures. While it should be acknowledged that subjective assessments are potentially subject to social desirability bias, they can (a) examine the extent to which people meet their housing needs, which cannot be completely explained merely by assessing current income, and (b) provide a picture of financial circumstances when income-related information is limited.

In light of such strengths and limitations of measures regarding the housing cost burden, future studies may wish to rely on an appropriate measure to adequately explore health disparities and housing insecurity.

Identification of housing cost-burdened and housing asset-poor households

In future studies, it would be prudent to examine which groups are more likely to experience a housing cost burden. For example, there might be a geographical variation in living expenses between urban and rural areas since each region has heterogeneous characteristics (e.g., population size and access to public transport). Additionally, levels of housing cost burden can vary within housing tenure between subsidized renters and private renters or owner-occupiers and mortgagors. To address this, relevant data should provide detailed information for housing tenure and housing expenses, including mortgage principal and interest payments, monthly rental costs, property taxes and

utilities, etc. Furthermore, to better understand the role of housing assets regarding health, studies can estimate how homeowners utilize their housing assets over time (e.g., selling a home and borrowing against home equity). These studies can include both longitudinal study designs and qualitative study methods.

Research on the effectiveness of programmes and interventions

There are different types of housing and non-housing programmes and interventions that can (a) directly provide (un)conditional cash benefits, (b) provide (subsidized and social) housing stock or vouchers for those who cannot afford living expenses, (c) introduce a variety of policy measures that regulate housing markets (e.g., rent control and eviction bans) and (d) provide financial support for homebuyers (e.g., mortgage relief for over-indebted homeowners and tax credit to first-time buyers) (OECD, 2021). While this thesis focused on two housing policies, namely, rent control and social housing, other programmes, such as housing vouchers and eviction bans, can relieve stressors caused by the housing cost burden. Additionally, programmes may differ by jurisdiction and/or country. Conceptual typologies of programmes can make a fundamental contribution to the understanding of how and whether programmes improve individual health and wellbeing.

Concluding Remarks

Housing problems have emerged as an urgent issue in wealthy countries. As with previous research on the social determinants of health, this thesis makes notable contributions to the evidence for the association between housing (e.g., housing cost burden and housing assets) and health. To my knowledge, this thesis is the first to (a) estimate the combined effects of housing assets and income on the mortality of older adults and (b) test the preventive role of policies in mitigating the link between the housing cost burden and mortality. It also provides further evidence of why future studies and policies are required to investigate this issue.

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