FINAL REPORT NO. 393

Predicting risk to inform housing policy and practice

Authored by

Milad Ghasri, UNSW Canberra
Wendy Stone, Swinburne University of Technology
Hazel Easthope, UNSW Sydney
Piret Veeroja, Swinburne University of Technology

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Acronyms and abbreviations used in this report

ABS   Australian Bureau of Statistics

AIHW   Australian Institute of Health and Welfare

AHURI   Australian Housing and Urban Research Institute Limited

CRA   Commonwealth Rent Assistance

GCCSA   Greater Capital City Statistical Area

HILDA   Household Income and Labour Dynamics in Australia

HPA   home purchase assistance

KM   Kaplan Meier

PH   proportional hazard

PRA   private rent assistance

SOMIH   State Owned and Managed Indigenous Housing

Executive summary

Key points

- Increasing national housing-assistance expenditure and a growing proportion of the Australian population requiring support indicates the need for optimally targeted, effective forms of housing-assistance interventions.

- Existing evidence about intersectional drivers for housing assistance, coupled with administrative data about housing-assistance recipiency, allow us to examine how early prediction of housing-assistance need could support more effective delivery of this housing assistance.

- The study developed a national predictive model for entering housing stress, based on complexity of critical life events in interaction with household resources. This tool can be used to support timely policy intervention in response to housing shocks.

- Housing stress in this study is calculated using the 30/40 rule to identify low-income households: the bottom 40 per cent (regarding equivalised income) who spend more than 30 per cent of their gross income on housing (Gabriel, Jacobs et al. 2005).

- The study interrogates the Household Income and Labour Dynamics in Australia (HILDA) survey using the survival-analysis method. It examines the impact of critical life events on housing stress to identify characteristics that boost resilience to housing stress, and also to predict the impact of critical life events on the increased risk of entering housing stress. A set of predictive models of 'risk pathways' is developed and extended to the national level using ABS census data.

- Critical life events positively correlated with risk of entering housing stress span across housing, health, finance, family change and justice. The incidence of many critical life events is correlated with age.

- **The following characteristics are most closely associated with vulnerability to entering housing stress: young to early middle-aged adults (18-44 years), looking for work, and living in rental housing (including both private and social rental). The Northern Territory outside of Darwin has the highest proportion of people with all three characteristics, at 5.8 per cent of the population. In all other areas, that proportion is below 4 per cent.**

- **The methodology developed for the project provides a proof of concept to facilitate early intervention and prevention.**

- **Understanding more about upstream critical life events as contributors to housing stress can support policy development options that go beyond the usual administrative boundaries, and support intersectional approaches to reducing housing stress.**

- **A policy workshop with key stakeholders indicated strong and urgent support for the development of this methodology, and rapid policy application across policy realms, tenures, population cohorts and housing-assistance models.**

Key findings

The socio-demographic attributes of household members most vulnerable to entering into housing stress are:

- young to early middle-aged adults (18–44 years)
- looking for work
- living in rental housing (including both private and social rental).

Housing stress in this study is calculated based on the 30/40 rule to identify low-income households: the bottom 40 per cent (regarding equivalised income) who spend more than 30 per cent of their gross income on housing (Gabriel, Jacobs et al. 2005).

Approximately 70 per cent of people who were unemployed and living in rental housing were in the age group of 18–44 years in all capital cities and the balance of the state areas. The Northern Territory outside of Darwin has the highest proportion of people with all three characteristics: 5.8 per cent of the population. In all other areas, that proportion is below 4 per cent.

The resilient cohort—those least likely to enter housing stress—are owner-occupier older adults (65 years+) who have a postgraduate degree and are engaged in full-time work. Approximately 70 per cent of people aged 65+ were owner-occupiers, with the exception of the Northern Territory (NT): in Greater Darwin, 56.4 per cent of older adults were owner-occupiers and 42.1 per cent in the balance of NT. The proportion of homeowners aged 65+ among all homeowners was lower in capital cities, and especially in Greater Darwin (12.4%) and higher in rest of the state/territory areas, being highest in SA (23.7%) and NSW (23.2%).

Figure 1 summarises the risk ratio of key socio-demographic attributes and critical life events compared to the most resilient cohort, which we have named the 'base person'.

The biggest predictor of risk of entering housing stress is age, with 18–24-year-olds being 214 per cent more likely to enter housing stress than the most resilient cohort (those aged 65+). This risk reduces only slightly to 154 per cent and 156 per cent for those aged 25–34 and 35–44 respectively.

Employment status is the next largest predictor, with unemployed people being 144 per cent more likely to enter housing stress than fully employed people, and retired people being 78 per cent more likely.

Not having a college or university education is associated with a 78 per cent higher chance of entering housing stress. Renters (in private and social housing) are 125 per cent more likely to enter housing stress than owners (outright and with a mortgage).

The critical life events that increase the likelihood of entering housing stress the most compared to the base person are:

- birth/adoption of a child (34%)

- providing care to a family member (15%)

- getting separated (30%) or married (15%)

- being fired or made redundant (14%).

Figure 1: Risk ratio of key socio-demographic attributes and critical life events
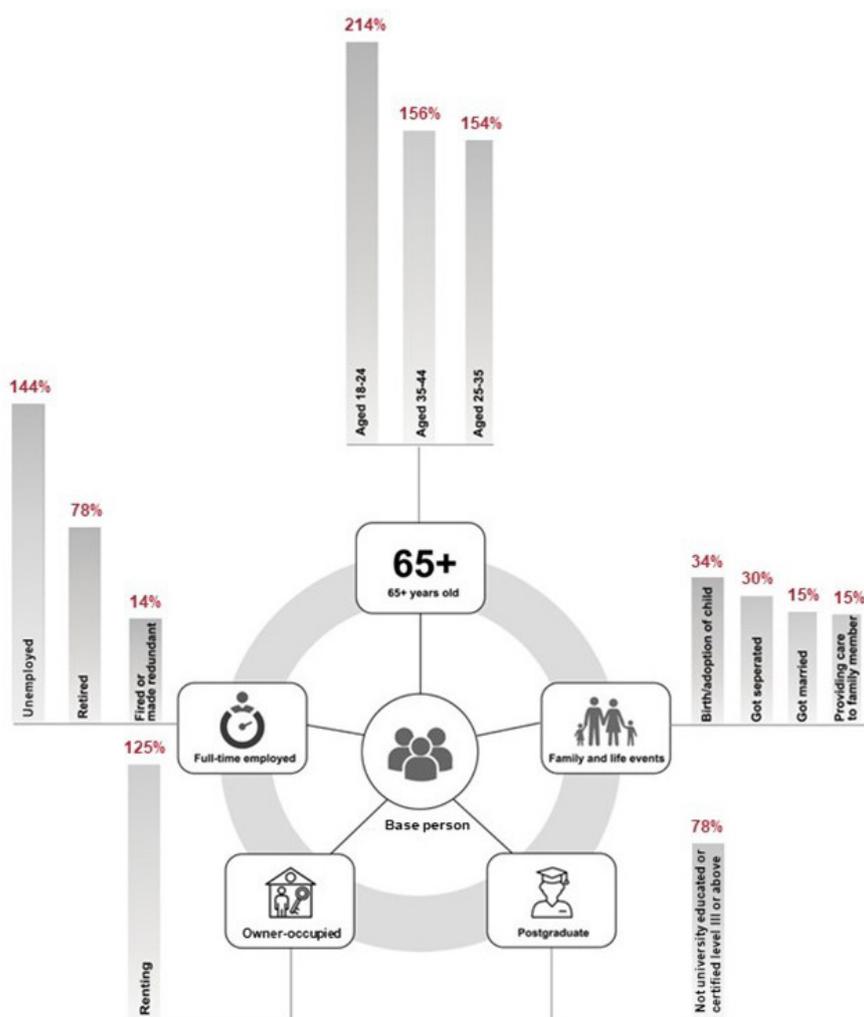
Notes: Definition of housing stress - households in the bottom 40% of household income are spending more than 30% of their income on housing. See Appendix 4 for the complete list of risk ratios.
Source: Authors (image: Jiahang Li).

The incidence likelihood of critical life events varies over individuals' lifetime and the type of critical life event. Figure 2 summarises the probability of critical life event occurrence for the entire 2018 HILDA sample.

Figure 2: Frequency of critical life event occurrence in 2018 HILDA sample
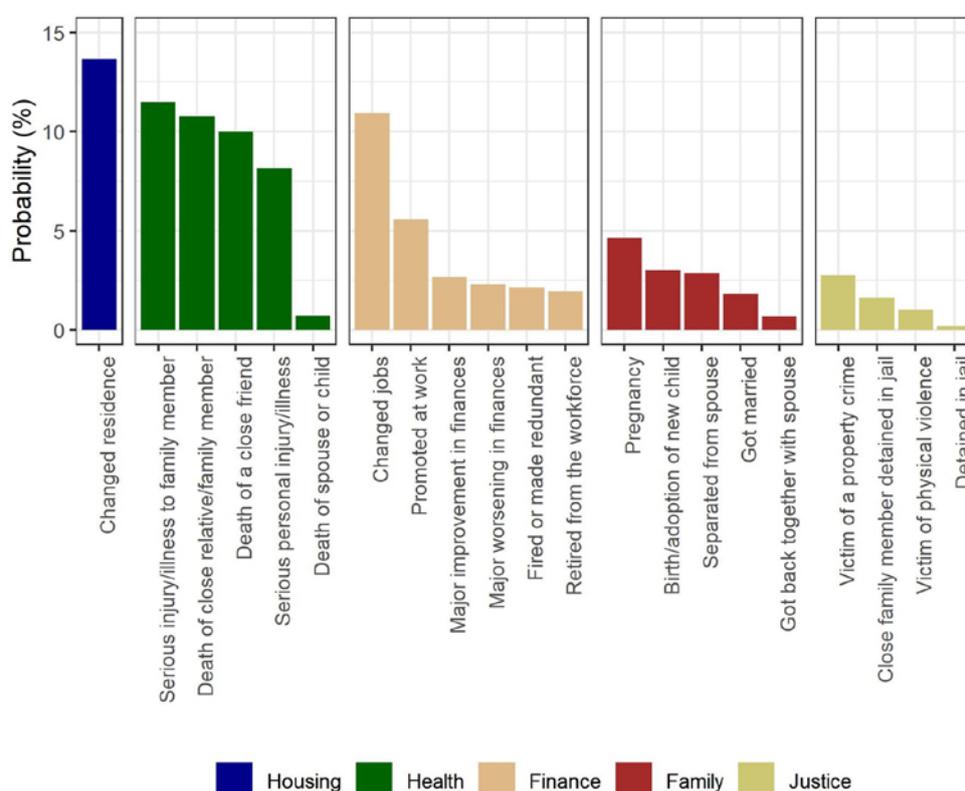
Source: Data from HILDA survey; authors' original analysis.

The housing critical life event has the highest incidence probability (13.7%); the health critical life event with the highest incidence probability is serious injury or illness to family member (11.5%); and the finance critical life event with the highest probability is changing jobs (10.9%). Family-related critical life events have a lower incidence probability, the most likely being pregnancy (4.6%). Among justice-related critical life events, being a victim of property crime has the highest incidence probability (2.8%).

The incidence of many critical life events is associated with age. Marriage, pregnancy and birth or adoption of a new child are more probable between 25 and 35 years of age. The likelihood of separation before age 25 is between 5 per cent to 6 per cent, which is followed by a decreasing trend after age 25. The likelihood of changing job shows a monotonically decreasing trend from nearly 25 per cent for ages below age 25, to zero after age 70 years. Promotion at work has its peak (at around 12%) between ages 25 and 28. The likelihood of justice-related critical life events remains below 5 per cent at all age groups.

Policy development options

To a large degree, housing-assistance and specialist homelessness service interventions are developed and delivered in relative isolation from wider and interrelated social realms. These include, for example, policies geared toward employment and training, supporting individuals and families through family changes, and policies associated with disability, health or caring. Yet critical life events associated with these wide policy fields can directly affect the ability of households to access and afford adequate housing—or to sustain existing tenancies.

Existing forecasts of housing assistance are based on expressed demand, coupled with population forecasting that does not take account of complex interactions of upstream, contributing factors that result in the need for households to seek housing assistance. As such, they provide limited evidence about how housing policy development can be geared toward a proactive, early interventionist role. Understanding the impact of critical life events that lead to the need for housing assistance is critical to:

- support innovative policy interventions that seek to intervene early and reduce long-term cost to governments, individuals and society

- enable the most effective targeting of housing assistance to households in need

- assess the ways in which household resources interact with housing assistance in short-term and long-term models of housing-assistance provision.

Through the development of a risk-pathways model, we make a case for a targeted systems approach to housing support, which has the potential to increase the resilience of households to weather shocks at the same time as allowing for more efficient targeting of government resources. This research has developed a proof of concept. This comprises a conceptual and methodological approach toward a wider interrogation of how a prevention and early intervention approach can form a central component of future housing-assistance models in the Australian context.

A policy workshop with key stakeholders confirmed the relevance of the approach developed in this research. The discussion indicated strong and urgent support for the development of our methodology in the form of a 'how to' prototype, for ongoing development and rapid policy application across policy realms, tenures, population cohorts and housing-assistance models.

Further development of a systems approach to housing intervention will require the following.

- A wide-ranging review of international and national best-practice prevention and early intervention housing-assistance approaches to inform policy thinking in the local context.

- Scaling up of the methodology developed in this report to large-scale administrative linked data sources to further refine the method and enable investigation of housing responses to a wider range of critical life events including those associated with justice policy and practice.

- Ongoing dialogue with key policy, practice communities and recipients of supports, to inform development of prevention and early intervention approaches as a mainstream and core component of the housing-assistance ecology nationally.

1. Introduction

- An increase in housing-assistance expenditure nationally and a growing proportion of the Australian population requiring support indicates the need for optimally targeted, effective forms of housing-assistance interventions.

- Existing evidence indicating intersectional drivers for housing assistance, coupled with increasingly available administrative data about housing-assistance recipiency, gives us the opportunity to examine how early prediction of housing-assistance need could support more effective delivery of housing assistance.

- This project uses a predictive modelling approach to identify households at risk of short-term, medium-term and longer-run housing assistance, focussing on residents in rental housing.

- Critical life events are the focus of this project. Critical life events are an under-examined point of early intervention for joined-up housing assistance that could have wide population benefit.

- The methodology developed for the project provides a 'proof of concept' to facilitate early intervention and prevention.

- Understanding more about upstream critical life events as contributors to housing stress can support policy development options that go beyond the usual administrative boundaries and support intersectional approaches to reducing housing stress.

Previous research identifies critical life events experienced by individual household members—or households as a unit—as 'upstream events' that can result in housing shocks (Stone, Sharam et al. 2015).

Critical life events include positive events—for example, partnership formation, birth of child, promotion at work—as well as negative events. Negative events typically have a negative effect on household income—for example, separation or divorce, unexpected job loss, acute health conditions (Baxter, Qu et al. 2012; Stone, Sharam et al. 2015).

Critical life events can be short-term or long-term in duration, can be planned or unanticipated, and can have acute or chronic impacts on housing and living arrangements and other spheres of life (Moloney, Weston et al. 2012). 'Housing shocks' can include:

- inability to afford rent or mortgage payments

- eviction

- overcrowding

- housing precarity (Stone, Sharam et al. 2015).

Many such shocks are underpinned by housing stress, in which household resources are inadequate to manage affordability pressures when combined with a critical life event.

In their articulation of the relationship between critical life events and housing outcomes, Stone, Sharam, et al. (2015) examined the interaction of critical life events, household resources—such as formal insurances, household wealth/assets, social capital—and overall resilience of households to withstand income shocks associated with single or multiple critical life events. That study developed definitional clarity about the interaction of critical life events, housing shocks, the household resources and 'insurances' required for household resilience to withstand income shocks associated with critical life events—as well as the possibility of both direct and indirect consequences of critical life events on living arrangements and other spheres of life. For example, recent research points to health and wellbeing impacts of the interaction of life events and housing precarity (Moloney, Weston et al. 2012; ViforJ, Singh et al. 2022). These and similar studies can be broadly conceptualised within the critical life event framework developed by Stone, Sharam, et al. (2015) as an interaction of critical life events, limited household resources, housing shocks and indirect flow-on effects, such as poor health and wellbeing outcomes.

The immediate and long-run implications of critical life events and their effects can also have implications for individual and household housing pathways. Clapham (2002: 68) described housing pathways as 'the social practices of a household relating to housing over time and space', providing an avenue for understanding intersectional disadvantage within housing over time, as well as within specific housing sectors (Powell, Meltzer et al. 2019: 1). Existing empirical evidence linking housing pathways with policy development in Australia focusses primarily on housing-assistance recipiency rather than the factors that lead to the need for support (Baker, Leishman et al. 2020; Wiesel, Easthope et al. 2012).

However, previous research has paid limited attention to developing an empirical methodology for understanding the complex relationships between critical life events, income shocks and the possible flow-on implications for housing shocks in quantifiable ways for policy use. The present study draws heavily on existing conceptualisation of the interaction of critical life events, housing shocks, household resources and resilience, and their direct and indirect effects to develop a policy-oriented 'proof of concept' model. The study draws on the concepts of 'resilience' and risk pathways to explore 'undesirable housing outcomes' associated with critical life events experienced at household levels which, in turn, affect housing outcomes. As outlined in more detail throughout this report, the research develops a national predictive model for entering housing stress for households facing critical life events and housing shocks.

This project introduces the concept of 'risk pathways' to quantitatively model the likelihood of undesirable outcomes in housing pathways. It uses household longitudinal data to develop national risk-pathway models with a focus on critical life events and household resilience. Risk pathways model the dynamics of housing shocks and household resilience to serve as an early diagnostic tool to support early intervention policy. Social inclusion and exclusion research, studies in intersectionality and extensive evidence about the interaction of housing and disadvantage points to an accumulation and spiralling of direct and indirect effects of critical life event and housing shocks, where assistance and interventions are limited, non-existent or inadequate (Australian Institute of Health and Welfare [AIHW], 2021b; O'Connor, Bright et al. 2019). The empirical component of the research develops a risk-pathway-profile typology, based on complexity of critical life events—for example, change of jobs, pregnancy, illness, death of family member or friend—in interaction with household resources, as a methodological tool that can be developed in future work to support timely policy intervention in response to housing shocks.

1.1 Research questions

The overarching research question is:

> **What is the impact of critical life events on housing outcomes, and how can identification of 'risk pathways' support an early intervention model of housing assistance, across population groups?**

Six research questions guide the project as a whole.

1. Which housing outcomes should be categorised under undesirable housing outcomes that may necessitate government support?

2. Which critical life events are likely to cause undesirable housing outcomes?

3. What socio-demographic attributes of household members are significant in forming household resilience?

4. Given the heterogeneity of the explored relationships in research questions 2 and 3, which socio-demographic attributes are most associated with vulnerability to critical life events?

5. What is the national-level spatial distribution of vulnerable cohorts identified in research question 4?

6. What are potential support schemes for early intervention to assist vulnerable households identified in research question 5?

Figure 3 shows the research design used to address the research questions in this study.

Figure 3: Research design and activity processes used to address the research questions
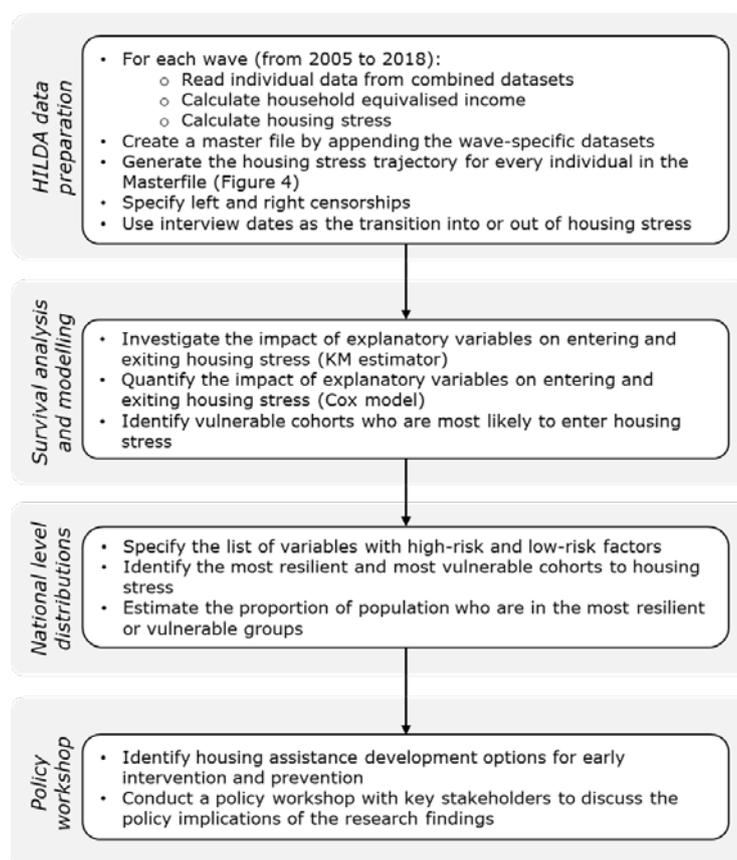
Source: Authors.

1.2 Policy context

1.2.1 Current approaches to housing-assistance provision

Government expenditure on housing assistance in Australia includes both direct and indirect expenditure:

- **Indirect expenditure** provides housing benefits through the tax system and includes negative gearing for rental-housing investors and capital gains tax exemptions for owner-occupiers.

- **Direct expenditure** includes public and social housing provision, homelessness services, first homeowner grants and private rental assistance.

Previous work by Groenhart (2014: 2) demonstrated that per-dwelling expenditures on indirect housing assistance in Australia far outweigh those of direct housing expenditures and that these indirect expenditures are poorly targeted, with the majority going to advantaged locations. Among forms of direct housing assistance, Groenhart (2014: 2) demonstrates that expenditure is highest on private rental assistance, then first home ownership grants and finally public housing, and that these expenditures are typically well targeted to disadvantaged locations.

Direct housing assistance in Australia is primarily based on income support eligibility and administered on the basis of housing tenure (Stone, Parkinson et al. 2016: 12). Housing assistance for private renters includes rental subsidies—most notably Commonwealth Rent Assistance (CRA)—along with bond loans, tenancy guarantees, relocation assistance and private tenancy facilitation (Stone, Parkinson et al. 2016: 13). Housing assistance for owner-occupiers differs between states and includes first homeowners grants, concessions on duties, taxes and fees, mortgage relief and shared equity products, among others (For more detail, see Stone, Parkinson et al. 2016: 12-15). Housing assistance for social housing tenants involves direct provision of housing with rents capped at a proportion of income, and very tight eligibility criteria.

Research by Stone, Parkinson et al. (2016) found that direct housing-assistance provision in Australia is no longer able to effectively offset problems of housing affordability. The same research identified anomalies in support, such that households with similar needs received different types and levels of support depending on housing tenure. They noted that assistance to private renters is spread 'very thinly' and assistance to homeowners 'relatively thickly' (Stone, Parkinson et al. 2016: 15). They also observed that the practice of linking housing support to income support has meant that some households that do not receive income support but are in need of housing support have been ineligible to receive it (see also Jacobs, Hulse et al. 2016). Stone, Parkinson et al. (2016: 1) suggested that an increasingly individualised model of housing-assistance provision provides a policy opportunity to improve the provision of housing assistance (Stone, Parkinson et al. 2016: 1). The approach taken in this report of identifying risk pathways provides important insights into how such individualised assistance might be better targeted and managed.

1.2.2 The financial cost of a 'crisis' approach to housing-assistance provision

The Australian Government, state and territory governments and community-based organisations are responsible for providing housing assistance in Australia (AIHW 2021). The Australian Government provides Commonwealth Rent Assistance (CRA) and the National Rental Affordability Scheme (AIHW 2021b). In 2019–2020, the federal government spent $4.7 billion on CRA, compared to $4.5 billion in 2018–2019 (AIHW 2021b). CRA is the most common housing assistance received in Australia, and in June 2020 about 1.7 million income units received it. This was 414,200 more income units than in 2019 (AIHW 2021b).

State and territory governments are responsible for providing public rental housing, State Owned and Managed Indigenous Housing (SOMIH), home purchase assistance (HPA), private rent assistance (PRA), the National Rental Affordability Scheme and the first homeowner grant (AIHW 2021b). During 2019–2020, state and territory governments spent $4.3 billion on social housing—which includes public rental housing, SOMIH, community housing, and Indigenous community housing—compared to $4.1 billion in 2018–2019 (Productivity Commission 2021). In 2019–2020, about 802,000 occupants were in social housing (AIHW 2021b).

Historically, public housing was established to stimulate the economy, and was available for working families, but increasing demand unmatched by supply has meant that public housing can only be accessed by those with the highest needs (Wiesel, Easthope et al. 2012: 8). Notably, 51 per cent of new public housing tenants experienced homelessness prior to moving to social housing (AIHW 2021b). Lawson, Pawson et al. (2018) estimated that to meet the current (unmet) need and projected future need, 727,300 additional social housing dwellings are required in the next 20 years.

HPA includes a range of financial assistance for eligible households to improve access and maintain home ownership. In 2019–2020, 43,700 households in Australia received a form of HPA (AIHW 2021b). PRA is usually a one-off payment and provides a range of financial assistance to households having difficulties in maintaining private rental accommodation—for example, bond loans, relocation payments or rental grants (AIHW 2021b). In 2019–2020, about 117,900 PRA payments were made, worth $157 million (AIHW 2021b).

1.2.3 Towards a systems approach

Existing empirical evidence linking housing pathways with policy development in Australia focusses primarily on housing-assistance recipiency rather than factors leading to the need for support (Baker, Leishman et al. 2020; Wiesel, Easthope et al. 2012).

This study introduces the concept of 'risk pathways' to quantitatively model the likelihood of entering housing stress in housing pathways. It uses household longitudinal data to develop national risk-pathway models with a focus on critical life events and household resilience. Critical life events can result in undesirable outcomes, such as forced relocation and debt financing. The available resources to overcome housing shocks include wealth, savings and social networks, which collectively form household resilience. Risk pathways model the dynamics of housing shocks and household resilience to serve as an early diagnostic tool to support early intervention policy.

This study supports policy development in two ways.

First, housing assistance is typically linked to the income support system. However, household resilience does not only depend on income—it also relates to resources such as wealth, housing equity, formal insurance and various forms of social support (Stone, Parkinson et al. 2016; Stone, Sharam et al. 2015). Risk-pathways models can enable early detection of households with low resilience that are in need of support, but are not (yet) eligible for income support.

Second, housing assistance is typically provided when household resources are exhausted, and the household is in urgent need for support. Risk-pathways models can capture the diversity of households in need of support to inform early intervention policies to prevent worsening of undesirable housing outcomes—for example, inability to sustain rental payments that could be supported with short-term loans rather than resulting in eviction or homelessness, or temporary financial support to bridge periods of income loss that could lead to mortgage arrears and loss of the home. In some cases, early intervention can potentially reduce long-term assistance need.

The interactions between critical life events and household resilience with undesirable housing outcomes, and the role of housing assistance to support households, are shown in Figure 4. This framework illustrates the role of housing stress as a measure of early intervention prevention, and the suggested mechanism for targeted and integrated assistance. Critical life events, including economic, health and social life events, can cause housing shocks and may result in undesirable housing outcomes such as unwanted relocation, unwanted change of tenure, eviction and foreclosure. The ability to manage the shock depends on household resilience, which is formed by available resources—including income, wealth, social networks and insurance.

Most existing government financial supports are designed to support households struggling with undesirable housing outcomes. This study recommends a targeted early intervention approach, and identifies critical life events that should be the focus of early intervention, as well as demographic groups that are most likely to require support. The modelling framework of this study quantifies the impact of critical life events and socio-demographic attributes on the likelihood of entering housing stress. The analytical framework of this study can identify salient characteristics of vulnerability and resilience to housing stress in forming a 'risk pathway'.

Figure 4: Conceptual framework for early intervention/prevention and the role of housing stress
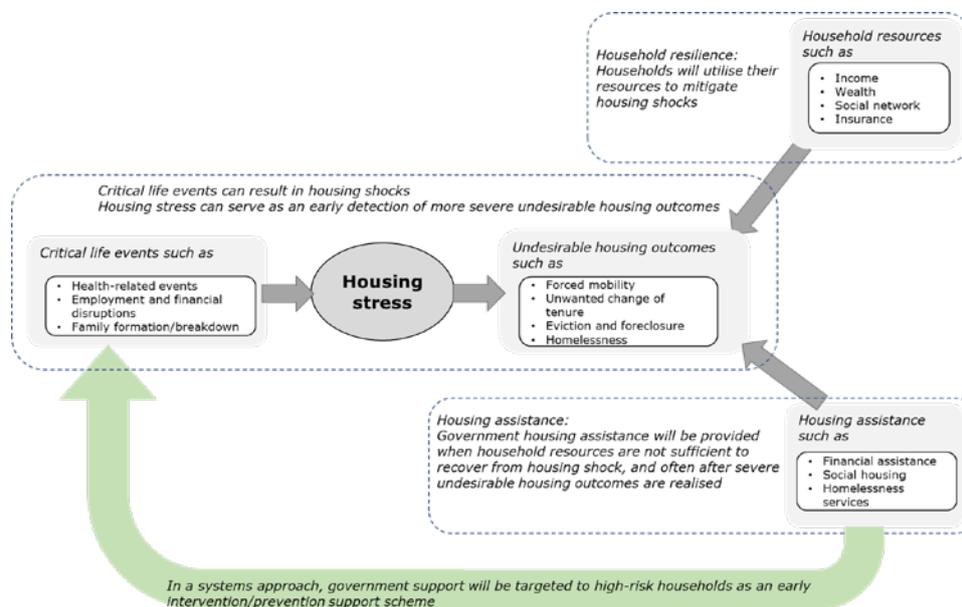
Source: Authors.

1.3 Research methods

This study uses a multi-method research approach to address the research questions. The research method includes four stages, each of which informs and supports the next.

- **Stage 1:** Scoping review

  The study starts with a review of previous research to summarise the reported impacts from critical life events on housing outcomes; this will enable us to develop a list of undesirable housing outcomes and significant critical life events that may result in undesirable housing outcomes.

- **Stage 2:** Data preparation

  The study uses the longitudinal Household Income and Labour Dynamics in Australia (HILDA) surveys between 2005 and 2018 to examine the impact of critical life events on risk pathways. HILDA records 21 major life events —including unemployment, major worsening in finances, marriage, separation and retirement. HILDA provides information about residential relocation, change of tenure, financial hardship, and difficulty meeting housing payments. The identified critical life events, undesirable housing outcomes and socio-demographic and socio-economic attributes are extracted from HILDA.

- **Stage 3:** Data analytics, modelling and generalisation

  The processed data is analysed to identify significant relationships between critical life events and risk pathways, while controlling for household resilience and socio-demographic attributes of household members. Household information is combined over the most recent 15 waves of HILDA to study the dynamics of housing outcomes and the disruptive impact of critical life events, and also to identify risk-pathway types and their characteristics.

  This study introduces the concept of risk pathways to address the stochasticity and the dynamic nature of housing pathways. The risk pathway represents the likelihood of experiencing undesirable housing outcomes over time. Risk pathways can have various trajectories, depending on individuals' circumstances. Although the focus of this study is examining the impact of critical life events and household resilience on the risk of entering housing stress, the introduced method can be used for other determinants and housing outcomes.

We use the survival-analysis method (Jenkins 2005; Stevenson and EpiCentre 2009) to model risk pathways. Survival analysis (aka hazard-based modelling) provides a consistent platform to model *time of an event*. The event of interest in this study is experiencing housing stress.

The ABS 2016 *Census of Population and Housing* (2016 a) was used to understand the spatial distribution of the most vulnerable groups. Using census data, the analysis is extended to obtain a national-level perspective towards the spatial distribution of individuals at risk and the required government support.

- **Stage 4:** Policy development, reporting and engagement

The final stage of the research considers the implications of the study findings for policy development, focussing on the potential for early support schemes to assist vulnerable households. In October 2021, the models developed in Stage 3 and the conclusions inferred from the model were tabled at a workshop of seven key policy makers and practitioners. A summary paper based on the findings of Stage 1 and Stage 3 was distributed to the participants in advance.

1.4 Report structure

The rest of this report is organised as follows.

In Section 2, a review of previous research on undesirable housing outcomes is provided, and the relationships between households' socio-demographic attributes and housing outcomes is conceptualised. In this section, several undesirable housing outcomes are identified and their consequences for households are discussed. Moreover, the HILDA survey is examined for potential records of undesirable housing outcomes. This chapter addresses research question 1.

In Section 3, the range of critical life events that can affect housing outcomes are conceptualised. Moreover, the list of critical life events recorded in the HILDA survey is examined, and the probability of experiencing critical life events by age is extracted. This chapter addresses research question 2.

Section 4 provides a detailed explanation about the data-driven approach to model and predict risk to inform housing policy. The foundation of the modelling approach and a non-parametric method and a semi-parametric method to address research questions 3 and 4 are discussed, and research findings presented.

Section 5 is dedicated to research question 5. The findings from the modelling practice discussed in Section 4 are extended to the general population to obtain the national-level spatial distribution of the vulnerable cohort.

Section 6 provides a summary of the topics discussed in the policy workshop and policy recommendations.

2. Understanding 'risk landscapes' and the factors underpinning them

- **Existing evidence indicates that housing stress is a 'risk landscape' for the onset of more severe housing shocks or enduring negative housing outcomes. As such, the onset of housing stress represents a potential early intervention point for housing assistance.**

- **Housing stress is identified as being correlated with a range of discrete or cumulative critical life events, including those related to employment or training, family or household dynamics, as well as health and caring.**

- **A methodology is developed to account for critical life events, the relative risk of housing stress, as well as household resources and resilience.**

- **The HILDA longitudinal panel dataset enables quantitative prediction of critical life events that lead to housing stress, using hazard and survival modelling, illustrating the utility of longitudinal and administrative data for early intervention and prevention approaches to housing assistance.**

2.1 Existing research: housing stress and affordability as a risk context

Existing evidence points to the need to better understand and respond to what we term 'housing risk landscapes' within the present research. Risk landscapes involve household experiences, attributes of household members, and resources (or capabilities), as well as the range of factors that can embed households within risk contexts in their housing pathways.

Nationally and internationally, extensive evidence over decades identifies risk factors that further worsen households' living arrangements. These risk factors include households' inability to:

- pay for the cost of housing while maintaining an adequate standard of living (Saunders 2017)
- make ends meet after paying for housing costs (Wiesel, Ralston et al. 2021)
- pay for rising housing costs (Bradbury and Saunders 2021).

The evidence also points to the need for deeper or more enduring forms of housing assistance and welfare support.

On average, since the turn of the century, housing costs in Australia have increased and affordability has decreased (AIHW 2021a). Relative stagnation of wages and income support payments across a range of major pension and benefit types (Davidson, Wong et al. 2020; Gilfillan 2016) means that incomes for very-low-income, low-income and moderate-income households have not kept pace with rising costs of shelter (Thomas and Hall 2021). Unsurprisingly, this period has also witnessed an overall increase in the total cost of direct housing-assistance expenditure to eligible households, as well as the overall number of households seeking housing support (AIHW 2021a), with predicted rises in housing-assistance need into the foreseeable future (Rowley, Leishman et al. 2017).

Housing affordability challenges are widespread and arguably most pronounced in the private rental sector, although they are also evident in the social housing sector. The Australian housing system currently comprises very low levels of social housing provision by international standards, and as such is targeted to individuals and priority households identified as having complex assistance requirements (Muir, Powell et al. 2020). Increasing proportions of households eligible for social housing but unable to access public or community housing reside in the private rental sector (AIHW 2021a). At the same time, generational decline in opportunity to purchase a home (Burke, Nygaard et al. 2020) means that the private rental sector is home to a diverse and growing population of low-income to moderate-income households that cannot (yet or permanently) access home purchase (Martin, Hulse et al. 2018). As the main alternative to either home purchase or social housing, privately rented housing is now home to approximately 24 per cent of the Australian households, or 2.02 million households (Hulse, Reynolds et al. 2019).

Both social housing and privately rented housing are in demand and pose affordability risks for tenants. Recent analyses of social housing as infrastructure (Lawson, Pawson, et al. 2018) used a forecasting model based on current and projected need, and concluded that there is a national shortfall of social housing in Australia in the order of 727,300 dwellings. Analysis of the most recently available 2016 Census data indicated that, at that time, a supply and accessibility shortage of private rental housing for Australia's lowest-income households was in the order of 305,000 dwellings—and was steadily increasing (Hulse, Reynolds et al. 2019).

Supply shortages, coupled with a relatively light regulatory context in private rental housing (Hulse, Reynolds et al. 2019) and pressure to apply market rents in social housing sectors to achieve financial viability (Lawson, Pawson et al. 2018; Hall and Berry 2007), arguably contribute to affordability problems, and exacerbate other poor housing conditions in Australia's rental sectors. For example, low rental affordability is associated with:

- poor housing conditions (Baker, Leishman et al. 2020)
- relative insecurity and heightened residential mobility (Stone, Sharam et al. 2015; Wiesel, Pawson et al. 2014; Hulse, Milligan et al. 2011)
- poor secondary outcomes in liveability, health issues, and reduced productivity (Gurran, Hulse et al. 2020).

2.1.1 Impacts of poor housing options for individuals and society

There is a plethora of evidence that poor housing outcomes have important negative consequences for individuals, households and local communities. Poor housing outcomes include housing affordability pressures, as well as poor quality housing or inappropriate housing. The two problems are related, with people experiencing housing affordability pressures more likely to live in poor quality housing.

Poor quality housing has been associated with:

- poor physical and mental health (Brackertz, Borrowman et al. 2020; Waters 2001)
- increased costs of home maintenance and use (Liu, Martin et al. 2019).

Housing affordability pressures are linked with:

- overcrowding (Herath and Bentley 2018)

- relationship breakdown (Sharam 2017; Stone, Sharam et al. 2015)

- difficulty paying for other daily essentials—including food, adequate heating and cooling, and transportation (Instone, Mee et al. 2014).

These challenges not only impact on the individuals and households directly affected, they also impact on their surrounding local communities through:

- increased residential mobility (Stone and Hulse 2007)

- neighbour disputes (Crommelin, Easthope et al. 2017b)

- constrained spending in local businesses (Crommelin, Easthope et al. 2017a).

As explored in recent research that sought to identify the relationship between forms of housing deprivation (Daniel, Baker et al. 2018), as well as establish housing-assistance pathways related to accumulated housing impacts (Baker, Leishman et al. 2020), an accumulation of housing-related stressors leads to a 'risk landscape'.

A risk landscape is underpinned most significantly by 'housing stress', measured in terms of inadequate income to pay for housing costs among low-income to moderate-income households, which places families and households in a situation of reduced capacity to respond to future—and often related—housing challenges, such as rent arrears, housing debt and limited financial capability to relocate to lower-cost dwellings where this is an option.

Where housing affordability pressures and poor housing outcomes are experienced by a substantial proportion of the population, as is the case in Australia (Gilbert, Rowley et al. 2020), they also have broader systemic societal impacts. These include:

- increasing inequality in wealth (Pawson, Milligan et al. 2020)

- intergenerational inequity (Flatau, Conroy et al. 2013; Yates and Milligan 2007)

- financial and economic instability (Maclennan, Long et al. 2021).

A recent report for the Housing Productivity Research Consortium reported:

> Over the last 40 years Australia's housing system outcomes have exacerbated inequalities of both income and wealth, compromised economic and financial stability, and negatively impacted on labour productivity. (Maclennan, Long et al. 2021)

2.1.2 Housing pathways

Unaffordable and inaccessible housing for low-income and very-low-income households, in particular, are also known to have long-run effects as well as the shorter-term effects, described earlier. David Clapham's (2002) 'housing pathways' is a popular analytical framework to consider more targeted approaches to housing support. As Clapham explained: *'The housing pathway of a household is the continually changing set of relationships and interactions, which it experiences over time in its consumption of housing'* (2002: 64).

For Clapham, the concept of a housing pathway builds upon that of the 'housing career' by allowing for consideration of not only the characteristics of different types of housing but also the meanings the household associate with their housing and the ways they interact with and within it (including their relationships with others as a result of their tenure). He goes on to explain:

> Housing is not consumed in isolation from other aspects of life. Moving house may be triggered by employment or family issues. The meaning attached to a house may be part of a personal identity and lifestyle … All of these elements need to be considered together as it may be impossible to disentangle them satisfactorily. Therefore a housing pathway will run alongside and be closely associated with other types of pathways such as employment. (Clapham 2002: 65)

The concept of a housing pathway has been effectively utilised in recent Australian research on:

- social housing pathways (e.g. Baker, Leishman et al. 2020; Flanagan, Levin et al. 2020; Muir, Powell et al. 2020; Powell, Meltzer et al. 2019)

- pathways for low-income renters (e.g. Parkinson, James et al. 2018)

- pathways for vulnerable groups (valentine, Cripps et al. 2020).

The pathways approach allows for consideration of housing outcomes as a dynamic process, and the identification of common patterns of housing mobilities over the life course or between different demographic groups, by reflecting on the needs, choices and constraints of households over time (Wiesel, Easthope et al. 2012: 2, 15).

This project focuses on the factors leading to the need for support, and introduces the concept of 'risk pathways' to quantitatively model the likelihood of undesirable outcomes in housing pathways. As outlined in the analysis that follows, the short-term or long-term experience of housing stress by social and private tenants is conceptualised as central to a housing risk pathway, which can be preceded by critical life events, and which may lead to additional housing shocks.

2.1.3 Systems approach to policy

Recent evidence that builds on concepts based in systems thinking and joined-up policy, in which housing assistance is located and designed as a component part of a wider support suite of interventions, is underscored by recent advances in analytical capability using linked data across policy realms and sectors.

For example, in their analysis of social housing pathways, Muir, Powell et al. (2020) identified the multiple points of possible policy and practice failure within complex systems, which:

- lack coherence around end goals

- lack integration of component subsystems

- do not coordinate responses to individual housing-assistance clients.

The work of Muir, Powell et al. (2020) is extended in analysis that interrogated how the practices that support non-aligned assistance programs can lead to both innovation and discretion, on the one hand or, alternatively, missed opportunities and assistance gaps for households in need, on the other (Flanagan, Levin et al. 2020). Using linked administrative data, Baker, Leishman et al. (2020) examined the resultant housing-assistance pathways, across, within and between subsystems of housing and welfare support and identified a range of key assistance pathway types, some of which involve inadequate responses to need—arguably due to a lack of coordination between policy and practice spheres.

Most recently, a detailed example of linked-up support interrogated with linked administrative data has been undertaken within an AHURI-funded account of the interactions of people with justice services in conjunction with housing-assistance provision (Martin, Cordier et al. 2021). Findings also pointed to a need for integrated responses to achieve effective outcomes where households experience a low-income risk landscape involving experience of housing stress, and where multiple other factors impair the ability of the household to respond to each additional stressor effectively, without system-wide support.

2.2 Analysis: housing-stress trajectories in HILDA

2.2.1 Data processing

To examine the impact of critical life events on risk pathways, we use the HILDA dataset between 2005 and 2018. HILDA records 21 major life events, including unemployment, major worsening in finances, marriage, separation, and retirement. Also, HILDA provides information about residential relocation, change of tenure, financial hardship, and difficulty meeting housing payments.

Figure 5 presents the flowchart of modelling data construction[1]. As shown, the process comprises two modules. In the first module, housing stress is identified. To that end, equivalised income and the proportion of housing costs on household gross income are calculated. Then the 30/40 rule is applied to identify housing stress (Gabriel, Jacobs et al. 2005). Note that in this study, housing stress is calculated as an individual-specific attribute, so family formation and dissolution will not interfere with housing-stress trajectories.

Figure 5: Flowchart of constructing the modelling dataset using HILDA
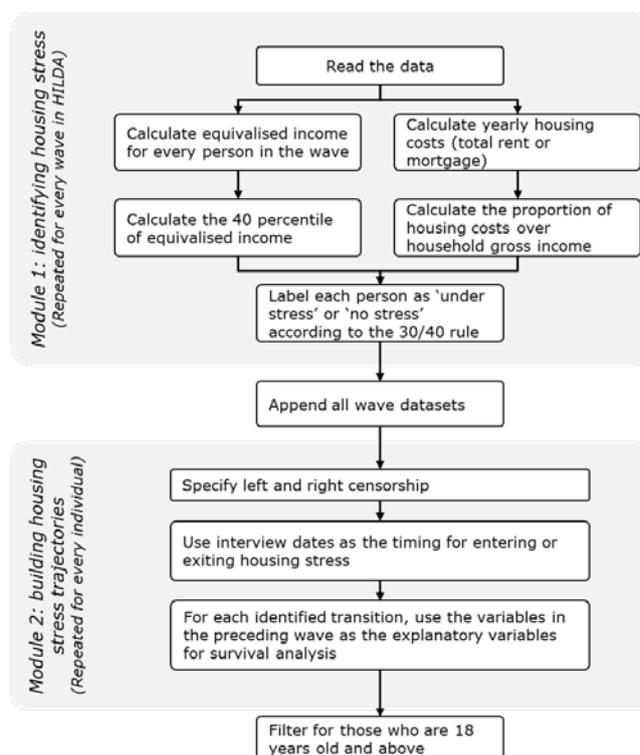
Source: Authors.

The second module is dedicated to constructing housing-stress trajectories. In this module, information from all waves is appended to create a longitudinal profile for each individual. Then transitions into and out of housing stress are identified on the longitudinal profile. The date of interview is assumed to represent the transition date. When a transition is observed, the information from the preceding wave is assumed to represent the attribute corresponding to the transition. The list of variables is detailed in Table A1 in Appendix 1.

In this study we use housing stress as a measure of undesirable housing outcome. Housing stress is calculated based on the 30/40 rule to identify low-income households (the bottom 40 per cent regarding equivalised income) who spend more than 30 per cent of their gross income on housing (Gabriel, Jacobs et al. 2005).

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1   The research team will make the R script available upon request.

We calculated housing stress based on households' income and housing expenditure, then we attributed this measure to all individuals within the household. Thus, in this study, housing stress is an individual-specific measure.

Housing stress is calculated for all available waves in HILDA (from 2005 to 2018). Available data for each individual are listed sequentially to form a longitudinal trajectory of housing stress. Figure 6 shows a sample schematic trajectory diagram for five hypothetical individuals. As shown in this figure, waves 2001 to 2004 are excluded from the trajectories. This is because some variables such as 'difficulty in paying rent or mortgage' is not available for these waves.

Individual 1 was under housing stress from 2005 to 2007. Since no information is available before 2005, the trajectory for this individual is indicated as left censored. This individual has made a transition to no housing stress in 2007, and has not experienced housing stress again until 2011, when they make another transition into housing stress. The next transition (out of housing stress) is observed in 2017. The trajectory for this individual is right censored at 2018 (the latest available wave of HILDA) as no information is recorded after that. Individuals 2 and 3 represent cases with no transition. Individual 4 represents those individuals who were added to HILDA in 2010, when the HILDA sample was augmented by an additional 2153 new households. Individual 5 represent a generalised version of trajectory, as individuals can be added to HILDA or be excluded at any wave.

Figure 6: Schematic diagram of housing-stress trajectories
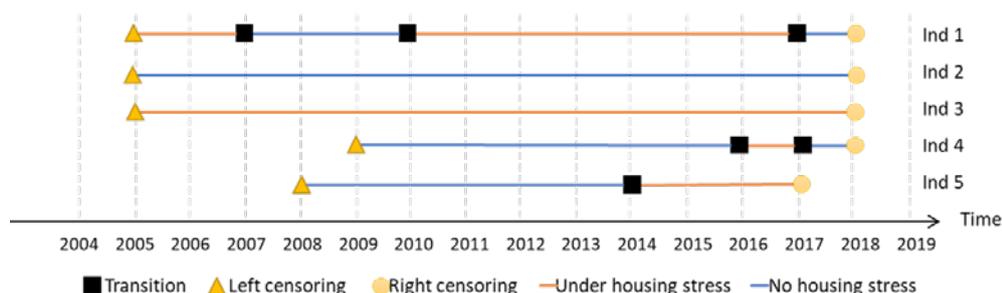
Source: Authors.

In survival analysis, the transitions are commonly known as *failures*, the right-censored segments are known as *survivals*, and the duration between any two consecutive transitions is referred to as *spell length*. In the cases of censoring, spell length is measured from or to the time of censoring.

2.2.2 Failure and censoring profiles

The processed dataset contains 29,691 unique individuals. Overall, these individuals have experienced 35,951 segments of no housing stress and 11,682 segments of housing stress. The total number of transitions is 17,942.

Figure 7 shows the histogram of spell lengths. The distributions are stratified based on housing stress and censoring conditions. The bottom two plots show histograms for right-censored observations, and the top two plots show histograms for observations with transition. The left plots pertain to those who are not under housing stress and the right plots represent those who are under housing stress. The colour coding separates left-censored observations from those with known spell commencement date.

According to Figure 7, the majority of segments are right-censored spells for individuals with no housing stress (27,057 records in the bottom-left plot). The spike at 15 in the bottom-left plot represents those who have been interviewed in HILDA from 2005 and never experienced housing stress over the 16 years of HILDA survey (e.g. Individual 2 in Figure 6). The second spike at 9 years in the bottom-left plot pertains to individuals added in the HILDA 2010 augmentation who had not experienced housing stress until 2018. The bottom-right plot shows the spell length histogram for right censored under-stress segments (e.g. the last segment for Individual 5 or the trajectory of Individual 3 in Figure 6). The top two plots in Figure 7 show the spell length duration for failure cases. According to these plots, the majority of transitions occur in one year.

Figure 7: Histogram of the spell length stratified, based on housing stress and censoring
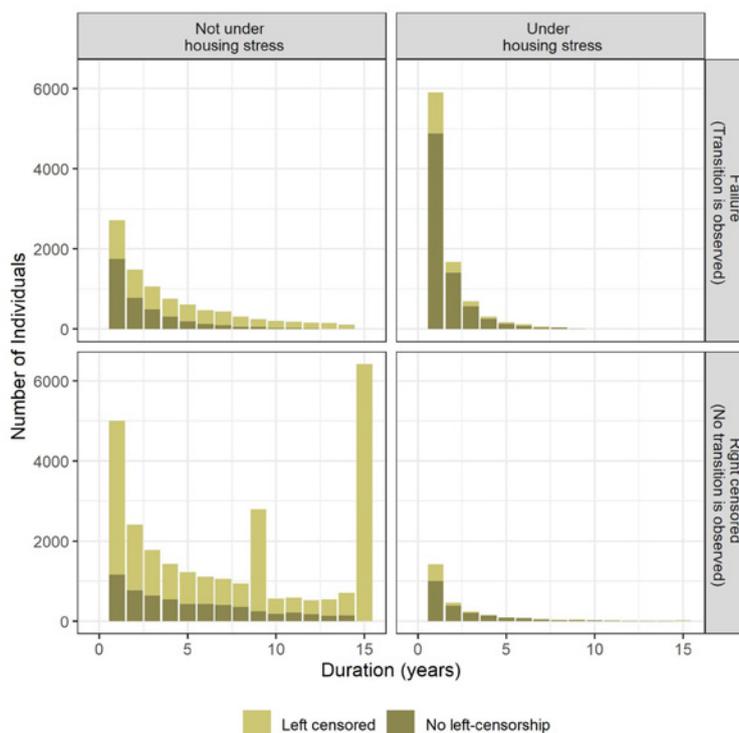
Source: Data from HILDA survey; authors' original analysis.

2.2.3 Resilience and vulnerability to housing stress

This subsection compares the attributes of those who never experienced housing stress (the spike at 15 in the bottom-left plot in Figure 7) against those who have transitioned into housing stress in one year (the spike at 1 in the top-left plot in Figure 7). In this study, these cohorts are referred to as *resilient individuals* and *vulnerable individuals* respectively. This analysis is applicable to individuals who are not under housing stress.

Figure 8 shows the distributions of age group, employment, family type and tenure status for the resilient and vulnerable cohorts. For the vulnerable cohorts, these variables are measured at the beginning of the spell—in other words, one year prior to entering housing stress—to describe the demographic attributes preceding the transition to housing stress. For the resilient cohort, these variables are measured from the time they entered the survey, to depict the demographic attributes that have resulted in 15 years without housing stress.

Rental tenure includes both private and social housing tenants. The decision to combine rental tenures was made with consideration to sample size, as well as the existing complexity of the model.

The age distribution for the resilient cohort shows a monotonically increasing trend, whereas the age distribution for the vulnerable cohort reveals a decreasing trend. This observation suggests higher housing stability for older individuals. When no major disruption is experienced, individuals' resilience will increase over time as more wealth is accumulated and social capital is increased. Therefore, when a disruption occurs, older individuals who have built higher resilience are more likely to absorb the impact and not experience housing stress.

For the resilient cohort, 42 per cent are full-time workers, 31 per cent are retirees, 18 per cent are part-time workers, and only 2 per cent are looking for a job. But for the vulnerable cohort, nearly 9 per cent are looking for a job, with only 29 and 23 per cent engaged in full-time and part-time jobs respectively.

The family structure distribution of the resilient cohort is skewed towards couples (39 per cent are couples without kids, and 37 per cent are couples with kids) and the portion of singles is 16 per cent. For the vulnerable cohort, the proportion of couples without kids and couples with kids is 22 per cent and 32 per cent respectively, and the proportion of singles is 24 per cent.

In terms of the tenure status, 84 per cent of the resilient cohort are owner-occupiers and only 13 per cent are renter-occupiers, whereas for the vulnerable cohort, 60 per cent are renter-occupiers and 35 per cent are owner-occupiers.

Figure 8: Demographic attributes of resilient and vulnerable cohorts
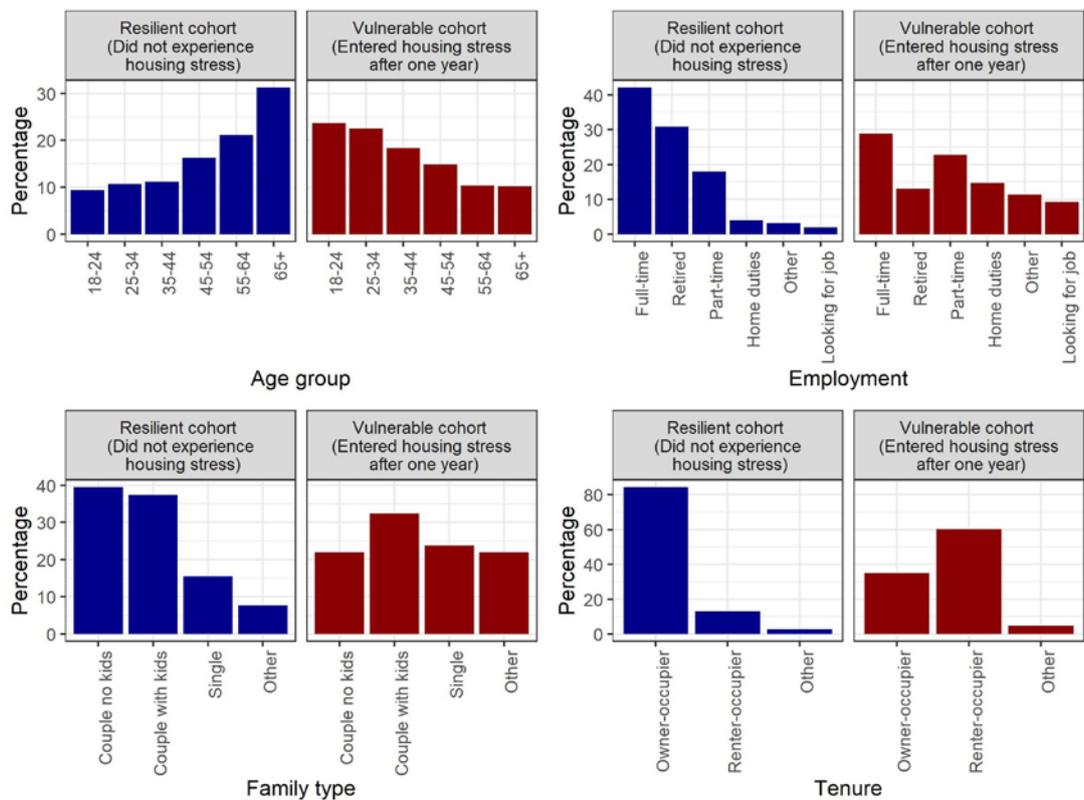
Source: Data from HILDA survey; authors' original analysis.

3. Critical life events as risk and intervention opportunities

- In this section, the 21 critical life events collected in HILDA surveys are divided into five groups: financial; family formation and dissolution; health; area of justice; and housing. The likelihood of experiencing each critical life event in 2018 is then calculated.

- The most likely event is 'change of residence' with a frequency of 13.7 per cent. In the 'health' category, 'serious injury or illness to a family member has the highest likelihood (11.5%) and death of spouse or child has the lowest (0.7%). In the finance group, changing job is the most likely critical life event (10.9%). In the family formation and dissolution group, pregnancy has the highest likelihood (4.6%). The most likely critical life event in the justice group is being victim of a property crime (2.75%).

- HILDA waves 2005–2018 are investigated to understand the likelihood of critical life events over an individual's lifespan.

- Marriage, pregnancy and birth or adoption of a new child are more probable between ages 25–35. The likelihood of separation before age 25 is between 5–6 per cent, followed by a decreasing trend after age 25. The likelihood of changing jobs shows a monotonically decreasing trend from nearly 25 per cent for ages below 25 years to zero after age 70 years. Promotion at work has its peak at around 12 per cent between ages 25–28. The likelihood of justice-related critical life events is always below 5 per cent.

3.1 Existing research

Conceptualising the range of income-affecting events that can influence the likelihood of a household to enter or become more precarious within an overall housing affordability risk landscape within a coherent framework is important for identifying discrete risk pathways, as well as intervention points. In recent evidence, the concept of critical life events—borrowed from health and psychology to describe the interaction of events that have major impacts on peoples' lives—has been usefully operationalised within housing research to account for the relationality of risk, critical life events experienced by households, and need for housing-assistance intervention.

As established by Stone, Sharam et al. (2015:19), with regards to housing:

> A critical life events framework has the capacity to inform our understanding of (i) the non-housing life events and housing 'shocks' experienced by individuals and households, (ii) the ways parts of the housing system compound or mitigate adverse consequences of these events, (iii) and the role of personal/household capabilities and other 'insurances' that enable households to manage various life events and potentially avoid the accumulation of multiple adverse events that can lead to homelessness or increased reliance on government housing supports.

As Stone, Sharam et al. (2015:20) and related studies argue, critical life events are transitions that reflect developmental or life-course milestones such as partnering, loss of partner, re-partnering, birth of children, employment and housing transitions.

The way in which individuals experience adverse critical life events are influenced by personal and contextual circumstances (Baxter, Qu et al. 2012). Critical life events are of interest to public policy as adverse events are associated with losses, which range from health to personal resilience to economic losses. These losses are sometimes temporary but are often long-lasting or permanent and, in turn, are often associated with further losses.

Critical life events can be grouped into three main types (Moloney, Weston et al. 2012; Stone, Sharam et al. 2015). All affect the financial or other capacity of households to manage various aspects of their lives—and, for the purposes of this study, are important as potentially resulting in housing affordability stress and a context of household risk that renders the ability of a given household to respond to further 'shocks' difficult, without the intervention of housing or other welfare assistance.

The critical life events of interest in this study of housing stress are related to:

- engagement in financial or labour-market activities
- family/household change—which in turn affects financial capacity
- illness, disability and ageing—which also affects the financial capabilities of households, as well as other personal capabilities.

Building on the work of Moloney, Weston et al. (2012) and Stone, Sharam et al. (2015), these three types of critical life event, and examples of each, are set out in Table 1.

Table 1: Types of critical life event that can lead to housing affordability stress

Event type		Adverse impact on capacity to manage tenancies	Positive impact on capacity to manage tenancies
Financial		Unemployment	Gain employment
		Underemployment	Increase work hours or pay rate
		Low educational attainment	Undertake education or training
Family formation and dissolution	Partnering	Separation or divorce	Partner
		Death of spouse	Re-partner
	Dependants	Child bearing	Child achieves adult independence
		Care of dependant/s	
Health and ageing	Illness/disability	Short-term or chronic illness	Rehabilitation/recovery of health
		Disability	Rehabilitation/appropriate training for employment
	Ageing	Retirement	

Source: Original reclassification of Social Readjustment Rating Scale, as shown in Moloney, Weston et al. (2012); modification of Stone, Sharam et al. (2015).

Within the present research, critical life events are examined in relation to the extent to which they lead to housing stress, the enduring nature of any housing stress that is associated with critical life events, as well as exits from any housing stress associated with the initial critical life experience. Housing stress limits the ability of individuals and households to respond to future shocks, and may be associated with varied risk of ongoing need for assistance, according to life stage, existing wealth and resources, and income.

3.2 Analysis section: longitudinal profile of critical life events

To investigate the potential impact of experiencing critical life events on entering housing stress, the longitudinal profile of critical life event occurrence is needed. HILDA collects a list of life events that respondents have experienced. This list contains 21 life events, which are divided into five categories, as shown in Table 2.

Table 2: List of critical life events in HILDA

Category	Events	Variable name in HILDA
Financial	Changed jobs	lejob
	Promoted at work	leprm
	Retired from the workforce	lertr
	Major improvement in finances	lefni
	Major worsening in finances	lefnw
	Fired or made redundant	lefrd
Family formation and dissolution	Birth/adoption of new child	lebth
	Got married	lemar
	Pregnancy	leprg
	Got back together with spouse	lercl
	Separated from spouse	lesep
Health	Serious injury/illness to family member	leinf
	Serious personal injury/illness	leins
	Death of a close friend	ledfr
	Death of close relative/family member	ledrl
	Death of spouse or child	ledsc
Area of justice	Detained in jail	lejls
	Close family member detained in jail	lejlf
	Victim of a property crime	lepcm
	Victim of physical violence	levio
Housing	Changed residence	lemvd

Source: Events and variable names from HILDA (2022); categories by authors.

Figure 9 shows the likelihood of critical life event occurrence in 2018, calculated using the HILDA sample. The data used to obtain the likelihood of critical life events includes 17,612 individuals who are 18 years and older. The likelihood for a critical life event is calculated as the proportion of individuals reporting experiencing the critical life event in the past year, over total number of individuals in the sample. The bar charts in Figure 9 shows the likelihoods for the 21 critical life events categorised into five groups.

According to Figure 9, the most likely event is change of residence, with a likelihood of 13.7 per cent. In the health category, serious injury or illness to family member has the highest likelihood (11.5%) and death of spouse or child has the lowest likelihood (0.7%). In the finance group, changing job is the most likely critical life event, with a likelihood of 10.9 per cent. This is followed by receiving promotion at work, with a likelihood of 5.57 per cent. In the family formation and dissolution group, pregnancy has the highest likelihood (4.64%) and reuniting with spouse has the lowest likelihood (0.70%). Critical life events in the justice group show relatively lower likelihood compared to other categories. The most likely critical life event in this group is being victim of a property crime, with a likelihood of 2.75 per cent.

Figure 9: Frequency of critical life event occurrence in HILDA 2018 sample
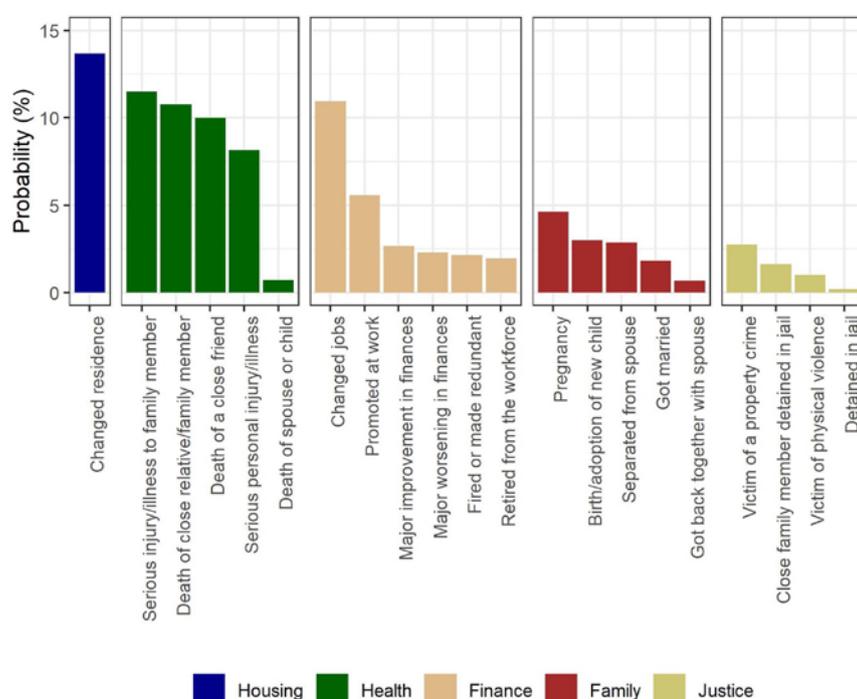
Source: Data from HILDA survey; authors' original analysis.

Likelihood of a critical life event occurrence

The likelihood of a critical life event occurrence varies over a lifetime. Some critical life events are more likely during early adulthood, and some are more probable at older ages. Understanding the rate of critical life event occurrence over a lifespan—along with investigating the contribution of critical life events on entering housing stress—can inform more targeted assistance.

In this study, we use the HILDA survey to obtain the occurrence profile of critical life events. To that end, all those who are above 18 years old are extracted from waves 2005 to 2018, then the ratio of number of critical life events over total individuals is calculated for different ages. The profile obtained from this shows average probability of occurrence for each critical life event by age. This profile does not reflect the period effect and cohort effect. The results are presented in Figure 10.

The sample size for age 90+ is less than 250. This small sample size can cause wide variations in the profiles, so the profiles are trimmed at 90. The sample size by age is shown in Figure A1 in Appendix 2.

Health-related critical life events

From the health-related critical life events, death of a spouse or child has relatively less probability in the sample of this study. Death of a close friend shows an increasing trend by age, and it exceeds 20 per cent between ages 73–88. In terms of family-related critical life events, marriage, pregnancy and birth or adoption of a new child are more probable between ages 25–35. Separation shows a decreasing trend, starting from slightly above 5 per cent for ages below 25 years, with the trend approaching zero as age increases. The probability for returning to a spouse is negligible in the HILDA sample.

Changing jobs

Changing jobs shows a monotonically decreasing trend starting from nearly 25 per cent for ages below 25 years, and it becomes nearly zero after age 70. At this age, many individuals are retired and changing jobs is not an applicable critical life event for them. Promotion at work has its peak at around 12 per cent between ages 25–28. Similar to job change, the probability of promotion at work approaches zero after age 70. The probability of redundancy and dismissal is always below 5 per cent, and it becomes negligible after age 70 years. Retirement mainly occurs between age 60 and 90, and it reaches its peak at age 65 years. Major worsening in finance and major improvement in finance show relatively low probability in the HILDA sample.

Justice-related critical life events

When it comes to justice-related critical life events in HILDA, the probability of all critical life events is always below 5 per cent. Although the probability of critical life events in this category is low, the consequences of these events can be severe (Martin, Reeve et al. 2021). Therefore, a targeted data collection is required for a thorough investigation of justice-related critical life events and their potential impact on housing outcomes.

Figure 10: Probability of critical life events by age, from HILDA waves 2005–2018
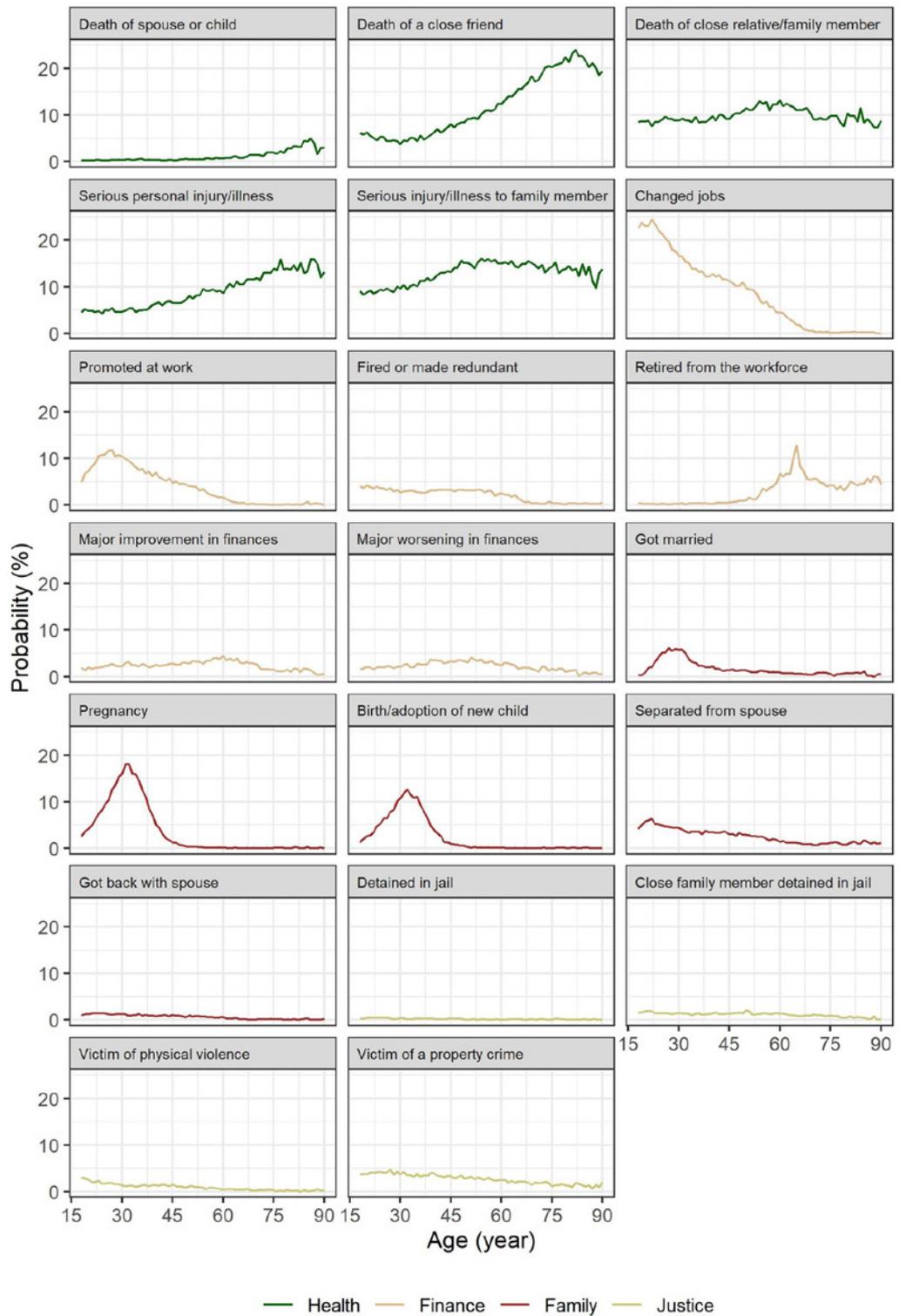
Source: Data from HILDA survey; authors' original analysis.

Residential mobility

The probability of residential relocation is presented in Figure 11. The curves are stratified based on tenure status and housing stress condition. For comparison purposes, the two different arrangements of stratifications are presented. According to this figure, residential mobility shows a decreasing trend by age. Renter-occupiers are more mobile compared to owner-occupiers. However, experiencing housing stress does not show a significant impact on residential mobility.

Figure 11: Residential mobility probability by age, from HILDA waves 2005–2018
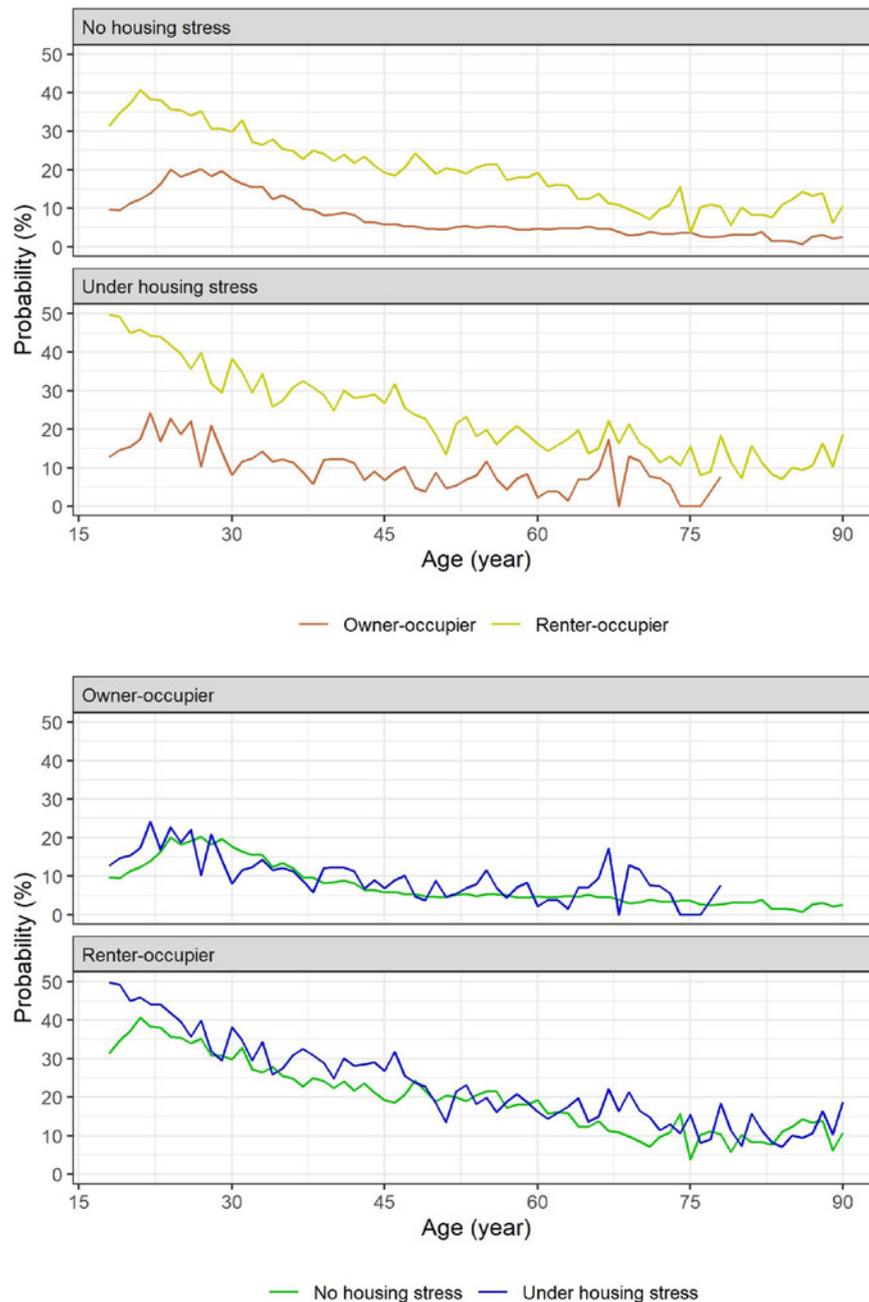
Source: Data from HILDA survey; authors' original analysis.

3.3 Policy development implications of this research

Longitudinal and panel household data, such as HILDA, provide detailed information about the life conditions of individuals and households. Understanding the history of experienced critical life events provides an accurate and objectively assessable measure of vulnerability.

The temporal variations in the likelihood of critical life events over an individual's lifespan, and the likelihood of experiencing multiple critical life events, can also be obtained from such datasets. This enables policy makers to identify the most critical life stages in which the likelihood of experiencing shock is relatively higher.

Despite their enormous benefits, longitudinal household surveys over a representative sample fall short in providing an accurate and detailed picture about some cohorts. For example, the sample of HILDA includes only a few individuals who have experienced jail detention, and no reliable or significant conclusion can be drawn from such a sample size. Conducting targeted surveys and integrating data from different sectors are strategies recommended to mitigate this issue.

4. Quantifying risk and resilience: a data-driven approach to predict housing stress

- This section uses the survival-analysis method to model the risk of entering housing stress.

- Renter-occupiers are more likely to enter housing stress than owner-occupiers, and less likely to recover from it. The non-parametric Kaplan Meier estimator shows the risk of entering housing stress is three to five times higher for renter-occupiers. The probability of recovering from housing stress in the first year of entering housing stress is 39.4 per cent for renter-occupiers and 48.9 per cent for owner-occupiers. The Cox proportional hazard (PH) model indicates a risk ratio of 2.252 for renter-occupiers, which shows that renter-occupiers are 2.252 times more likely to enter housing stress compared to owner-occupiers.

- The Cox PH model shows that younger individuals are more likely to enter housing stress, while those aged 18–25 years old are 3.146 times more likely than those above 65 years old to enter housing stress. Compared to individuals engaged in full-time employment, those who are looking for a job are 2.411 times more likely to enter housing stress. The ratio for those engaged in home duties is 2.226, and for part-time employees and retirees it is 1.671 and 1.785 respectively.

- Marriage in the past year increases the risk of entering housing stress by 14.8 per cent, separation increases the risk by 30.1 per cent, pregnancy increases the risk by 12.8 per cent, and birth or adoption of a new child increases the risk by 34.1 per cent. Redundancy or dismissal increases the risk of entering housing stress by 14.2 per cent, and major worsening in finance increases the risk by 72.1 per cent. Promotion at work *decreases* the risk of entering housing stress by 39.4 per cent.

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4.1 Existing research on survival analysis and its application in housing studies

This study introduces the concept of risk pathways to address the stochasticity and the dynamic nature of housing pathways. The risk pathway is conceptualised as the likelihood of entering housing stress. To examine the impact of critical life events and other factors on the risk of entering housing stress, this study uses the survival-analysis method (Stevenson 2009; Jenkins 2005). Survival analysis (aka hazard-based modelling) provides a consistent platform to model *time of an event*.

The survival-analysis method is not new in the literature of housing studies. Modelling residential mobility is the most common application of survival analysis in housing studies. The event of interest in this application is residential relocation, and the method is utilised to understand the effect of covariates on accelerating or decelerating mobility.

Early studies in this area investigated the impact of socio-demographic attributes on residential mobility (e.g. Clark and Davies Withers 1999). This method enables researchers to study the effect of tenure choice as an external covariate, or to jointly model tenure choice with residential mobility (Deurloo, Dieleman et al. 1997; Henley 1998; Ioannides 1987). With computational advancements and enhancement in disaggregate data availability, survival analysis could be used to investigate the impact of life-course events (Clark 2013; Morris 2017), and neighbourhood characteristics (Archer, Ling et al. 2010; Clark, Deurloo et al. 2006) on residential mobility.

Survival analysis is flexible and includes latent variables on residential mobility, reflecting the impact of psychological constructs such as:

- intention to move (Clark and Lisowski 2018; 2017)

- anticipation of future tenure status (Ghasri and Rashidi 2018)

- individuals' risk attitude (Morrison and Clark 2015; Rashidi and Ghasri 2019).

The event of interest in this study is entering housing stress, and the dependent variable in the modelling practice is the time it takes to enter housing stress. The potential impact from covariates is investigated using the non-parametric Kaplan Meier (KM) estimators, and the semi-parametric Cox proportional hazard (PH) model.

4.2 Application of survival analysis in predicting risk of entering housing stress

4.2.1 Methodology

This section provides a brief introduction to the mathematical definition for the main functional forms in survival analysis, then elaborates on the interpretation of these functions in the context of this study.

Survival analysis is commonly used to model time of an event (Jenkins 2005; Stevenson 2009). The models in survival analysis can be set up using four interrelated functional forms. These are:

1. Failure function—the probability of the event occurring between time t and $t + \Delta t$ where Δt is an infinitesimal interval.

2. Survival function—the probability of the event not occurring before time t.

3. Hazard function (aka hazard rate or risk)—the rate of the event occurring, conditional on survival until time t. (Hazard function represents the rate of failure, *not* the probability of it.)

4. Cumulative-hazard function—the cumulative rate of failure until time t.

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Equation (1) shows the mathematical definition of failure function. Equation (2) shows the relationship between the hazard function, and the failure and survival functions. In these equations, $h(t)$ denotes the hazard rate, $f(t)$ denotes the failure function and $S(t)$ indicates the survival function (Jenkins 2005). As shown in these equations, all of the functions are interrelated and can be converted into one another. However, each function provides a unique interpretation.

$$f(t) = \lim_{\Delta t \to 0} \frac{\Pr(t \leq T \leq t + \Delta t)}{\Delta t} = -\frac{\partial S(t)}{\partial t} \qquad (1)$$

$$h(t) = \lim_{\Delta T \to 0} \frac{P[T + \Delta T > t \geq T | T \leq t]}{\Delta T} = \frac{f(t)}{S(t)} \qquad (2)$$

In this study, two types of transitions are possible:

i.   entering housing stress

ii.   recovering from housing stress.

Accordingly, two sets of functions can be estimated. Where entering housing stress is concerned, the failure function shows the probability distribution for entering housing stress. This function shows the probability of transitioning to housing stress at a specific time over the housing trajectory. The survival function shows the cumulative probability of not entering housing stress until any specific time on the trajectory. This function reports the probability of remaining in the no-housing-stress phase until time t. The survival function has a non-increasing trend, which starts from one at t=0 and approaches zero as times goes towards infinity.

The hazard function is a conditional rate. This function shows the risk of entering housing stress at any time, given the transition is not observed before then (Cleves, Gould et al. 2008). The hazard function evaluates the risk of transition at time t for those who are still in the no-housing-stress phase by that time. This function shows the rate of transition (and not its probability), and in principle it can vary from zero to infinity. If the hazard rate is zero, then the probability of transition is zero. If the hazard rate is constant over time, then the probability of transition does not change over time. In this scenario, the probability of entering housing stress remains unchanged regardless of how long the individual is in the no-housing-stress phase.

An increasing hazard rate suggests a bleak future. In this scenario, the probability of entering housing stress will increase over time. An increasing hazard can be a suitable measure to identify early intervention. In contrast, a decreasing hazard indicates a brighter future. In this scenario, entering housing stress becomes less likely as time passes. The cumulative-hazard rate measures how the risk of transition to housing stress accumulates over time. This function is a non-decreasing function starting from zero, but as it measures risk (and not probability) it can increase to infinity.

Where recovering from housing stress is concerned, the failure function shows the probability distribution for recovering from housing stress, the survival function shows the cumulative probability of not recovering from housing stress, and the hazard function shows the conditional rate of recovering from housing stress.

4.2.2 Kaplan Meier estimator

This section presents a non-parametric method for estimating the survival and cumulative-hazard functions. The Kaplan Meier (KM) estimator is a non-parametric method commonly used to estimate the survival curve, and we can derive the cumulative-hazard function from the non-parametric survival function. The KM estimator relaxes the need for a parametric distribution on the target variable.

This study uses the cumulative-hazard rate to model the behaviour of entering housing stress, and it uses the survival function to explain the recovery from housing stress. The cumulative hazard reveals the accumulation of risk of entering housing stress over time, and the survival function shows the probability of remaining under housing stress. This combination enables us to identify the characteristics of the cohort vulnerable to entering housing stress, and the attributes of those who are less likely to recover from housing stress.

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Equation (3) shows the KM survival function. In this equation $\hat{S}(t_j)$ is the estimated survival during the time interval t_j, d_j is the number of failures (transitions) during interval j and n_j is the number of individuals in risk during this time interval. From the non-parametric survival function, we can derive the cumulative-hazard function as specified in equation (4) (Jenkins 2005). In this equation $\hat{H}(t_j)$ denotes the cumulative-hazard rate at the time interval t_j.

$$\hat{S}(t_j) = \prod_{j|t_j<t} (1 - \frac{d_j}{n_j}) \tag{3}$$

$$\hat{H}(t_j) = -\log\left(\hat{S}(t_j)\right) \tag{4}$$

Figure 12 shows the cumulative-hazard curve for those who are not under housing stress, and the survival curve for those who are under housing stress. To calculate these curves, the left-censored records are excluded from the dataset. As explained in subsection 2.2.1, the spell lengths are calculated using interview dates. In this section, and for the non-parametric survival and hazard functions, the spell lengths are rounded to the closest integer. The cumulative-hazard rate (left) shows how the risk of transitioning to housing stress increases over time. A sharp leap is noticeable at Year 1, after which the curve continues with a relatively constant slope. This indicates on average a higher risk of transitioning to housing stress in the first year, followed by a constant risk afterwards. The survival curve (right) shows the probability of remaining under housing stress over time. As shown in this curve, the probability of survival in Year 1 is 54.8 per cent, indicating that 45.2 per cent (100–54.8) of individuals will recover from housing stress after one year.

Figure 12: Cumulative risk of entering housing stress (left), and the probability of remaining under housing stress (right)
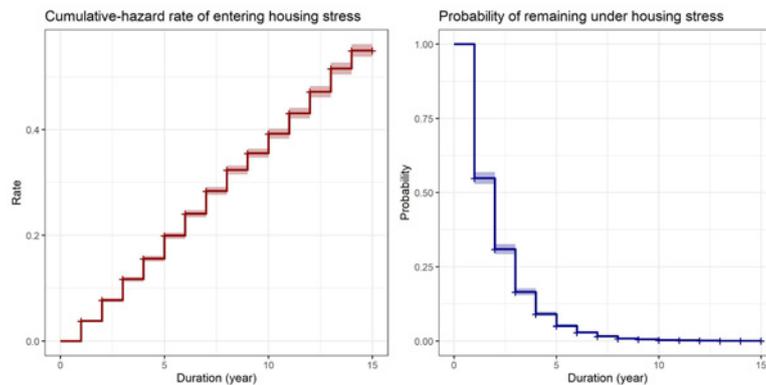
Source: Data from HILDA survey; authors' original analysis.

The cumulative-hazard rate and survival functions can be stratified based on individuals' attributes. Figure 13 shows the stratified curves based on tenure status. Tenure status is measured at the beginning of the spell. According to this figure, the risk of entering housing stress is higher for renters, and the gap between renter-occupiers and owner-occupiers increases over time. The risk of entering housing stress in Year 1 for renter-occupiers is 0.067, which is three times higher than for owner-occupiers (0.022). In Year 15, the accumulated risk for renter-occupiers is 1.19, which is nearly four times higher than the accumulated risk for owner-occupiers (0.32). On the other hand, compared to owner-occupiers, the survival curve for renter-occupiers is higher, which indicates a higher probability of staying under housing stress for renter-occupiers. In Year 1, the probability of remaining under housing stress for renter-occupiers and owner-occupiers is 57.1 per cent and 48.5 per cent respectively. The probability of remaining under housing stress after five years is 7.1 per cent for renter-occupiers but only 2.2 per cent for owner-occupiers. Overall, renter-occupiers are more likely to enter housing stress, and less likely to recover from it.

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Figure 13: Cumulative risk of entering housing stress (left), and probability of remaining under housing stress (right), stratified by tenure
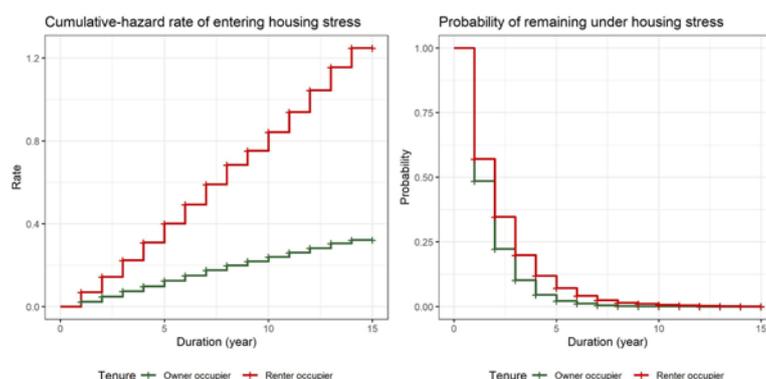
Source: Data from HILDA survey; authors' original analysis.

Figure 14 shows the stratified curves based on employment. As shown in this figure, those who are looking for a job are at higher risk of entering housing stress and relatively less likely to recover from it. Full-time workers have lower risk of entering housing stress and lower probability of remaining under stress. Retirees show mixed behaviour. On one hand, retirees have a relatively low risk of entering housing stress but, at the same time, they show a relatively low probability of recovering from it.

In Figure 15, the cumulative-hazard rate and survival curves are stratified by age group. According to the cumulative-hazard rate, as age increases, the risk of transitioning to housing stress becomes higher. However, when it comes to recovering from housing stress, individuals younger than 55 years old have similar survival curves. The survival curve for those between 55 and 64 years old is slightly higher than younger age groups and the survival curve for those above 65 is significantly higher than other age groups.

Figure 16 shows the cumulative-hazard rate and survival curves stratified by family type. According to this figure, the first-year jump in cumulative hazard for singles and couples with children is close. However, the risk accumulates faster for singles, with the cumulative risk for singles becoming more than two times higher than for a couple without kids after 15 years. Regarding recovery from housing stress, the survival curve for singles is higher than others, which suggests a lower probability of recovery for singles.

Figure 14: Cumulative risk of entering housing stress (left), and probability of remaining under housing stress (right), stratified by employment
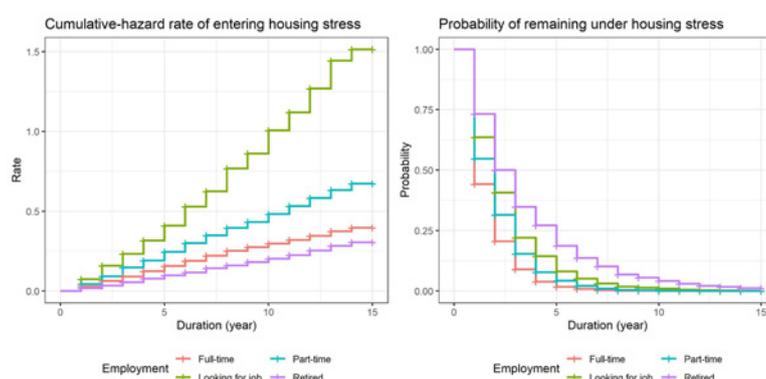
Source: Data from HILDA survey; authors' original analysis.

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Figure 15: Cumulative risk of entering housing stress (left), and probability of remaining under housing stress (right), stratified by age group
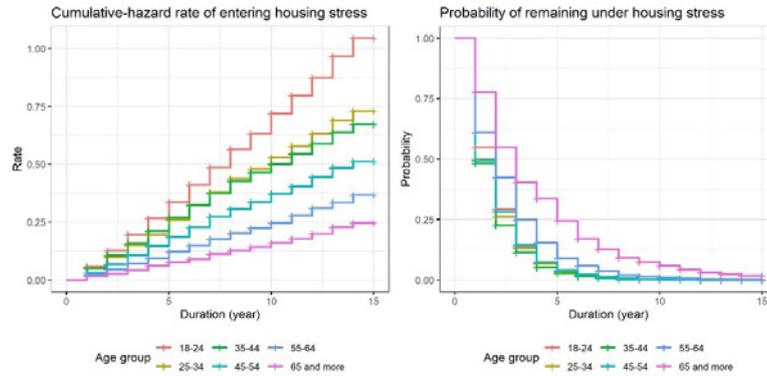
Source: Data from HILDA survey; authors' original analysis.

Figure 16: Cumulative risk of entering housing stress (left), and probability of remaining under housing stress (right), stratified by family type
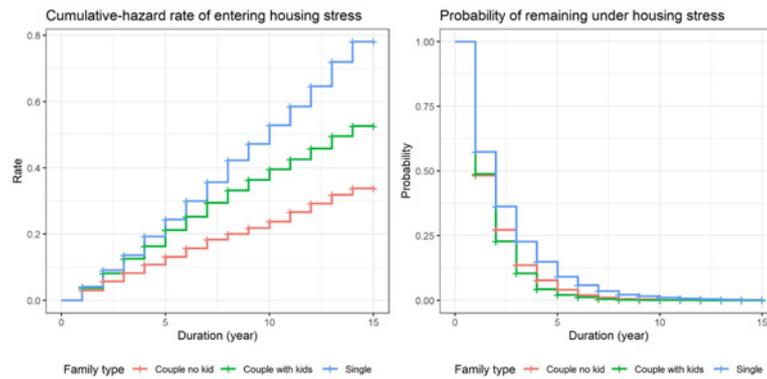
Source: Data from HILDA survey; authors' original analysis.

4.2.3 Cox proportional hazard model

In this section, the effect of covariates on the risk of transitioning to housing stress is discussed. The functions introduced in subsection 4.2.1 are only functions of time and cannot capture the heterogeneity in the sample. The non-parametric KM survival curve presented in subsection 4.2.2 provide some visual cues on the impact of covariates on risk. In this subsection, we use the Cox's proportional hazard model (aka the Cox model) to quantify the impact of covariates (Jenkins 2005).

The Cox model is a semi-parametric model that provides insight on the impact of covariates on the hazard rate without making any assumption about the baseline hazard distribution. In this model (and in all proportional-hazard-based models), the effect of covariates on the hazard rate is formulated as equation (5). In this equation, $h(t,x)$ denotes the hazard function, $h_0(t)$ is the baseline hazard as introduced in subsection 4.2.1, x is a vector of covariates and β is a vector of coefficients to be estimated. The Cox model enables us to estimate the parameters of this relationship (β) without the need to make any assumption about the baseline hazard ($h_0(t)$). The likelihood of this model is shown in equation (6). In this equation, $\mathcal{L}_k$ is the probability of individual k experiencing the transition at time t, conditional on this individual being at risk at that time (Jenkins 2005).

$$h(t,x) = h_0(t)\exp(\beta x) \tag{5}$$

$$PL(\beta) = \prod_{k=1}^{K} \mathcal{L}_k \tag{6}$$

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In this study, we assume unobserved heterogeneity is negligible. Therefore, the model does not include any random individual effect. The point estimates of coefficients will represent average sensitivity towards covariates across the sample and will remain constant over time. Ignoring unobserved heterogeneity in case it is significant may cause estimation biases, but this issue is not critical for the proof of concept modelling approach in this study. Besides, ignoring unobserved heterogeneity is common practice in the field of housing studies (e.g. Dantzler and Rivera 2019; Hsu, Rice et al. 2019; Kamruzzaman, Giles-Corti et al. 2021; Rashidi and Ghasri 2019).

The focus of this study is capturing the effect of critical life events on risk pathways. Since critical life events, as well as several other attributes, are time-varying covariates, we need to restructure our dataset.

In this section, we measure the spell lengths from the first time individuals are observed in a HILDA survey. Since the Cox model is concerned with the transition between stages and not the baseline hazard, the left-censored records are not excluded. Also, we assume the attributes only vary from survey to survey and remain unchanged in between. Therefore, the trajectory of each individual is separated into yearly pieces.

Figure 17 shows one example of this transformation. In this figure, the trajectory diagram for Individual 4, which was discussed in Figure 6, is separated into nine 1-year segments. For each segment, the observed attributes at the beginning of the period are considered as the covariates. For each segment from 2009 to 2015, the segments are labelled as right censored as no transition has occurred. In 2016, a transition from no-housing stress to under housing stress is recorded. During the next one-year period from 2016 to 2017, Individual 4 is under housing stress, with a recovery out of housing stress in 2017. This is followed by another year out of housing stress with right censoring in 2018.

Figure 17: Transformation of housing trajectory data for time-varying analysis
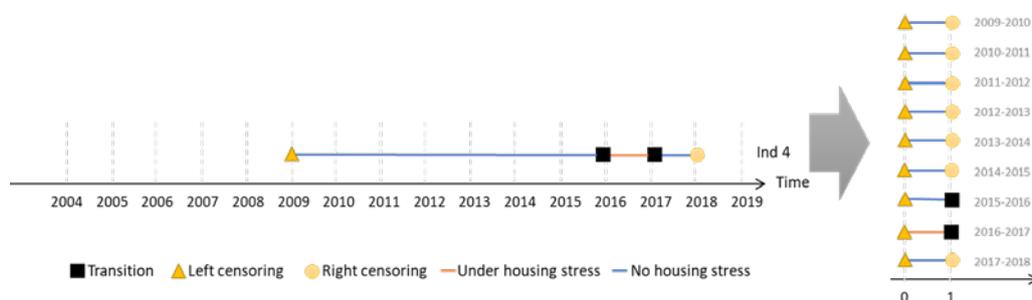
Source: Authors.

Once all of the housing-stress trajectories are split into yearly segments, as described earlier, then the data for those who are not under housing stress is extracted for modelling.

The parameters of the model are estimated using the 'survival' package in the statistical software package of R[2]. Table 3 shows the estimated risk-ratios and their corresponding 95 per cent confidence interval. The estimated coefficients and model goodness of fit details are reported in Table A2 in Appendix 3.

The investigated explanatory variables include age, education, employment, tenure, health condition and critical life events experienced in the past year. The base case for the categorical variables is selected in a way that all risk ratios are greater than one. As this model shows the risk of entering housing stress, the selected base case will represent the characteristics of the most resilient cohort.

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2   The research team will make the code available upon request.

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Table 3: Risk ratios of entering housing stress, obtained from the Cox PH model

Variables	Risk ratio	Lower.95.	Upper.95.
Age between 18 and 24	3.146	2.669	3.71
Age between 25 and 34	2.543	2.157	2.998
Age between 35 and 44	2.566	2.182	3.019
Age between 45 and 54	1.964	1.67	2.31
Age between 55 and 64	1.475	1.271	1.712
Age above 64	Reference	-	-
Education is Advanced diploma or Diploma	1.608	1.338	1.933
Education is Bachelor or Honours	1.154	0.963	1.382
Education is Certificate III or IV	1.712	1.444	2.029
Education is Grad. diploma, Grad. certificate	1.028	0.826	1.277
Education is Other	1.788	1.513	2.114
Education is Postgraduate	Reference	-	-
Employment is home duties	2.226	2.042	2.427
Employment is looking for job	2.441	2.187	2.725
Employment is other	2.534	2.286	2.808
Employment is part-time	1.671	1.556	1.795
Employment is retired	1.785	1.545	2.063
Employment is full-time	Reference	-	-
Tenure is other	1.236	1.039	1.47
Tenure is renter-occupier	2.252	2.125	2.385
Tenure is owner-occupier	Reference	-	-
Caregiver for a household member	1.145	1.027	1.276
Long-term health condition	1.089	1.023	1.16
Critical life events			
Fired or made redundant	1.142	1.012	1.29
Major worsening in finances	1.721	1.539	1.924
Pregnancy	1.128	1.009	1.26
Promoted at work	0.606	0.527	0.697
Got married	1.148	0.994	1.326
Separated from spouse	1.301	1.159	1.461
Birth/adoption of new child	1.341	1.184	1.518

Source: Authors.

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Age

Age is divided into a categorical variable, and the risk ratio for 65 years and more is set to 1 as the base case. The risk ratios in Table 3 show younger age is associated with higher risk. For instance, the risk ratio for ages 18–24 is estimated as 3.146, which means that individuals in this group are 3.146 times more likely to enter housing stress. In other words, being aged between 18 and 24 can increase the risk ratio by 214.6 per cent. As we move towards older age groups, the risk ratio decreases until it reaches 1.475 for ages 55–64, indicating 47.5 per cent higher risk of entering housing stress for individuals aged 55–64.

Education

For education, the base case is set to 'Postgraduate degree'. Compared to 'Postgraduate degree', holding an 'Advanced diploma or Diploma' will increase the risk of entering housing stress by 60.8 per cent (a risk ratio of 1.608). Holding a 'Certificate III or IV' will increase the risk by 71.2 per cent (a risk ratio of 1.712). For 'Bachelor or Honours' and 'Grad diploma, Grad certificate', the estimated-risk ratio is not statistically different from 1.

Employment

For employment, the base case is set to engaged in 'Full-time employment'. The risk ratio for those 'looking for job' is 2.441, which indicates that compared to the base case, those who are looking for a job are 144.1 per cent more likely to enter housing stress. Similarly, those engaged in 'home duties' are 122.6 per cent more likely to enter housing stress. The risk ratios for part-time employees and retirees are 1.671 and 1.785 respectively.

Housing tenure

In the tenure-status category, owner-occupiers are set as the base case. The risk ratio for renter-occupiers is 2.252, which suggests that renter-occupiers have a 125.2 per cent higher likelihood of entering housing stress.

Caregivers

Those who are caregivers for a household member are 14.5 per cent more likely to enter housing stress. We also examined the risk ratio of caregivers for non-household members, but the coefficient was not statistically significant. Living with a long-term health condition increases the risk of entering housing stress by 8.9 per cent.

Experiencing critical life events

When it came to experiencing critical life events in the past year, seven critical life events (out of the 21 critical life events discussed in Section 3.2) are found significant in the model. From the family-related category, marriage[3], separation, pregnancy and birth or adoption of a new child are found significant, with risk ratios higher than one. Accordingly, marriage increases the risk of entering housing stress by 14.8 per cent, separation by 30.1 per cent, pregnancy by 12.8 per cent, and birth or adoption of a new child by 34.1 per cent.

From the finance-related category, redundancy or dismissal increase the risk of entering housing stress by 14.2 per cent, and a major worsening in finance can increase the risk by 72.1 per cent. Promotion at work is the only critical life event with a risk ratio below one, which indicates that promotion at work decreases the risk of entering housing stress by 39.4 per cent (0.394 = 1 – 0.606).

Resilient and vulnerable cohorts

Figure 18 summarises the risk ratios obtained from the model. The model reveals the characteristics of resilient and vulnerable cohorts entering housing stress. (The complete list of risk ratios is presented in Figure A2 in Appendix 4.)

According to the results, the most resilient cohort based on age, tenure status, employment and education are owner-occupier older adults (65 years+) who have a postgraduate degree and are engaged in full-time work.

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3   Marriage is significant at 90 per cent confidence level.

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The most vulnerable group based on age, tenure status and employment are early middle age to younger adults (aged 18–44 years) who are looking for work and renting their home. In Section 5, the spatial distribution of key demographic attributes (e.g. age, employment, tenure status) in forming vulnerability and resilience are studied. Exploring the univariate distribution of demographic attributes—and the multivariate distribution of the selected attributes informing the so-called most vulnerable and most resilient cohorts—is undertaken to showcase the ability of the model to identify individuals likely to enter housing stress for early intervention and prevention.

Figure 18: The risk ratio of key demographic attributes and critical life events
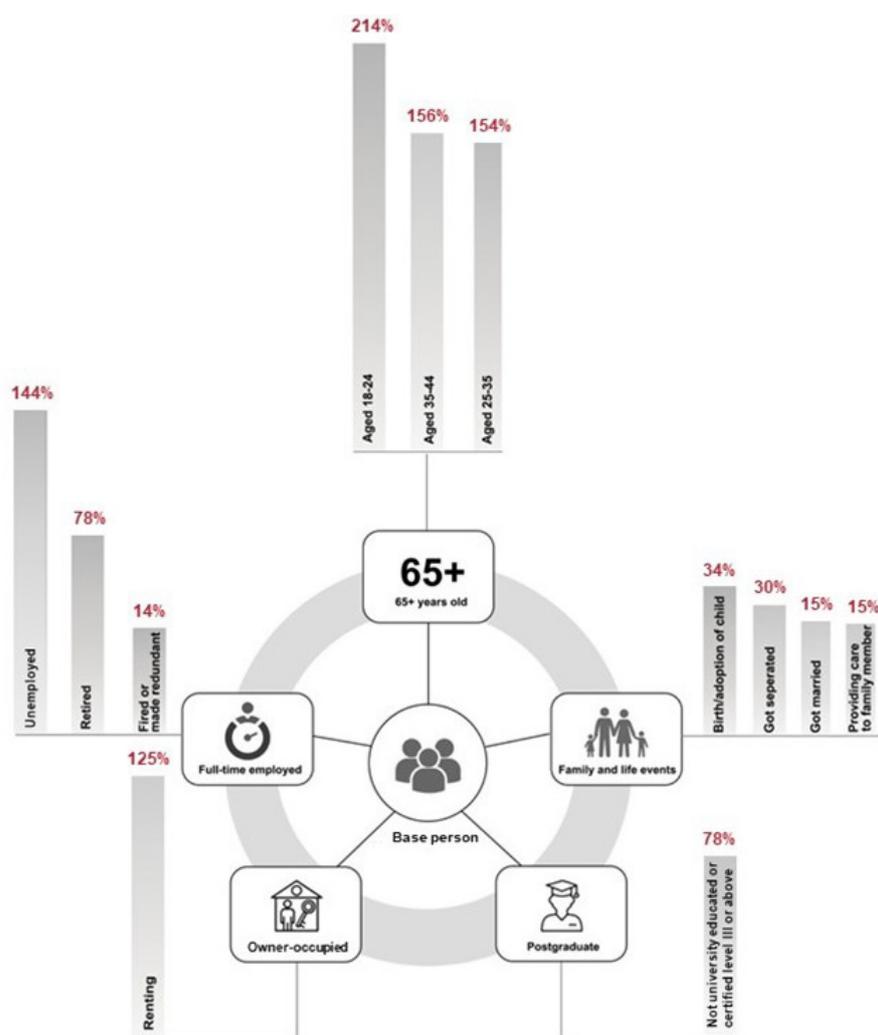
Notes: Definition of housing stress - households in the bottom 40% of household income are spending more than 30% of their income on housing.
Source: Authors (image: Jiahang Li).

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4.3 Policy development implications of this research

The analysis in this section provides one example of how econometrics methods can be applied to granular longitudinal household data to quantitatively model housing pathways. The modelling practice can be enhanced by using integrated data.

The results show that tenure status has a paramount role in housing support policy, as renter-occupiers are more likely to enter housing stress, and less likely to recover from it.

The risk ratios underpin the need for an integrated support system, as both the level of education and employment status are found to have a significant effect on the risk of entering housing stress. This finding suggests that improving individuals' qualifications and skill sets, and supporting them to find appropriate occupations, can prevent undesirable housing outcomes.

The role of critical life events in a systems-approach integrated support system is vital. The findings suggest family formation and dissolution can significantly increase the likelihood of entering housing stress. Further research is needed to understand the effect of less-frequent critical life events.

5. National-level spatial distribution of resilient and vulnerable cohorts

- Section 5 captures the spatial distribution of the modelling results nationally. The analysis aimed to understand the scale of the issue, and to estimate the proportion of population who are in the most vulnerable group and the most resilient group.

- The ABS 2016a *Census of Population and Housing* was used to generate the data in capital cities and rest of the state and territory areas.

- Based on the survival analysis, the most vulnerable group was young to early-middle-aged adults (18-44 years), who were looking for work and in rental occupancy. The proportion of the most vulnerable group was below 4 per cent in all adults aged 18–44 years, except in the rest of the NT (i.e. outside Darwin), where the proportion was 5.8 per cent. However, approximately 70 per cent of people who were unemployed and in rental occupancy were in the 18–44 age group in all areas.

- The most resilient group was older adults in owner-occupancy. About 70 per cent of people aged 65+ were owner-occupiers, with the exception of NT. In Greater Darwin, 56.4 per cent of older adults were owner-occupiers, and 42.1 per cent in the rest of NT. The proportion of homeowners aged 65+ among all homeowners was lower in capital cities, and especially in Greater Darwin (12.4%), and higher in rest of the state and territory areas, being the highest in SA (23.7%) and NSW (23.2%).

5.1 Application of census analysis in generalising the findings from the modelling

5.1.1 Methodology

This section provides a brief explanation of the national distribution analysis. Data for the analysis was obtained from the 2016a ABS *Census of Population and Housing*. The 'Counting Persons, Place of Enumeration' (MB) dataset was utilised via the ABS TableBuilder online tool.

This part of the analysis aimed to respond to research question 5:

> **What is the national-level spatial distribution of vulnerable cohorts identified in research question 4?**

To recap, the survival analysis concluded that age, employment status and tenure type contributed the most to the housing stress model (risk ratios were >2). The ABS census is Australia's largest statistical collection, with a person-response rate of 94.8 per cent nationally. It enables the connection of socio-demographic data with geographical locations (ABS 2016b). However, one limitation of this analysis is that the census data does not collect information on critical life events. Despite this, one of the purposes of this research was to prove the concept, and follow-up studies could explore different datasets for similar analysis.

In terms of geographical coverage, Greater Capital City Statistical Areas (GCCSAs) were chosen as the geographical units. GCCSAs divide each state and territory into capital city areas that are designed to represent the functional extent of capital cities (including population within the city, but also habitants from smaller regional towns located close to the city who regularly work, socialise or shop within the city) and the balance of the state and territory areas (ABS 2021a). This division was considered sufficient for responding to research question 5 and providing high-level information about each state and territory, while also considering that socio-demographic attributes of inhabitants may differ between urban areas and the rest of the state or territory.

The ABS *Census of Population and Housing* is a secondary dataset that has a different purpose, methodology and custodian than HILDA. However, the most similar socio-demographic variables between the two datasets were selected for this study. These variables are listed in Table 4.

Table 4: Variables entered into the national distribution analysis, compared to variables from the HILDA surveys

Socio-demographic characteristic	Variables entered into survival analysis from HILDA	Variables entered into national analysis from the 2016 Census
Age	Age (hgage): • 18–24 • 25–34 • 35–44 • 45–54 • 55–64 • 65+	Age (AGEP): • 18–24 • 25–34 • 35–44 • 45–54 • 55–64 • 65+
Employment	Employment status (hges): • Employed, usually works 35+ hours per week • Employed, usually works less than 35 hours per week • Not employed but is looking for work • Retired • Home duties	Labour-force status (LFSP): • Employed, working full-time • Employed, working part-time • Unemployed, looking for full-time or part-time work • Not in the labour force
Tenure	Own, rent or live rent free (shstenr): • Own/currently paying off mortgage • Rent (or pay board)	Tenure type (TEND): • Owner (owned outright & owned with mortgage) • Renter (social housing & private renters)

Source: Authors.

5.1.2 Resilient and vulnerable cohorts: national-level spatial distribution

First, spatial distribution of age, labour-force status and tenure type were plotted, as depicted in Figure 19 to Figure 26.

Age distribution

Figure 19: Age split in GCCSAs
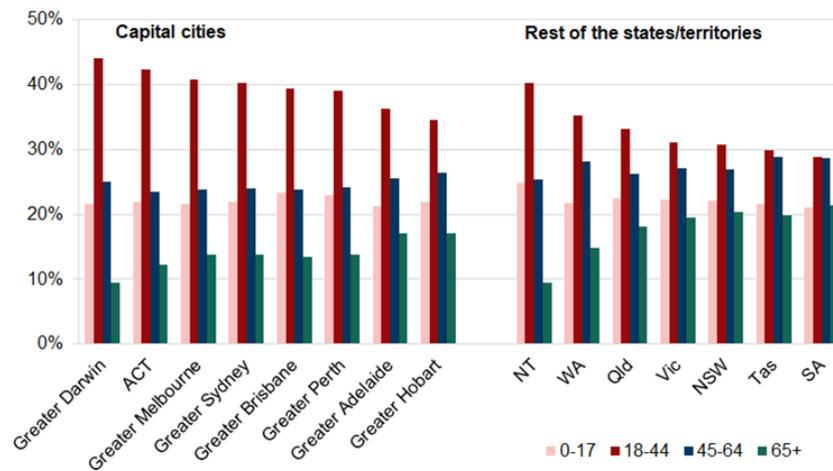
Source: Data from 2016a ABS Census; authors' original analysis.

Belonging to a younger age group (aged 18–44) considerably increases the risk of entering housing stress (risk ratio >2). Distribution of age groups in each GCCSA are shown in Figure 19. Red represents the most vulnerable cohort (18–44 years), while green shows the most resilient cohort (65 years+).

In general, there was a higher proportion of the younger (or 'red') cohort in capital cities, and a higher proportion of older (or 'green') cohort in the balance of the state and territory areas. The Northern Territory (NT) was an exception, as only 9.4 per cent of the population was aged 65 years or above, and this was true for both Greater Darwin and the rest of the NT area. Moreover, compared to other GCCSAs (and also states and territories), Greater Darwin and the balance of NT had the highest proportion of the younger cohort and the lowest proportion of the older cohort. South Australia (SA) and Tasmania (Tas) had the lowest proportion of people aged 18–44 years and the highest proportion of older adults.

Labour-force status

Figure 20: Labour-force status in GCCSAs
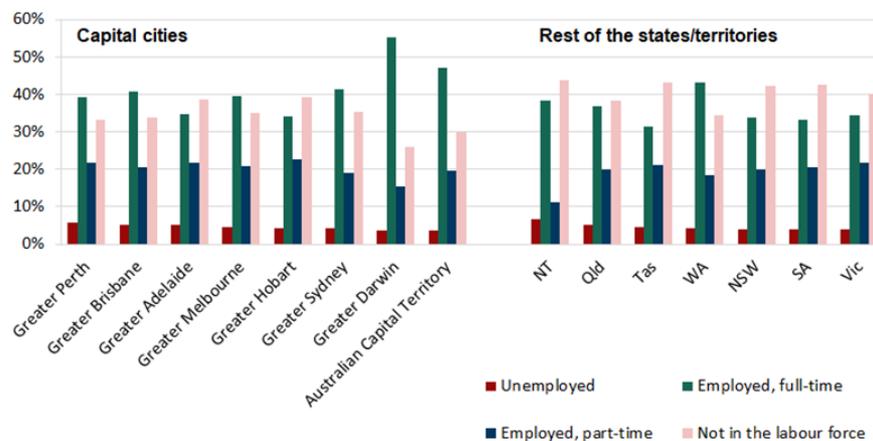
Source: Data from 2016a ABS Census; authors' original analysis.

Labour-force status—especially being unemployed and looking for work or having 'other' employment status
—was the second-highest contributor to the housing-stress model. Figure 20 shows labour-force status split
in each GCCSA. As for Figure 19, red represents the most vulnerable cohort (unemployed; looking for work) and
green represents the most resilient cohort (people in full-time employment).

The proportion of the red cohort was less than 6 per cent in each capital city, being highest in Greater Perth (5.8%)
and Greater Brisbane (5.2%), and lowest in the Australian Capital Territory (ACT) and Greater Darwin, 3.6 per cent
and 3.5 per cent, respectively. In the balance of state and territory areas, the proportion of people looking for work
was highest in NT (6.6%) and lowest in Victoria ([Vic] 3.8%). Note that the impact of COVID-19 on the economy
may have changed the labour-force statistics. ABS (2021b) monthly monitoring captured 0.6 per cent increase in
the Australian unemployment rate between September 2021 (4.6%) and October 2021 (5.2%). This was just after
the lockdowns related to the COVID-19 Delta variant. However, the unemployment rate decreased by 0.1 per cent
when compared to March 2020, prior to COVID-19 (ABS (2021b)).

Overall, there were more people engaged in full-time employment in capital cities—with the exception of Western
Australia (WA), where the rest of state area had more people in full-time employment (43.1%) than in Greater Perth
(39.2%). People not in the labour force was the highest in the balance of the state and territory areas: highest in
Northern Territory (43.8%) and Tasmania (43.1%).

Tenure type

Figure 21: Tenure split in GCCSAs
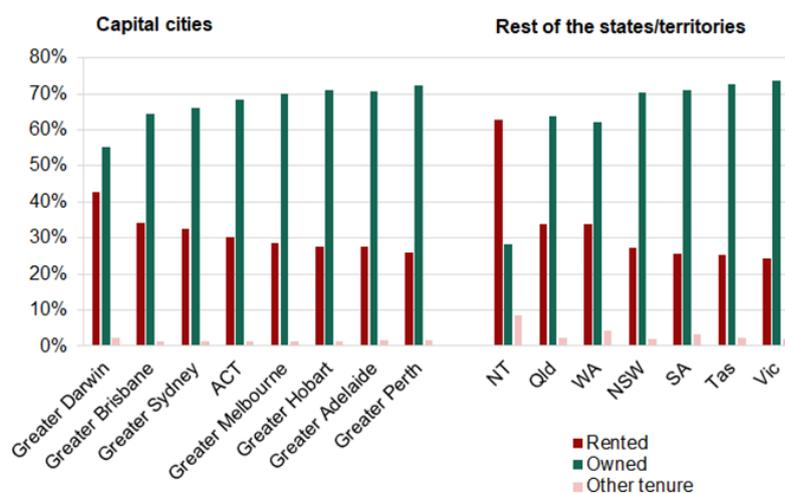
Source: Data from 2016a ABS Census; authors' original analysis.

Renter-occupiers have higher chances (risk ratio >2) of falling into housing stress compared to owner-occupiers.
Renter-occupiers (red: the most vulnerable cohort) versus owner-occupiers (green: the most resilient cohort) in
each GCCSA are shown in Figure 21. Both capital city areas and the balance of state and territory areas had more
owner-occupiers than renter-occupiers, with the exception of the balance of NT, where less than 30 per cent of
population were owner-occupiers. Greater Darwin had also the lowest proportion of owner-occupiers (55.1%)
compared to other capital cities.

It is important to note that CoreLogic (2021b) recorded the highest annual increase in rents in Darwin compared
to other capital cities, being 21.8 per cent for all dwellings. Nationally, rents have grown more in regional areas
(11.3%) compared to capital city areas (5.0%) in the period June 2020–June 2021. This means that renter-occupiers
in regional areas might experience increased risk of falling into housing stress. However, owner-occupiers might
be better off, as Australian values are 21.6 per cent higher over the 12 months (CoreLogic 2021a).

Owner-occupiers who own outright might be more resilient to housing stress than owner-occupiers with a mortgage. Figure 22 shows that more than half of the owner-occupiers have a mortgage in all areas studied. More than two-thirds of owners have a mortgage in Greater Darwin (70.8%), Greater Perth (67.0%) and the ACT (66.0%). There are more outright owners in the balance of the state and territory areas compared to capital cities. The highest proportion of mortgage holders was in balance of QLD (58.8%), Vic (56.2%) and WA (56.0%).

Figure 22: Owner-occupiers by owned outright and owned with mortgage in GCCSAs
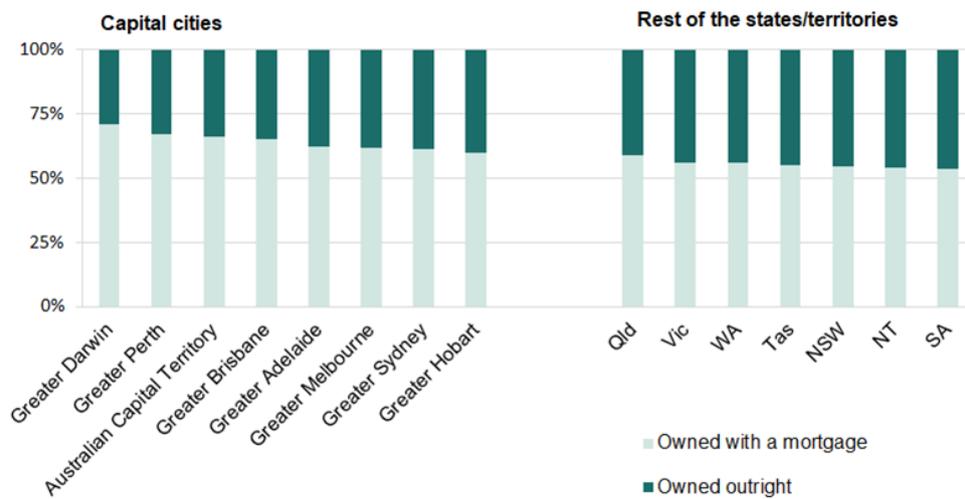
Source: Data from 2016a ABS Census; authors' original analysis.

Figure 23: The most vulnerable group: percentage of adults aged 18–44 years who were renting and looking for work among all people aged 18–44 years
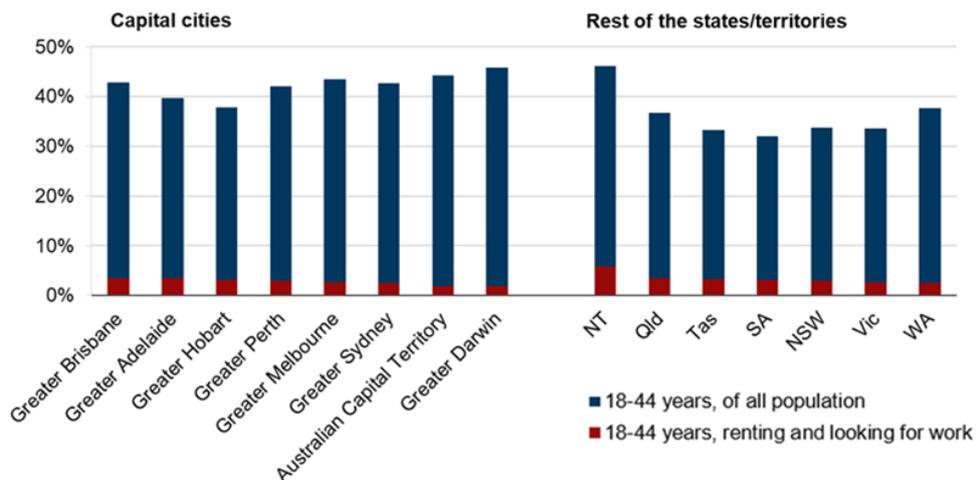
Source: Data from 2016a ABS Census; authors' original analysis.

Figure 24: The most vulnerable group: percentage of adults aged 18–44 years who were renting and looking for work among all people who were renting and looking for work
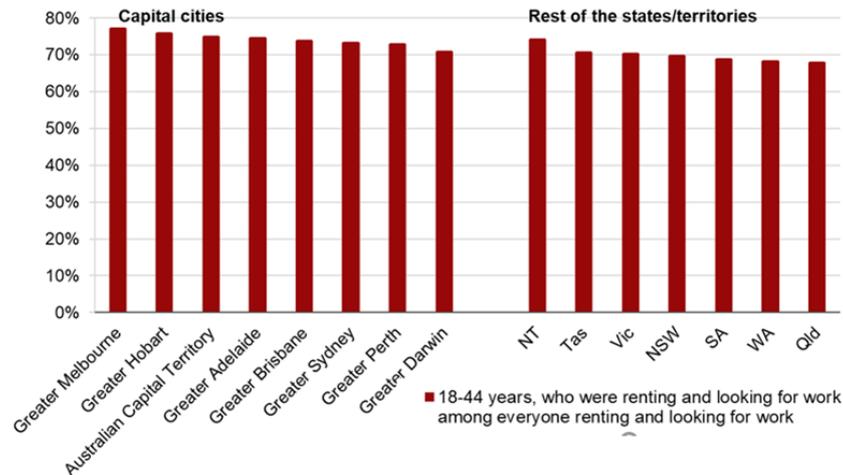
Then the most vulnerable cohort was captured: young to middle-aged adults (18–44 years), looking for work and in rental occupancy. The red bars in Figure 23 show the proportion of this group; the blue bars show everyone in this age group. The proportion of the most vulnerable group is low (below 4%) in adults aged 18–44 years group—apart from in the rest of NT, where the proportion is 5.8 per cent.

However, Figure 24 shows that the majority of people who are unemployed and in rental occupancy are in the 18–44 years group in all areas.

The most resilient

Figure 25: The most resilient group: percentage of homeowners aged 65+ among all people aged 65+
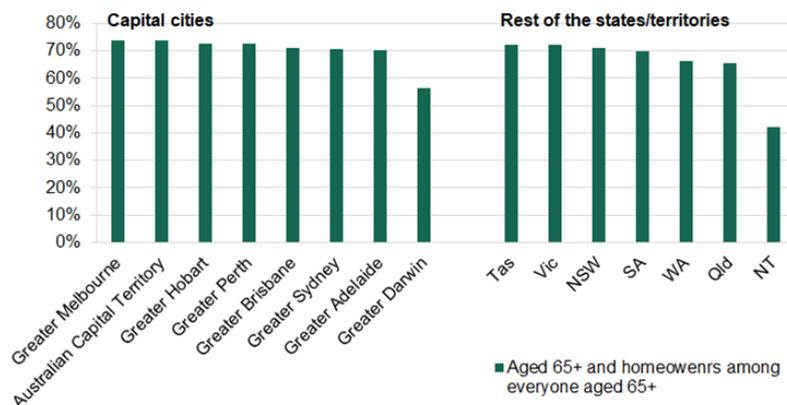
Finally, the most resilient profile was captured: older adults in owner-occupancy. Figure 25 shows that about 70 per cent of people aged 65+ were owner-occupiers, with the exception of NT: 56.4 per cent of older adults in Greater Darwin were owner-occupiers, and 42.1 per cent in the balance of NT. Note that the proportion of older adults in NT was lower than in other areas studied.

Figure 26 shows the proportion of homeowners aged 65+ among all homeowners. The proportion is visibly lower in capital cities—especially Greater Darwin (12.4%)—and higher in rest of the state and territory areas, being highest in SA (23.7%) and NSW (23.2%).

Figure 26: The most resilient group: proportion of homeowners aged 65+ among all homeowners in capital city and regional areas
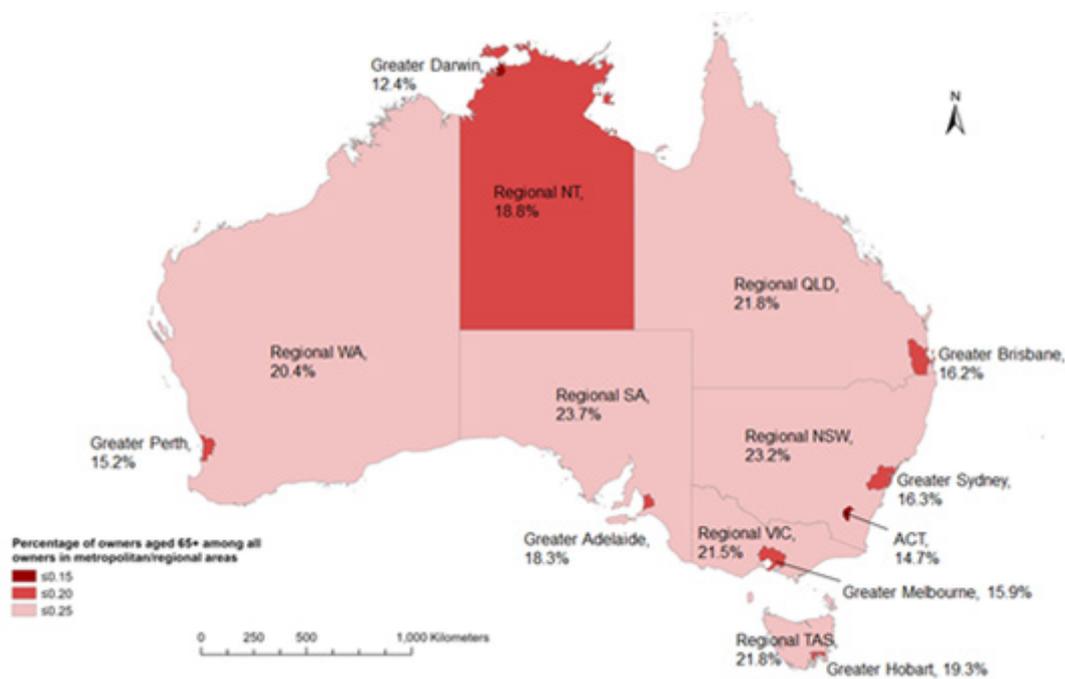
Source: Data from 2016a ABS Census; authors' original analysis.

5.2 Policy development implications of this research

The Northern Territory had the highest proportion of young to middle-aged adults and people in rental occupancy. Moreover, the rest of the Northern Territory had the highest unemployment rate. This, combined with the highest annual increase in rents, may expose a higher proportion of people into housing stress.

Subsection 5.1.2 highlights the need for federal, Territory and local governments to monitor housing trends in the Northern Territory and provide affordable and secure housing combined with employment programs. Besides strengthening existing housing-assistance programs, build-for-rent could be an alternative tenancy model to the traditional build-to-sell model. Policy incentives to build affordable housing facilities within the build-for-rent projects might help to secure housing for the most vulnerable group, and help them move towards owner-occupancy in the long term.

Around 70% of people who were unemployed and in rental occupancy were aged 18–44 years. Additionally, the rest of the state and territory areas had slightly higher proportions of the most vulnerable group compared to the capital-city areas.

This means that policy makers need to monitor and support young to middle-aged adults—especially in areas outside capital cities. Housing models such as Housing First, combined with employment or training programs are needed for this age group. Additionally, one-off personalised support payments or supportive counselling/ training services are needed in the cases of critical life events, such as loss of job, worsening of finances, pregnancy, marriage, separation from spouse, and birth or adoption of a new child.

6. Policy development options

- Understanding more about upstream critical life events as contributors to housing stress can support policy development options that go beyond the usual administrative boundaries, supporting intersectional approaches to reducing housing stress in the population.

- A policy workshop with key stakeholders indicated strong and urgent support for the development of our methodology for ongoing development and rapid policy application across policy realms, tenures, population cohorts and housing-assistance models.

- Housing-assistance development options identified in this research include housing impact assessment frameworks across policy realms, targeted life-stage interventions at critical life event occurrence, and a focus on prevention and early intervention to reduce housing stress.

- Data development and policy requirements to assist in development of early intervention approaches to reduce housing stress include ongoing development of accessible linked administrative data, and sharing infrastructure across housing and related policy portfolios.

Sections 1–5 of this report focussed on addressing each of the interrelated research questions driving this research. In this final section, we consider the policy and practice implications of the research findings. Section 6 first provides a summary of findings in relation to the five research questions, before presenting consideration of the policy implications of the research in response to research question 6. This section concludes with consideration of the implications of the research for key future directions in housing interventions that are aligned with critical life events in an early intervention and prevention approach.

The scope of the research did not extend to a detailed policy analysis. However, it is possible to reflect on policy implications of the approach developed here, along with its potential application. This section identifies broad principles and future directions, rather than a detailed or specific review of current or future policy. As discussed later, a policy review of how policy responses to critical life events are currently aligned with housing policy is one of the recommended future directions of the present study.

6.1 What are the key questions this research answers?

The research asked and answered six questions with respect to data available in HILDA. Questions 1–5 have been answered in previous sections. The answers are summarised in Table 5.

Table 5: Summary of answers to research questions 1–5

Research questions	Summary of findings
1. Which housing outcomes should be categorised under undesirable housing outcomes that may necessitate government support?	The research identifies housing stress, a situation in which households in receipt of low or very low incomes (lowest 40% of equivalised income distribution) pay more than 30% of their income in housing costs, as a critical-risk landscape that acts as a foundation for a risk pathway for short-term, medium-term or long-term need for housing assistance.
2. Which critical life events are likely to cause undesirable housing outcomes?	A range of critical life events are correlated with moving into housing stress. The family-related critical life events positively correlated with risk of entering housing stress are birth or adoption of a new child (34.1%), separation (30.1%), marriage (14.8%) and pregnancy (12.8%); and the finance-related critical life events positively correlated with the risk of moving into housing stress are major worsening in finance (72.1%) and redundancy or dismissal (14.2%). Promotion at work is the only critical life event which reduces the likelihood of entering housing stress (39.4%).
3. What attributes of household members are significant in forming household resilience?	The factors most closely associated with resilience to entering housing stress are being above age 65, living in owner-occupied housing, holding postgraduate qualifications and being in full-time work.
4. Given the heterogeneity of the explored relationships in research questions 2 and 3, which socio-demographic attributes are most associated with vulnerability to critical life events?	Taking these household attributes as a base, we were able to describe the increased likelihood of entering into housing stress associated with other demographic attributes and life events. The factors more closely associated with risk of entering housing stress were being under 45 years old (ranging from 148–224% more likely), living in rental accommodation (125%) and being unemployed (147%) or retired (81%).
5. What is the national-level spatial distribution of vulnerable cohorts identified in research question 4?	In most Australian capital cities and rest of the state and territory areas, less than 4% of adults in 18–44 age group were looking for work and in rental occupancy, apart from the balance of NT, where the proportion was 5.8%. Approximately 70% of people who were unemployed and in rental occupancy were in the 18–44 years age group in all capital cities and the balance of the state/territory areas.

Source: Authors.

Research question 6, which is the focus of this chapter, is:

> **What are potential support schemes for early intervention to assist vulnerable households identified in research question 5?**

In approaching question 6, the research team considered what our model reveals, and its implications for policy principles related to early intervention for the provision of support to people vulnerable to entering housing stress. To support this consideration while optimising the 'real-world' applicability of the research, the research project concluded with a workshop with key stakeholders to discuss the policy implications of the research findings, while reflecting on the outcomes of the risk-pathways model developed within the research and applied using HILDA data.

Participants from the following organisations participated in the workshop with the research team:

- Australian Institute of Health and Welfare (AIHW)

- Carers New South Wales

- Community Housing Institute Australia

- Homes Victoria

- Australian Government Department of Social Services

- Housing and Homelessness, Australian Capital Territory

- Shelter New South Wales.

This section summarises the insights from that workshop and provides commentary on potential implications for future policy development. It focuses on each of the following themes in turn.

- Conceptual underpinnings of income and housing-assistance models.

- Systems thinking and targeted approaches to responding to housing impacts of critical life events.

- Data and infrastructure requirements of a systems approach to prevention and early intervention as a core component of housing-assistance interventions.

- The validity of the 'proof of concept' and methodology developed within this research project for future development in support of housing-assistance efficacy.

6.2 What is the optimal form of housing assistance: income support, housing support, or both?

Current policy responses to reducing risk of—or responding to—housing stress take two main forms.

Housing-asset approach

The first is a housing-asset approach, in the form of the promotion of home ownership as a means to support people into old age and reduce or eliminate housing costs in later life (Burke, Nygaard et al. 2020: 55). This strategy is becoming increasingly out of reach for greater proportions of the Australian population, with more people entering their retirement years:

- with a mortgage (Burke, Nygaard et al. 2020; Ong, Wood et al. 2019)

- living in private rental housing (Hulse, Burke et al. 2012: 12)

- experiencing homelessness (Spinney, Beer et al. 2020: 12).

Incomes approach

The second is an incomes approach, in which housing support is tied to household income and means-testing (Gurran, Rowley et al. 2018). The incomes approach has been criticised for not reaching some people who are in need of support, as well as not being responsive to short-term shocks that can threaten housing stability (Dockery, Feeny et al. 2008; Jacobs, Hulse et al. 2016; Parkinson, James et al. 2018). Also, while there is broad recognition both in research and practice (Brackertz, Borrowman et al. 2020) of the relationships between housing and other policy areas such as health, education, employment and family services, the operationalisation of Australian social policy has been criticised for a siloed approach to policy thinking and operationalisation (Muir, Powell et al. 2020).

Housing stress is an outcome of inadequate income relative to housing costs. A focus on housing stress as a predictive risk for increased likelihood of enduring or deepening housing disadvantage draws policy attention to the inadequacy of income support and low-wage settings that largely determine the overall income of low-income and very-low-income households' ability to respond to income shocks associated with critical life events with income alone. Findings in our research indicate that, by virtue of the onset of housing stress for some tenants in both social and private rental housing, their income is by definition inadequate. The inadequacy of income for people living with low wages or who are in receipt of income support, to respond to housing costs is exacerbated in a housing system, such as the private rental sector in Australia, where housing costs are not fixed. Further research investigating relative risk in both social housing and private rental housing is warranted. However, existing evidence suggests that risks will be most pronounced in private rental tenancies in Australia, which are relatively lightly regulated and where rent-capping is absent (Hulse, Milligan et al. 2011).

In responding to the risk of housing stress identified in this research, we can also point to two different types of opportunities for early intervention and prevention, depending on which rental tenure households or individuals at risk of housing stress reside in.

Social housing tenants

- Within a social housing context, existing wraparound case-management support, coupled with the ability to adjust rent settings with relative agility, in principle provide opportunity to reduce housing stress before additional housing problems develop, such as rent arrears or a notice to vacate.

- Rates of rental-arrears evictions within social housing sectors nationally and their underlying causes warrant investigation to determine how and to what extent the use of a critical life events identification model for agile income or rent adjustment could be implemented to reduce evictions.

Private-rental tenants

- Private-rental sector regulatory and practice settings are more dispersed than those of social housing, sitting across state and territory departments, rental tribunals, national assessments of income support and rental assistance payment benefits, as well as market-based intermediaries such as real-estate agencies and investor-landlords or housing providers.

- Determining how to utilise critical life events as a mechanism to support private rental tenants' income settings or rental assistance needs will require coordination infrastructure to respond to rapid changes in the ability of tenants to manage rental costs.

6.3 Systems thinking and targeted approaches to the housing impacts of critical life events

The major focus of the research explored how critical life events can be used to predict short-term, medium-term and long-term periods of housing stress for individuals and households, which might, in turn, lead to further housing and related forms of disadvantage and support needs. Implicit in the investigation of how critical life events in the realms of employment and training, family, and health and disability relate to housing stress, is a focus on how well-aligned the relevant policy spheres are. Also implicit is a focus on targeting housing-assistance interventions in a way that is aligned to responding to critical life events and their impacts in a timely way to reduce risk of housing stress or the additional risks of housing shocks that housing stress results in.

Existing evidence indicates that to respond to respective correlates of housing stress, an integrated, systems approach to policy and practice—rather than siloed thinking—is required (Flanagan, Levin et al. 2020; Muir, Powell et al. 2020). In a context in which housing stress increases in the population, associated with high housing costs, it is imperative that housing assistance—in the form of increased income support to meet housing costs, or reduced housing costs and other support services related to sustaining tenancies—is as effective as possible.

Our research findings indicate that key risk factors associated with housing stress include those directly related to income such as unemployment/underemployment/low education, as well as critical life events that act to reduce income in either the short-term or long-term. These include family events such as the birth of child or partnership dissolution, as well as circumstances of ill health, ongoing caring or disability that limit income and earnings capacity.

Policy workshop discussions included consideration of both joined-up policy responses that more closely link critical life events to assessment of assistance related to risk of housing stress, as well as targeted interventions.

- **Housing impact assessment frameworks**, in which the housing impacts of various critical life events are considered by a range of housing and non-housing policy and practice agencies at the time of critical life events. For example, this might include:

- assessment of housing support needs at the time of loss of employment

- interaction with family services such as maternal and child health

- legal services around partnership dissolution

- assessment of housing impacts and housing support needs at the time of ill health or onset of disability or caring roles.

The aim is to link these supports directly to the reduction of housing-stress risk, *before* housing stress is experienced.

- The findings also suggest that **targeted life-stage interventions of housing assistance** are relevant to investigate and potentially expand. For example, supports targeted at younger age groups that extend beyond current non-targeted youth allowance approaches. While existing approaches and evidence are geared to pre-earning, post-earning and earning years, more nuanced approaches can additionally take account of key life-stage housing-support needs. Many life-stage events require practical as well as financial supports—for example, leaving the family home to undertake education or training; partnership dissolution; birth or arrival of children or other family dependants. Aligning housing-assistance types and quantum for disability and health conditions and care at all life stages was identified in the policy workshop as a major area for future policy investigation.

- **Predictive tools to implement prevention and early intervention approaches** are used in this research. Policy reflections included a focus on how existing or future data or policy systems could best target housing assistance, based on risks that can be identified in a broad data sample, such as the HILDA surveys used in this study, or administrative data (see Section 6.4), or on a case-by-case basis where individuals indicate that they experience risk factors associated with housing stress or other housing shocks.

In relation to the three main critical life events areas the findings focussed on, the policy workshop raised key questions for future research focus, which follow.

Focus area 1: Family change and life events

Key policy questions identified in the policy workshop that relate to family change and life events are as follows.

- When people experience key events like separation, marriage, birth of a child, what can be done for households at that point to support them to remain housed?

- Where we have family and domestic violence, we have become better at having conversations and linked-up policy responses to that type of event. There will be a housing consideration as well as income support and immediate safety justice support. But can we do something similar for other life events? For example, when there is the birth of a child for someone living in private rental, can we consider whether any support might be required above any Commonwealth rent assistance?

- There are a raft of private rental assistance programs available—for example, bond assistance—that are underutilised, so how might we connect people to these programs when they are experiencing major life events?

Focus area 2: Education, training and employment

Key policy questions identified in the policy workshop that relate to education, training and employment are as follows.

- How might we support young people leaving home? Can we have a linked-up housing response when people enter training programs and how might we link that support? For example, through the uptake of apprentice positions.

- How might this impact on productivity? How can joined-up housing, employment, education and training better serve individuals and society as a whole?

- What will it take to have the resources, data, skill sets and human services to realise an early intervention targeted approach to support increased employment and training outcomes, for young adults as well as for life-long learning?

Focus area 3: Disability and health

Key policy questions identified in the policy workshop that relate to disability and health critical life events or ongoing assistance need are as follows.

- How might we support people at the onset of illness or disability support need via a housing intervention approach?

- Can we have a linked-up housing response when people are identified as living with disability, or are carers, and how might we link those health and disability services more directly?

- What types of specialised data can support better service alignment, particularly where general datasets, including HILDA, do not adequately capture the lived experience detail and nuance of housing need in relation to disability or care?

6.4 Data and infrastructure requirements for prevention and early intervention forms of housing assistance

While the risk-pathways model is a useful outcome of the project in itself, it also provides a proof of concept. Through the process of modelling risk pathways, we demonstrate how large datasets can be used to inform understanding the risk of entering housing stress, and to help better understand which groups are likely to be most vulnerable to housing stress—and at what points. A predictive approach to housing-assistance intervention raises implications for requisite infrastructure, specifically for data and processes that act to align interventions and data sharing across policy and practice realms.

Data implications of a predictive approach

The HILDA data used for our model has some shortcomings, including non-representative sample of persons living with high and complex needs, English-language only, and a small sample size for fine-grained analysis of both social housing and private rental housing tenants in relation to critical life events and housing impacts. However, the development of the model demonstrates the potential for using data modelling to inform policy and practice. This was the main focus of the workshop discussion, which focussed on this question:

> **Can data-driven early identification approaches help to implement more effective policy interventions to increase household resilience?**

There was strong support among the workshop participants for such a data-driven approach to more effective allocation of government resources. Key issues and questions raised in the discussion, related to progressing this approach, are discussed below.

- Importance of understanding cohorts and selecting appropriate data:

  There's also something in the data which, if we're putting forward a case that these events will have an impact, it's understanding that it's not just if you're over 65 and you're an owner-occupier or not … There's actually cohorts within that group. There are obviously [some people] more at risk and some of that intergenerational stuff isn't showing up in this, and that protective factor [of intergenerational support] … becomes really important, so I think, if we're thinking [about] =going forward and how you argue the case, there's got to be a much more focussed lens on specifically which cohorts within these kind of very broad groups [we should focus on]. (Workshop participant 4)

- Understanding the housing tenure and tenure impacts of critical life events for key cohorts:

  The importance of really understanding the cohorts that you're looking at. Data consistently from the ABS … is that carers as a whole actually have a higher rate of owner-occupier status than the general population, so you're saying carers have more secure assets, which is kind of counterintuitive when you're looking at a lot of other carer data … when we're looking at particular groups that we know to be at risk … they can sometimes be hidden in the data … from a carer perspective, where

> early intervention maybe could be worthwhile to look at … is the junction at which mature working women reduced their work and [went] into early retirement to care for ageing parents, and it's masked as retirement … It's withdrawing from the workforce for caring responsibilities, and that's often coupled with giving up housing assets and [that tracks to] homelessness in later life … if you can identify women that are considering reducing their work and getting rid of their [housing] assets to care [for family members], that's key. If you can keep those women engaged in work through increasing the flexibility of employment or through other advice around maintaining housing assets, that would probably reduce some risk. (Workshop participant 5)

- Data capability for 'looking backwards' from critical life events to at-risk populations:

> [You] absolutely need to identify a cohort because, if I come from the other way, the cohort that needs my greatest help at the moment is those escaping domestic and family violence, and that leads them to the next question, and of the way that this work is proposed to actually identify those cohorts. Is there a process of then distinguishing those people … who will be helped by the interventions and those who actually need the more traditional interventions going forward as well? … Who do we think we are actually helping with the early intervention? And how successful will it be for that person's household with those identifying attributes? (Workshop participant 7)

- Support for development of the approach using available data:

> The data is what it is. It's not perfect and [we] would want to keep working on the data. But unlike academics, policy makers can act on 80 per cent evidence being right … we don't necessarily need to sign off up to the 100 per cent stuff. So as long as I'm reasonably comfortable that it provides a really good evidence-base and a compelling story, then I think it's quite easy to use this for arguing about different ways that provide housing assistance. (Workshop participant 1)

Linked data and system-wide data sharing

Increasingly, linked data systems provide the opportunity for large-scale development and application of the methodology developed in this research, to support an integrated housing and intervention approach across policy and practice realms and portfolios. Integrated and linked data issues and direction raised in the policy discussions included enhanced ability to predict and respond to critical life events, across tenures and systems.

- Linked data across systems and portfolios:

> As we are maturing a lot of the data systems, you know [considering] Open Access to a lot of data which is currently commercial, such as bank data which none of us can get hold of, or you can only get a small slice of, is really important if we're going to actually understand. [If] someone is saying they've got a financial worsening situation … is that because they're an owner-occupier [and] interest rates changed and is it going to be a problem immediately or in three years' time … I think we're all getting a lot better, and we're all releasing a lot more data and longitudinal [data], but that's a really interesting space with these critical events and seeing what happens afterwards. Maybe it's HILDA plus a number of other products that would actually get you to that point. (Workshop participant 4)

6.5 Proof of concept and feasibility of model development

The policy workshop provided strong support for the predictive approach developed in this research, as outlined earlier. In addition to data implications, a raft of other implementation matters were discussed, related to the feasibility of the model for policy development. These warrant future interrogation in an ongoing investigation of the development of our approach for real-world application.

- Government investment in social housing to an adequate level to support early intervention and prevention:

> Government will never invest enough in social housing to really meet its demand as a primary response. So what else do we wrap around that as additional support? (Workshop participant 1)

- Demonstration of financial value of an early intervention and prevention approach aligned to critical life events:

  When we engage with Treasury … Treasury always has the argument back to us about what utility a dollar of investment in housing has, compared to a dollar of investment in education or health … they're seeing bids from all portfolios that are competing for limited funds. (Workshop participant 1)

  [Treasury] has often come back to me and said, 'Well, what can you do … to change the curve and change the trajectory of continuing demand on housing assistance?' So I think early intervention, the concept is sold at Treasury level, but we haven't really had the hard evidence and the data to support that … this [research] is building that case really strongly. (Workshop participant 1)

- Prediction of short-term and long-term impacts of housing assistance based on the methodology developed in this research:

  Treasury want to really understand what's a short-term impact and what is actually a long-term impact, and so that any policy response we're thinking of has to be kind of conceptualised in that way, and these kind of critical event theory exercises, really, you know, is this going to be a short-term impact? (Workshop participant 3)

- Investment in the methodology developed here to scale and policy application:

  The quicker and the faster we get it rolled out at policy level, the better. (Workshop participant 1)

- Data sharing and risk prediction across policy realms, as well as within and between layers of governance in a federal approach:

  Thinking about the whole system and all of the different levers that everybody actually needs to pull: I'm a big advocate for, 'What is the Commonwealth doing? What are the states doing? What are we doing [at] a local level?' and … I look at that as a system that had everybody bringing something to the table to actually make the change. And I think that's when I bring those sorts of compelling holistic proposals to Treasury. (Workshop participant 7)

- Overcoming existing challenges with sharing current best practice, including within and between community organisations:

  There are a lot of good practices that take an early intervention approach, but they're not currently captured publicly, they're not shared, and that's because of this competitive contracting requirement. (Workshop participant 8)

In response to this point, an early intervention clearinghouse might be considered to capture practice knowledge. It could provide a means to rapidly progress preventative and early intervention approaches to reducing housing risks and providing optimal interventions.

- Extension of the methodology to middle-income as well as low-income and very-low-income cohorts.

The policy discussion included consideration of extension of the approach developed in the research to middle-income households, as well as those already living in social housing or in low-income or very-low-income households in privately rented housing. Workshop participants considered that a focus on middle-income households would also be effective for targeting assistance in an early intervention approach.

In this research, secondary analysis of longitudinal panel survey data has provided the means for methodological development and proof of concept. Future development of housing assistance that is designed to provide prevention and early intervention support to reduce negative housing impacts of critical life events must also include the expertise, viewpoints and experiences of residents through qualitative and co-design approaches —within and across policy realms.

6.6 Final remarks and future directions

This research has highlighted the individual and housing-assistance cost burden of increasing proportions of the Australian population requiring direct forms of housing assistance as the context for an exploration of alternative approaches to housing-assistance provision. Specifically, the research has focussed on increasing rates of housing stress among renters, and considers how and under what conditions a predictive-risk approach could be used to support a shift from crisis intervention to prevention and early intervention forms of rental support. The research has empirically explored the utility of a data-driven early identification approach to help in implementing more effective policy interventions to increase housing resilience.

Drawing on the analysis presented in sections 1–5, as well as the outcomes of a policy workshop with key stakeholders, we make a case for a targeted systems approach to housing support that has the potential to increase the resilience of households to weather shock, at the same time as allowing for more efficient targeting of government resources.

Our research has developed a proof of concept. This comprises a conceptual and methodological pathway toward a wider interrogation of how a prevention and early intervention approach can form a more central component of future housing-assistance models in the Australian context. To further develop a systems approach to housing intervention, additionally requires the following:

- A wide-ranging review of international and national best-practice prevention and early intervention housing-assistance approaches to inform policy thinking in the local context.

- Scaling up of the methodology developed here, to large-scale administrative linked data sources to further refine the method and enable investigation of housing responses to a wider range of critical life events, including those associated with justice policy and practice.

- Ongoing dialogue with key policy and practice communities to inform development of prevention and early intervention approaches as a mainstream and core component of the housing-assistance ecology nationally.

The policy workshop within this project acted to 'ground truth' the relevance of the approach developed in this research. Importantly, the discussion indicated strong and urgent support for the development of our methodology in the form of a 'how to' prototype, for ongoing development and rapid policy application across policy realms, tenures, population cohorts and housing-assistance models.

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Appendix 1: Data preparation

The modelling dataset is obtained from the HILDA survey. In this study, waves 5 to 18 are used to construct the modelling dataset, as some critical details (such as difficulty in paying rent or mortgage) are missing from waves 1 to 4.

Table A1 shows the list of variables obtained from HILDA. This table also shows how each variable is processed and included in the analyses of this study.

Table A1: List of explored variables from HILDA

Variable in HILDA	Description	How utilised in this study
xwaveid	Cross wave ID	Factor to match individuals across waves
hhhqivw	Date of interview	Date to calculate transition timing
hgage	Age last birthday	Continuous
hhadult	Number of persons aged 15+ years	Continuous
hh0_4	Number of persons aged 0–4 years	Continuous: by adding the three to obtain number of kids (below 15 years old)
hh5_9	Number of persons aged 5–9 years	
hh10_14	Number of persons aged 10–14 years	
edhigh1	Highest education level achieved	Categorical with the following levels: Postgrad: masters or doctorate Grad diploma, grad certificate Bachelor or honours Advanced diploma, diploma Cert III or IV
hgsex	Sex	Categorical with the following levels: Female
hges	Employment status on Household Form	Categorical with the following levels: Full-time: Employed—usually works 35+ hours per week Part-time: Employed—usually works less than 35 hours per week Not employed but is looking for work Retired Home duties
mrcms	Current marital status	Categorical with the following levels: Married (in a registered marriage) In a relationship: Never married but living with someone in a relationship Divorced Widowed Separated but not divorced

Variable in HILDA	Description	How utilised in this study
tifdip	Financial year disposable regular income ($)	Continuous
hifdip	Household financial year disposable regular income ($)	Continuous
hhfty	Family type	Categorical with the following levels: Couple without kids (including couple family without children or others, couple family without children with other related, Couple family without children with other not related) Couple with kids (including Couple family with children < 15 without others, Couple family with children < 15 with other related, Couple family with children < 15 with other not related, Couple family with dependent student without others, Couple family with dependent student with other related, Couple family with dependent student with other not related, Couple family with non-dependent-child without others, Couple family with non-dependent-child with other related, Couple family with non-dependent-child with other not related) Single parent (including Lone parent with children < 15 without others, Lone parent with children < 15 with other related, Lone parent with children < 15 with other not related, Lone parent with dependent student without others, Lone parent with dependent student with other related, Lone parent with dependent student with other not related, Lone parent with non-dependent-child without others, Lone parent with non-dependent-child with other related, Lone parent with non-dependent-child with other not related) Lone person
hstenr	Own, rent or live rent free	Categorical with the following levels: Own/currently paying off mortgage Rent (or pay board)
hsrnti	Rent usual payments $ per month	Continuous
hsmgi	Mortgage usual repayments $ per month	Continuous
hsvalui	Home value ($)	Continuous
dodtyp	Interviewer recorded dwelling type	Categorical with the following levels: Apartment (including Flat/unit/apartment in one-storey block, Flat/unit/apartment in two-storey block, Flat/unit/apartment in three-storey block, Flat/unit/apartment in four to nine-storey block, Flat/unit/apartment in ten or more storey block, Flat/unit/apartment attached to a house, Flat/unit/apartment attached to a shop, office etc, Flat, no further information) House (including Separate house; Separate house with attached shop, office, etc; Semi-detached house with one storey; Semi-detached house with two or more storeys; Semi-detached house attached to a shop, office etc)

| Variable in HILDA	Description	How utilised in this study
lebth	Life events in past year: Birth/adoption of new child	Binary
ledfr	Life events in past year: Death of a close friend	Binary
ledrl	Life events in past year: Death of close relative/family member	Binary
ledsc	Life events in past year: Death of spouse or child	Binary
lefni	Life events in past year: Major improvement in finances	Binary
lefnw	Life events in past year: Major worsening in finances	Binary
lefrd	Life events in past year: Fired or made redundant	Binary
leinf	Life events in past year: Serious injury/illness to family member	Binary
leins	Life events in past year: Serious personal injury/illness	Binary
lejlf	Life events in past year: Close family member detained in jail	Binary
lejls	Life events in past year: Detained in jail	Binary
lejob	Life events in past year: Changed jobs	Binary
lemar	Life events in past year: Got married	Binary
lemvd	Life events in past year: Changed residence	Binary
lepcm	Life events in past year: Victim of a property crime	Binary
leprg	Life events in past year: Pregnancy	Binary
leprm	Life events in past year: Promoted at work	Binary
lercl	Life events in past year: Got back together with spouse	Binary
lertr	Life events in past year: Retired from the workforce	Binary
lesep	Life events in past year: Separated from spouse	Binary
levio	Life events in past year: Victim of physical violence	Binary
fibrelh	How would obtain (waves 1–8) $2,000 (waves 9–19) $3,000 (waves 20+) $4,000—Borrow from a relative who lives with you	Binary
fibrelo	How would obtain (waves 1–8) $2,000 (waves 9–19) $3,000 (waves 20+) $4,000—Borrow from a relative who lives elsewhere	Binary
fibfin	How would obtain (waves 1–8) $2,000 (waves 9–19) $3,000 (waves 20+) $4,000—Borrow from a financial institution	Binary
fibfri	How would obtain (waves 1–8) $2,000 (waves 9–19) $3,000 (waves 20+) $4,000—Borrow from a friend	Binary
fisass	How would obtain (waves 1–8) $2,000 (waves 9–19) $3,000 (waves 20+) $4,000—Sell an asset	Binary
fisav	How would obtain (waves 1–8) $2,000 (waves 9–19) $3,000 (waves 20+) $4,000—Use savings	Binary
fioth	How would obtain (waves 1–8) $2,000 (waves 9–19) $3,000 (waves 20+) $4,000—Use some other method	Binary
fina	How would obtain (waves 1–8) $2,000 (waves 9–19) $3,000 (waves 20+) $4,000—No A answer	Binary

Variable in HILDA	Description	How utilised in this study
fiemerf	Difficulty in raising (waves 1–8) $2,000 (waves 9–19) $3,000 (waves 20+) $4,000 for an emergency	Categorical with the following levels: Could easily raise emergency funds Could raise emergency funds, but it would involve some sacrifices Would have to do something drastic to raise emergency funds Couldn't raise emergency funds
helth	Long-term health condition	Binary
hemirh	Which long-term health conditions: Any mental illness which requires help or supervision	Binary
henec	Which long-term health conditions: A nervous or emotional condition which requires treatment	Binary
henca	Actively cares for non-resident due to long-term health condition, elderly, disability	Binary
herca	Actively cares for household member due to long-term health condition, elderly, disability	Binary

Source: Variable name and description from HILDA (2022), how utilised in this study by authors.

Appendix 2: HILDA sample size versus age

The age distribution in the HILDA sample (combined waves 2005 to 2018) is shown in Figure A1 This sample is used to calculate the probability of experiencing critical life events by age. The probability profiles are trimmed at age 90 due to the small sample size.

Figure A1: Sample size versus age
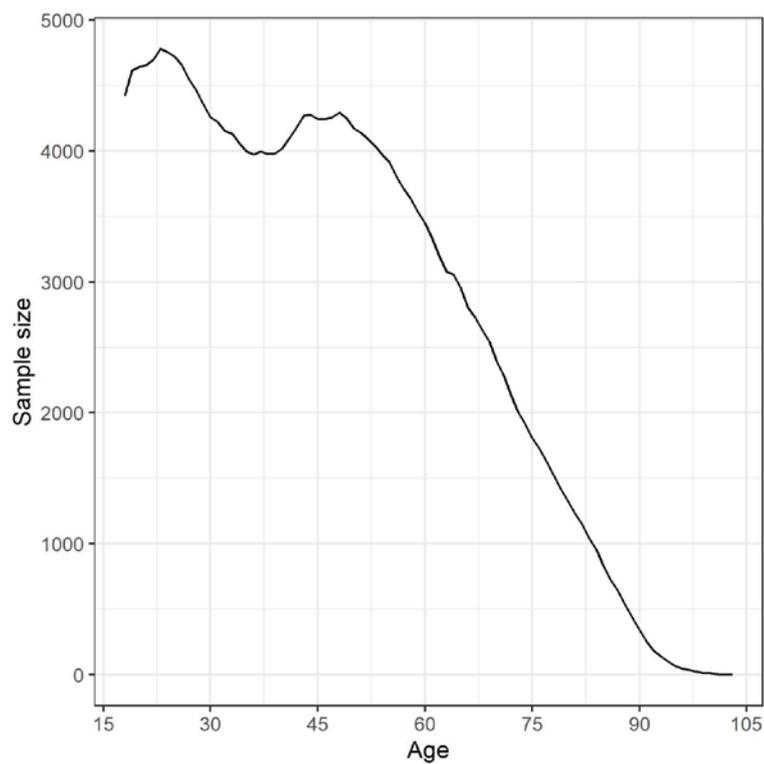
Source: Data from HILDA survey, authors' original analysis.

Appendix 3: Parameter estimates in the Cox model

Table A2 shows the parameter estimates for the Cox model. This model shows the risk of entering housing stress.

Table A2: Parameter estimates for the Cox model

Variables	Estimate	Sd.Err	HR	Lower.95	Upper.95	P.value
Age between 18 and 24	1.146	0.084	3.146	2.669	3.71	<0.001
Age between 25 and 34	0.933	0.084	2.543	2.157	2.998	<0.001
Age between 35 and 44	0.942	0.083	2.566	2.182	3.019	<0.001
Age between 45 and 54	0.675	0.083	1.964	1.67	2.31	<0.001
Age between 55 and 64	0.389	0.076	1.475	1.271	1.712	<0.001
Education is Advanced diploma or diploma	0.475	0.094	1.608	1.338	1.933	<0.001
Education is Bachelor or honours	0.143	0.092	1.154	0.963	1.382	0.121
Education is Certificate III or IV	0.538	0.087	1.712	1.444	2.029	<0.001
Education is Grad diploma, grad certificate	0.027	0.111	1.028	0.826	1.277	0.807
Education is Other	0.581	0.085	1.788	1.513	2.114	<0.001
Employment is home duties	0.8	0.044	2.226	2.042	2.427	<0.001
Employment is looking for job	0.892	0.056	2.441	2.187	2.725	<0.001
Employment is other	0.93	0.052	2.534	2.286	2.808	<0.001
Employment is part-time	0.514	0.037	1.671	1.556	1.795	<0.001
Employment is retired	0.579	0.074	1.785	1.545	2.063	<0.001
Tenure is other	0.212	0.088	1.236	1.039	1.47	0.017
Tenure is renter	0.812	0.029	2.252	2.125	2.385	<0.001
Caregiver for a household member	0.135	0.055	1.145	1.027	1.276	0.015
Long-term health condition	0.085	0.032	1.089	1.023	1.16	0.008
Critical life events						
Fired or made redundant	0.133	0.062	1.142	1.012	1.29	0.031
Major worsening in finances	0.543	0.057	1.721	1.539	1.924	<0.001
Pregnancy	0.12	0.057	1.128	1.009	1.26	0.034
Promoted at work	-0.501	0.072	0.606	0.527	0.697	<0.001
Got married	0.138	0.074	1.148	0.994	1.326	0.061
Separated from spouse	0.263	0.059	1.301	1.159	1.461	<0.001
Birth/adoption of new child	0.293	0.063	1.341	1.184	1.518	<0.001
AIC	100631.349					

Source: Authors.

Appendix 4: Risk ratios

Figure A2: Risk ratios and standard errors

Source: Authors.