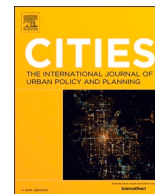




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Tracking the impact of COVID-19 in Victoria, Australia: Shocks, vulnerability and insurances among residents of share houses

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ABSTRACT

COVID-19 is re-shaping cities and regions, as residents respond to large disruptions to employment and social interaction and threats to public health. While the impacts of COVID-19 are extensive, certain groups are more vulnerable than others. Our research examines the impact of COVID-19 on members of share houses in the state of Victoria, Australia. This cohort is more likely to be young, casually employed, living in informal arrangements and at risk of homelessness than the broader population. We propose a conceptual framework for investigating the factors driving vulnerability to shocks and the resources most likely to support individuals to respond to or recover from these shocks. We surveyed 1052 share house occupants in June 2020. We found dramatic results, with 74% losing their job or having their hours reduced, 47% experiencing a reduction in their financial situation and 50% reporting that their mental health had deteriorated. These outcomes were worse for young people, casual employees or immigrants. Our research highlights the positive influence of social support for low-income individuals. We find that government social welfare payments are the most impactful form of insurance, calling for a greater appreciation of the role of social welfare in supporting resilience following a disaster.

1. Introduction

The Novel Coronavirus (COVID-19) that emerged in late 2019 has caused dramatic global disruptions to human health, well-being, financial security and behavior. Its repercussions will be felt well into the future. Besides the direct harm to public health, the lockdown measures introduced to stop the diffusion of the contagion have imposed huge economic, social and psychological costs (Brooks et al., 2020). Research is increasingly highlighting highly unequal experiences and impacts across populations. Research in Australia (Biddle et al., 2020), the UK (Judge, 2020) and the US (Aurand et al., 2020) has identified higher housing and financial stress among private sector renters and low-income households. Further, studies have documented that COVID-19 has amplified existing inequalities and precarities among vulnerable categories of individuals, such as the young (Churchill, 2020; Ferreira et al., 2020), workers with lower qualifications (Adams-Prassl et al., 2020) and those employed in casual, social and non-flexible jobs (Kikuchi et al., 2020).

One group that disproportionately embodies many of the characteristics of precarity listed above is members of share houses. We define share households as homes occupied by two or more people over the age

of 18 who are unrelated by romantic or family ties. In Australia, as in many other countries, members of group households are more likely to be young, insecurely employed, on low incomes, recent migrants, living in informal and overcrowded conditions and at a higher risk of homelessness than the general population (Australian Institute of Health and Welfare, 2019; Parkinson et al., 2019; Sarkar & Gurrin, 2017). Share houses also represent a growing proportion of all households. The number of 'group households' (share houses) grew 4.9% from 4.1% in 2011 to 4.3% in 2016 in Australia (Maalsen, 2020), echoing trends in many other countries. Internationally, scholars posit several reasons for this trend, including decreasing housing affordability, increases in precarious work contracts, extended periods of educational attainment and delayed or avoided marriage and family formation (Druta & Ronald, 2020; McNamara & Connell, 2007; Mykyta, 2012). Despite this, share house occupants are yet to be the focus of specific investigation in the context of COVID-19. Similarly, while increasing evidence of the impact of COVID-19 is emerging, it is rarely interpreted with reference to cumulative or cascading shocks associated with COVID-19 and the attributes or resources that drive vulnerability or resilience in response to these shocks.

Our contribution in this paper is twofold. First, we provide the first

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empirical investigation of the impact of COVID-19 on members of share houses in Victoria, the second most populous state in Australia. While it is empirically focused on one jurisdiction, the findings are reflective of emerging insights across other countries and results are likely to reflect experiences in other regions and global cities characterized by highly unaffordable housing markets (see, for example, [Judge & Rahman, 2020](#); [OECD, 2020](#)). Second, we posit a conceptual framework for understanding the impact of COVID-19 on households based on the intersecting experiences of shocks, vulnerability and access to insurances. We draw on insights from housing pathways literature and disaster recovery research to draw conclusions about the impact of COVID-19 on cities and their inhabitants. Further, we provide recommendations for urban researchers and policy makers concerned with supporting vulnerable households in the context of a multifaceted disaster.

This paper aims to

- identify the degree to which members of share houses have experienced ‘shocks,’ across the domains of income, employment, mental health and housing
- Identify the individual and household attributes of vulnerability driving susceptibility to shocks among share households
- Assess the mediating factors helping households and individuals cope with and recover from shocks

This paper begins with a brief review of literature pertaining to share houses and the impact of COVID-19 on vulnerable households before introducing a conceptual framework based on the consideration of shocks, insurances and vulnerability. Following this, we introduce the research methodology and case study area before presenting empirical findings. We conclude with a discussion of emerging insights and their implications for policy making in a pandemic-impacted world.

2. COVID-19 and residents of share households

COVID-19 is likely to be experienced differently by members of share houses for two key reasons. The first aspect relates to the role shared housing often plays in housing pathways. Share housing is often considered a transitional housing form that forms an important part of a non-linear pathway to adulthood and independence ([McNamara & Connell, 2007](#)). Similarly, it may form a ‘coping mechanism’ when other forms of family or state support are unavailable ([Arundel & Ronald, 2016](#)). For new migrants, lower-income households, international students and first-time renters it may be the only available option as it offers flexible rental arrangements and may circumvent the need to provide income and rental history documents ([Nasreen & Ruming, 2020](#)). Emerging research is identifying low income and young renters as the most vulnerable to cost of living and housing cost challenges in Australia ([Baker et al., 2020](#)) and internationally ([Klugman & Moore, 2020](#)). Unlike low income occupants of social housing, members of share houses usually negotiate their housing in the private market and often do not receive government housing support. As members of share households choose or are forced to leave their homes, share households may dissolve or remaining tenants may become suddenly burdened by substantially higher housing costs to cover rent for their former housemates. Similarly, as a group characterized by low incomes and high housing stress ([Parkinson et al., 2019](#)), members of share households are likely to have lower capacity to deal with the shocks associated with a pandemic.

Second, occupants of share houses cohabit in dwellings in ‘non-traditional’ household structures. While many scholars have highlighted the benefits of social connection and resource sharing among such arrangements ([Cho et al., 2019](#); [Maalsen, 2019](#)), others have noted the intense interpersonal conflict that may arise from shared domestic spaces ([Clark et al., 2017](#)). [Nasreen and Ruming \(2020\)](#) point to common power differentials between head tenants and other tenants as

different members access different rights in relation to whether they are formal lease holders or not. Such informal arrangements have been identified as a key barrier to accessing COVID-19 rental support payments or requesting rental reductions in Australia ([Raynor and Panza, 2020](#)). Similarly, financial resources are generally not shared in share households, potentially leading to additional rent-sharing tensions in the context of dramatic job losses. In the context of COVID-19 restrictions, where movement is severely curtailed and access to employment has drastically decreased, occupants are spending more time in close proximity. Particularly in households with differing levels of willingness or capacity to abide by government requirements, household members may find their ability to shape their home safely substantially compromised.

3. Conceptual framework: the role of shocks, vulnerability and insurances within the risk society

The unequal impacts of COVID-19 are exacerbated in many countries by the eroded certainties and increasing precarities of what [Beck \(1992\)](#) termed the ‘risk society.’ Through this lens, risk is increasingly being individualized through the retrenchment of the welfare state, casualization of the workforce, and fragmentation of family and marriage structures ([Arundel & Ronald, 2016](#)). In this context, increasing responsibility falls on individuals to protect themselves against shocks at the household level without the insurances of social welfare system or strong familial or social support networks. The inter-related experiences of insecure housing, family relationships, health and employment creates a situation of ‘precarious living’ with cumulative and damaging impacts on individuals ([Hulse & Saugeres, 2008](#)). This precarious living is reflected in contemporary housing transitions and pathways of vulnerable households and is exacerbated by crisis events. Indeed, economic crises often significantly undermine existing residential patterns and force re-alignment in living arrangements, with long-lasting impacts on housing markets, neighborhoods and households ([Lennartz et al., 2016](#)).

In this paper, we consider COVID-19 as a disruptive event that has compromised the functioning of many households and precipitated multiple shocks. While less advantaged households are always more susceptible to housing shocks or negative life events ([Fahlberg et al., 2020](#)), COVID-19 is exacerbating underlying inequalities ([Bullock et al., 2020](#); [Gaynor & Wilson, 2020](#)). We argue that underlying vulnerabilities are likely to increase the likelihood and intensity of shocks while access to individual, social and external insurances may serve protective functions by increasing an individual's ability to avoid or cope with shocks.

3.1. Shocks

Shocks are sudden events that cause a significant impact on something or someone's ability to function. Shocks have been conceptualized at various levels from individuals ([Stone et al., 2015](#)) through to urban districts ([Hudec et al., 2018](#)) and entire economies and housing systems ([Ayub et al., 2020](#)). Shocks may be positive (e.g. new job with higher salary, improved health, regional employment growth) or negative (e.g. loss of job or income, natural disaster, recession) ([Bayudan-Dacuyucy & Lim, 2013](#)). Focusing specifically on housing, [Stone et al. \(2015\)](#) pointed to foreclosures of mortgages or loans, change in residence, household formation or dissolution, health or disability challenges and lack of safe housing or security as key shocks. Shocks may be stand-alone events or may be experienced as a chain of events that lead to a specific housing pathway ([Clapham, 2002](#)). Understanding the prevalence of shocks is particularly important in this study as the accumulation of multiple adverse shocks can lead to homelessness, the need for greater support or transitions into poverty ([Bayudan-Dacuyucy & Lim, 2013](#); [Stone et al., 2015](#)). COVID-19 has precipitated household shocks globally with large increases in unemployment and underemployment ([OECD, 2021](#)),

increased rates of family violence (Sharma & Borah, 2020) and widely reported mental health reductions (Sher, 2020). While individuals and households might recover from a shock by drawing on the resources available to them, the compounding effects of multiple shocks, combined with intersecting experiences of vulnerability, often drives significant disadvantage (Bullock et al., 2020).

3.2. Vulnerability

The presence of vulnerability increases susceptibility to loss when an event or shock occurs. Vulnerability may be conceptualized at the individual, household, community, biophysical and built environment and infrastructure levels, with multiple factors interacting to define the degree of harm experienced (Van Zandt et al., 2012). Individual characteristics include employment status, income, disability, gender, ethnicity, citizenship status and physical and mental health (Alon et al., 2020; Midoes, 2020; O'Sullivan & Bourgoïn, 2010). Beyond individual characteristics, scholars have also considered the impact overcrowding and built form (Blumenshine et al., 2008), housing tenure (Van Zandt et al., 2012), a region's economic diversity (Hudec et al., 2018) and access to social networks (Fafchamps & Minten, 2002).

Vulnerability is dynamic and context-dependent. It reflects societal-level stratification and the unequal distribution of social relations, power and marginalization (Díaz McConnell, 2017). In the context of a pandemic, social vulnerabilities may increase the risk of exposure to contagion, unmet basic needs, insufficient support or inadequate treatment (O'Sullivan & Bourgoïn, 2010). In the US, the concentration of African Americans, Latinos and Native Americans in retail, hospitality, travel, transport and entertainment sectors has driven higher levels of unemployment in these groups (Kantamneni, 2020). Similarly, workers with less education, lower economic resources and lower levels of liquid assets have been more affected by unemployment (Mongey et al., 2020). Those living in overcrowded conditions are at greater risk of infection and are also less able to engage in activities that provide protective functions for their mental health (Raynor et al., 2020). Similarly, those in insecure employment are less likely to have personal savings, or ongoing employer financial support and so may feel compelled to put themselves at risk of contagion to meet other needs (Patel et al., 2020).

3.3. Access to insurances

An individual's or household's experience of a shock is largely mediated by their access to resources. Stone et al. (2015) refer to these resources as 'household insurances.' These insurances may increase a household's resilience, or their ability to prepare for, cope with, and adapt to shocks (Cutter et al., 2008; Vatsa, 2004). The converse is also true, as living in poverty constrains the capacity to save or invest in training or education to build future resilience (Hallegatte et al., 2017). A lack of resources can prompt the distressed sale of an asset or force sudden housing movements for renters (Bowen et al., 2020). Particularly within the risk society, low incomes, low savings and high debt burdens reduce a household's buffer while access to a range of resources support recovery.

The capacity to respond to shocks like job or income loss or dissolution of a household is substantially mitigated by access to a range of personal insurances such as savings, good physical and mental health and higher-income employment (Stone et al., 2015). These factors may create a 'buffering' effect that helps individuals to respond to crises. Substantial evidence now exists linking social ties and social support to improved mental and physical health, especially as a resource that buffers the harmful impacts of stress exposure (Ertel et al., 2009; Thoits, 2011). Social networks are particularly useful coping mechanisms for vulnerable populations (Cattell, 2001) and have been shown to mitigate financial hardship via monetary transfers and interpersonal loans in some cases (Lucas & Stark, 1985). Similarly, housing literature has highlighted the role of parents in supporting transitions into

independent living, through financial and in-kind support (Arundel & Ronald, 2016). Government-provided payments to vulnerable households can build the resilience of poor and vulnerable households to shocks (Bowen et al., 2020) and can 'smooth out' experiences during recessions (Martorano, 2013). For example, early analysis from the UK has found that lower-income families have been partially cushioned from income loss by strengthened social security payments introduced in response to COVID-19, although living standards appear to have fallen in this cohort (Brewer & Gardiner, 2020).

3.4. Introducing a conceptual framework

Based on the above, we propose a conceptual framework for investigating the factors driving vulnerability to and recovery from shocks. As depicted in Fig. 1, we take as our starting point exposure to the experience of living in a share house during COVID-19. We argue that experience of shocks is likely to be mediated by access to a range of individual, social and external insurances. Vulnerability, or the 'prevent, inherent characteristics or qualities... that create the potential for harm' (Cutter et al., 2008, p. 599) will increase both the likelihood and severity of shocks. This paper draws on this conceptual framework to identify the characteristics driving vulnerability, the insurances with the greatest protective capacity and the shocks most prevalent within the present study.

4. Data and methodology

4.1. Introducing Victoria, Australia, as a case study

Victoria is the second most populous and fastest growing state in Australia. Most of this growth is due to overseas migration. Over 75% of the 6.6 million people who live in the state of Victoria reside in the state's capital city of Melbourne (Australian Bureau of Statistics, 2020). The State has a diversified economy with health care, retail trade, education and training, construction and professional, technical and scientific services forming the top five employment sectors in the state. According to the 2016 census, 4.5% of households defined themselves as group households; a slightly higher rate than the Australian average of 4.3% (Australian Bureau of Statistics, 2016). Unlike countries like Japan where 'shared living' generally takes the form of whole apartment blocks managed by a real estate agency (Ronald et al., 2018), share housing in Australia and Victoria is more likely to occur through individual arrangements between a land lord and a group of tenants. While share houses are commonly clustered geographically around universities, employment centers or train stations, they may occur in units, townhouses or detached houses located anywhere throughout cities and regions (Nasreen & Ruming, 2019). Homes that house share households in Victoria are rarely designed with group households in mind, more commonly reflecting the needs of nuclear families or couples (Heath, 2018).

Victoria has a limited supply of affordable housing. While access to rental housing affordable to households receiving government pensions or support payments is more prevalent in regional Victoria than the capital city of Melbourne, access has been diminishing in recent decades. The proportion of rental homes affordable to households reliant on government payments fell from 73% of regional rentals in 2000 to 65% in 2017 and 18% of rentals in metropolitan Melbourne in 2000 to just 7% in 2017 (Raynor et al., 2017).

While the first positive case of the Novel coronavirus was identified on 25 January 2020, the large-scale impacts of the pandemic were arguably not felt until mid-March 2020. The government responded by enforcing closures of many businesses and services across the country. On March 16th the Australian stock market experienced its largest fall in value since the stock market crash of 1987. Through March the Australian government announced increasing levels of restrictions on businesses, services and community functions. By the end of March

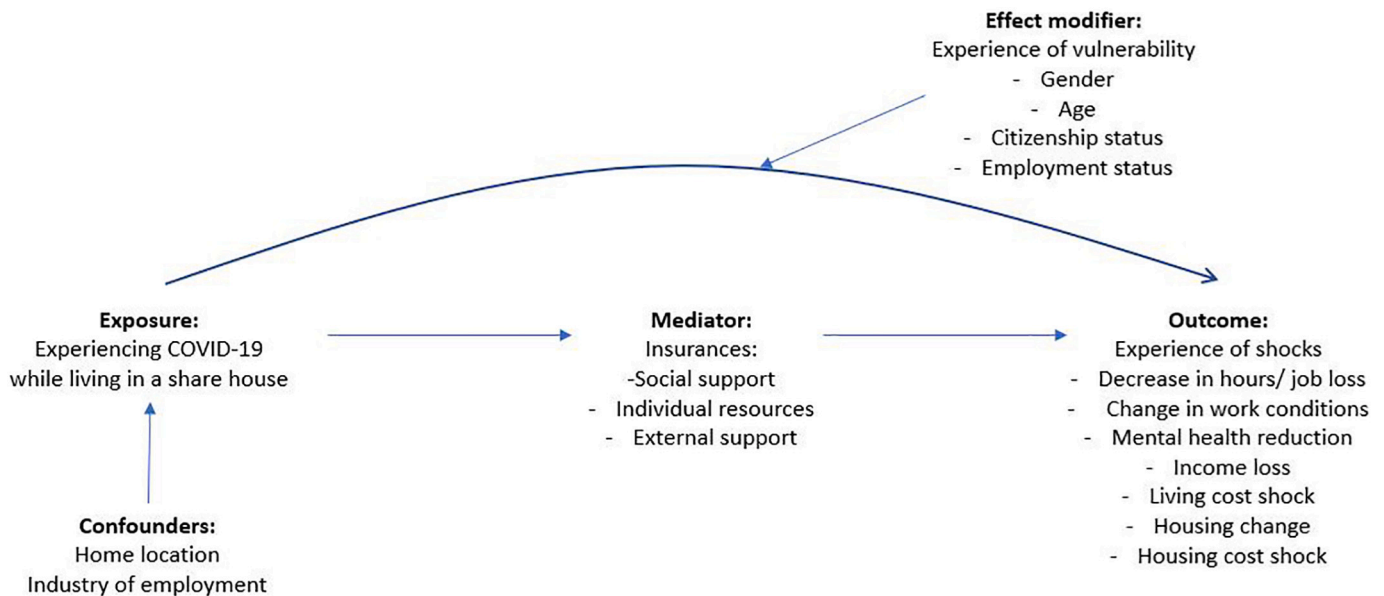


Fig. 1. Conceptual framework of shocks, vulnerability and insurances.

large-scale business closures had caused large spikes in unemployment and underemployment, particularly in arts, food and retail sectors. On the 30th of March the Australian Government introduced the ‘Job Keeper Payment’ that aimed to help employers keep their staff on pay roll. Similarly, the Australian Government announced an emergency CoronaVirus Supplement to existing social welfare payments, immediately doubling the income of many unemployed people and changing the payment name to the JobSeeker payment (Woods, 2020).

The Australian Government announced a six-month moratorium on rental evictions on March 29, 2020, although this decree was devolved to individual States to action. The new laws created a moratorium on evictions, facilitated rent relief for eligible tenants, suspended rental increases, and established a new dispute resolution process between tenants and landlords. The Victorian Government established a rental assistance fund to provide rent relief payments of up to \$AUD2,000 to Victorians experiencing rental hardship. The Victorian Government also announced a \$45 million fund to support disadvantaged international students (HousingVic, 2020). These government support packages were extended by some universities who also committed funds to supporting disadvantaged students.

4.2. Survey design and data collection

Data were collected through an online survey, yielding 1052 responses collected between June 4 and June 28, 2020. The survey was disseminated through multiple channels to reach the largest and most representative sample possible. The majority of responses (n = 670) were derived from an online survey panel service that targeted a representative selection of respondents currently living in Victoria. The remaining responses (n = 382) were targeted through three key channels; 1) targeted facebook and instagram advertisements 2) twitter and facebook messages posted by the University of Melbourne, the Tenants Union of Victoria, and Victorian Legal Aid and 3) posting of the survey in facebook groups aimed at international students and share houses in Melbourne and the six largest regional cities and towns in Victoria.

The survey was designed to capture key demographic trends in share houses in Victoria. These summary statistics are shown in Table 1. The survey also aimed to measure key outcomes in financial resilience, income, health and well-being, employment status, relationships with housemates, housing situation, overcrowding and adequacy of housing space both before and after COVID-19. The survey also asked

Table 1 Survey summary statistics.

	N	%
Gender		
Male	399	60%
Female	635	38%
Non-binary	15	2%
Age		
18–24	221	21%
25–34	547	52%
>35	284	27%
Citizenship		
Australian citizen	661	63%
Permanent resident	153	15%
Visa holder	238	22%
Employment status		
Employed full time	358	34%
Employed part time	376	36%
Unemployed	200	20%
Out of the labor force	97	9%
Home location		
Greater Melbourne	840	80%
Regional Victoria		20%
Employment contract		
Permanent	346	47%
Fixed-term contract	97	13%
Casual	250	34%
Tenure		
Home owner	53	12%
Renter with lease longer than 6 months	38	59%
Renter with lease shorter than 6 months	15	19%
Other	33	9%
Dwelling over-crowding		
Households not experiencing overcrowding	881	84%
Households experiencing overcrowding	168	16%

respondents to state how confident they felt about their ability to meet their housing costs over the next 6 months. See Appendix A1 for the full survey.

The survey tested housing and tenure security and adequacy using several metrics. It included a simple measure of overcrowding by asking for number of residents and number of bedrooms in the household. This question was supplemented by questions about resident's level of comfort using and occupying their home during isolation measures. Housing security was tested using questions about length of rental lease, and

whether respondents leased from a landlord or sub-let from a housemate. The survey also included a question about levels of confidence about rental legal rights. Affordability was tested by asking for salary and weekly rental or mortgage payments.

The final section of the survey related to the support mechanisms or resources that respondents accessed in response to COVID-19. Respondents were asked if they received government payments, support from their employers, friends, a charity organization, housemates or family, accessed their personal resources through savings or superannuation or sought a personal loan or mortgage relief. We generated a proxy for social support by asking respondents the degree to which their family, family, government, friends, neighbours and charities supported them throughout COVID-19. We also adapted a survey instrument from [Sherbourne and Stewart \(1991\)](#) to test the frequency with which respondents accessed emotional and pragmatic support from networks. Finally, the survey investigated experiences of rental renegotiations in Victoria and captured data about whether rent was reduced, by how much and why or why not this negotiation proceeded.

4.3. Methods

Using the questionnaires completed by the individual respondents, we first describe two key trends observed in the data focusing on: (i) the type of COVID-19 driven shocks experienced on average in the sample; and (ii) the individual characteristics associated with experiencing a shock.

Next, we use a regression analysis to investigate empirically the categories of respondents who were differentially affected by COVID-19 driven shocks. To this purpose we run a set of regressions where the outcome variables are:

- (i) the probability of experiencing a specific shock;
- (ii) the intensity of the shock experienced;
- (iii) the sum of shocks experienced (with the aim of measuring the compounded effect of experiencing multiple shocks).

The explanatory variables used are individuals' characteristics, namely: gender (female/male/non-binary), age, residency status (citizens/permanent residents/visa holders), work contract type (casual/fixed term/continuing) and income. The probability of experiencing a shock is a binary outcome equal to one if respondents reported to have a *worsening* in their income, work conditions, capability of covering living costs, mental health, if they had a change in their housing conditions or used a charity. These regressions are estimated using fixed effects logit specifications. The intensity of the shock experienced is coded in five categories, based on respondents' self-reported change in the above conditions (work, income, mental health, etc.), where the possible answers ranged from "becoming much better" (coded as 1) to "becoming much worse" (coded as 5). We estimate these regressions via ordered logit: this specification allows us to investigate the whole spectrum of the outcome (5 categories), and to account for the fact that the "distances" between these five categories may not be equal. For example, the "distance" between "became much better" and "became better" may be shorter than the distance between "did not change" and "became worse", hence having a differential impact on the outcome.

When looking at the compounded effect of multiple shocks, we sum the probability of experiencing a shock in six dimensions, manifested as: job loss, lower income, worse mental health, change in housing arrangement, financial hardship, and difficulty in paying rent.¹ This aggregate measure aims at capturing the cumulative effect of being

¹ The sum the probability of experiencing a shock ranges from zero, where a respondent has not reported any worsening in any of the six shock dimensions, to six, where a respondent has reported a worsening in all the six shock dimensions.

exposed to multiple negative shocks, hence being a proxy of shock intensity: the more the types of negative shocks experienced, the stronger the effect that COVID-19 had on an individual. Given that the intervals between each shock experienced may not be equal, we choose again the ordered logit as our preferred specification. Furthermore, we ensure that the results are robust to using standard count data estimation models (such as poisson) as well as OLS. All regressions include industry fixed effects, to capture any unobservable characteristics specific to a sector of employment.²

Lastly, we analyze the channels that helped to mitigate shocks, focusing on three main types of insurances: individual resources, social support and external support. To assess empirically the relationship between shocks and insurances, we use the following regression setup:

$$\text{Shock}_i = \beta_1 \text{Social support}_i + \beta_2 \text{Gov support}_i + \beta_3 X_i + u_i. \quad (1)$$

We measure social support in two ways: first as the presence of community or family networks used as risk-coping mechanisms (extensive margins). Specifically, we coded social support as a binary variable, where one was assigned to individuals who responded "yes" to the following question: "Do you have a support network (family, friends, community) that can help you in situations of financial hardship?". Our second measure of social support focuses on the frequency of access of support networks during the pandemic (intensive margins). Specifically, we adapted a survey instrument from [Sherbourne and Stewart \(1991\)](#) to test how often they interacted with someone: 1) they could count on to listen to them when they needed to talk 2) to give them information to help them understand a situation 3) to help with daily chores and 4) to have a good time with. We assigned a dummy variable equal to one if the response was "All of the time" or "Most of the time" and zero otherwise. We measure access to social support, rather than more generalized notions of social capital, as our interest is in immediate emotional and pragmatic resources in response to a crisis, rather than feelings of connection to community or notions of bridging or bonding capital.

To measure external support, we collected data on respondents' access to the packages offered by the government to assist financially those affected by COVID-19 and asked them whether such financial support was helpful. The four government supports were: a \$1500 per fortnight employment payment paid to eligible employees who were substantially impacted by COVID-19 (JobKeeper); a \$1115 per fortnight payment paid to eligible unemployed people (JobSeeker); a one-off rental supplement of up to \$2000 for low income renters; and an international student emergency relief fund of up to \$7500 for disadvantaged international students. Vector X_i includes the demographic and socio-economic controls discussed above: gender, age, residency status and employment contract type. Sector fixed effects are controlled for in all regressions; standard errors are clustered at the postcode level as the residual u_i is likely to be correlated for people living in the same neighborhoods.

Finally, in order to provide an in-depth analysis of various dimensions of support (monetary and non-monetary) which mitigated COVID-19 negative shocks, we investigate whether each of the support mechanisms accessed during the pandemic reduced the experience of COVID-19 shocks. To this purpose, we assigned a dummy variable of one if respondents indicated that they agreed or strongly agreed with the

² The employment sectors reported are: Accommodation and Food Services (10.7%); Administrative and Support Services (7.7%); Agriculture, Forestry and Fishing (1.5%); Arts and Recreation Services (4.1%) Construction (6.9%); Education and Training (10.4%) Electricity, Gas, Water and Waste Services (1.2); Financial and Insurance Services (2.5%); Health Care and Social Assistance (11.5%) Information Media and Telecommunication (5.6%); Manufacturing (3.6%); Mining (0.4%); Professional, Scientific and Technical Services (12.6%); Public Administration and Safety (2.7%); Rental, Hiring and Real Estate Services (1.2%); Retail Trade (11.9%); Transport, Postal and Warehousing (3.6%); Wholesale Trade (1.6%).

following statement: “The resources I have accessed in response to COVID-19 are sufficient for the next three months”. The types of support accessed included: own savings; financial support from housemates/charity/employer/family; government support (Jobkeeper or Job-Seeker, rent relief); International Students Emergency Relief Fund; and superannuation.

5. Empirical findings

5.1. Identifying COVID-19-driven shocks

We start by illustrating the type of COVID-19 driven shocks experienced by respondents. Fig. 2 shows that 86% of people reported experiencing at least one type of shock: changes in working conditions represented the most widespread type of shock, with 74% of respondents indicating that they either work less hours or have lost their job and 68% reporting a change in their working conditions due to COVID-19. Two of the most common work-related changes include a rise in working hours with the same pay and working from home. These figures are higher than the broader population of renters in Australia where 22% experienced reduced hours, 13% temporarily lost their job and 10% experienced total job loss by August 2020 (Baker et al., 2020). A large part of the sample stated that COVID-19 impacted their income negatively: the financial situation of 47% of respondents became worse or dramatically worse (income shock); 40% found it difficult or extremely difficult to meet their necessary cost of living expenses (living cost shock). In order to be able to cover expenses, 23% of the sample pawned or sold something, 20% went without a meal, 22% could not pay rent or mortgage rates on time, thus providing further evidence of financial hardship. Results are reflective of a broader survey of Australian households that found that 27% of renters and 22% of homeowners could not pay their rent or mortgage costs on time in the three months leading to May 2020 (Biddle et al., 2020). Moreover, 50% of the sample experienced a deterioration in mental health, suggesting that COVID-19 negative effects went beyond the economic and financial spheres.

We found high levels of housing-related challenges in this group with 26% of respondents in housing stress (paying more than 30% of their income on housing costs) and almost 1 in 5 in severe housing stress (paying more than 50% of their income on housing costs). Our survey of share households similarly found significant housing turbulence in this group with 39% reporting a change in their housing conditions (more occupants moving in [13.6%], moving in with parents or partner [29%], moving to a different share house [26%], and occupants leaving [20.5%]). Over a third of respondents reported lacking confidence in knowing or protecting their rights as renters while 19% were currently in rental contracts of less than 6 months. 24% reported feeling stressed by their lack of control over their domestic space, while 16% were living in overcrowded housing.³

5.2. The relationship between vulnerability and COVID-19-related shocks

We find that being an immigrant (visa holder), employed on a casual contract, and young (less than 35 years old) significantly increased the likelihood of being impacted by shocks. In particular, 26% of respondents under 35 were unable to meet their housing costs in the 3 months leading to June 2020, compared to just 10% of respondents 35 and older. While 33% of Australian citizens or permanent residents found it difficult to meet their living costs, 62% of visa holders reported

³ This measurement is used as a proxy for overcrowding, rather than the Standard Occupancy Guidelines often used for measuring overcrowding. To reduce the length of the survey, respondents weren't asked for the ages and relationships of other housemates and this precludes the use of the Standard Occupancy metric. For this reason, the proportion of overcrowding is likely to be underreported.

the same issue. Similarly, respondents employed on casual contracts were more likely to experience shocks than their permanent or fixed-term contract counterparts; in particular, 55% experienced income shock (45% for non-casuals), 53% experienced a living cost shock (36% for non-casuals), 84% experienced a decrease in hours or loss of their job (70% for non-casuals) and 32% experienced a housing cost shock (19% for non-casuals). See Appendixes B1–B3 for descriptive statistics on differences across the survey sample.

5.3. Results from regression analysis: the drivers of vulnerability to COVID-19 shocks

Fig. 3 plots the coefficients of the logit regressions, indicating individuals' characteristics associated with the probability of being affected by a single shock. It highlights that visa holders are more likely to: experience negative income shocks; struggle paying living expenses; work less hours or have lost their job and; have accessed a charity. Casual workers are associated with the likelihood of struggling to meet their costs of living and of losing work or hours. Young people and women were more likely to report a negative mental health shock and changes in housing conditions. Income is a significant mitigating factor for financial, living costs and work shocks. Unlike other studies that have found that women are disproportionately impacted by COVID-19 (Alon et al., 2020), this research does not find a similar pattern. Indeed, women were less likely to experience income or work shocks than men in this cohort.

Appendix Figs. B4–B7 plot the predictive margins generated by the ordered logit regressions, indicating the extent to which an increase in individuals' characteristics is associated with the intensity of experiencing each shock. The patterns emerging from these figures yield similar results to those illustrated in Fig. 2: for instance, the average predicted probability of experiencing a negative work shock is higher for young and visa holders (Fig. B6); the average predicted probability of experiencing a negative living cost shock is higher for casual workers and visa holders (Fig. B7); and income lowers the probability of experiencing negative shocks.

Table 2 reports the ordered logit regressions results describing the relationship between the number of shocks experienced and individuals' characteristics. Column 1 indicates that being young, a visa holder, employed with a casual contract increased the number of shocks experienced, thus confirming the descriptive statistics of Appendix Figs. B1–B3. On the other end, income acted in the opposite direction, alleviating the intensity of the shocks. In Column 2, we add a dummy variable equal to 1 for people being on a part-time contract and find that also this category of workers was more affected by a shock relative to those employed on a full-time basis.

Three further aspects of vulnerability are associated with COVID-19 driven shocks: being indigenous (Aboriginal or Torres Strait Islander) (col. 3), having non-binary gender (col.4); and being unemployed (col.5). In column 6 we replace income with education, since the two variables are typically strongly correlated. However, we find that education did not play a mitigating role. Column 7 controls for savings instead of income, and the results point to a mitigating effect of savings. In column 8 we additionally control for postcode fixed effects, to account for the potential for locational disadvantage or other unobservables associated with a particular location.⁴ The results are consistent with our baseline findings. The likelihood ratio Wald chi-square p-values are reported for all regressions. All *p* values are equal to 0.000 indicating that each model as a whole is statistically significant, as compared to the null model with no predictors. Furthermore, the results of the Brant test

⁴ Postcode fixed effects include 211 dummy variables taking the value of one for each postcode and zero otherwise.

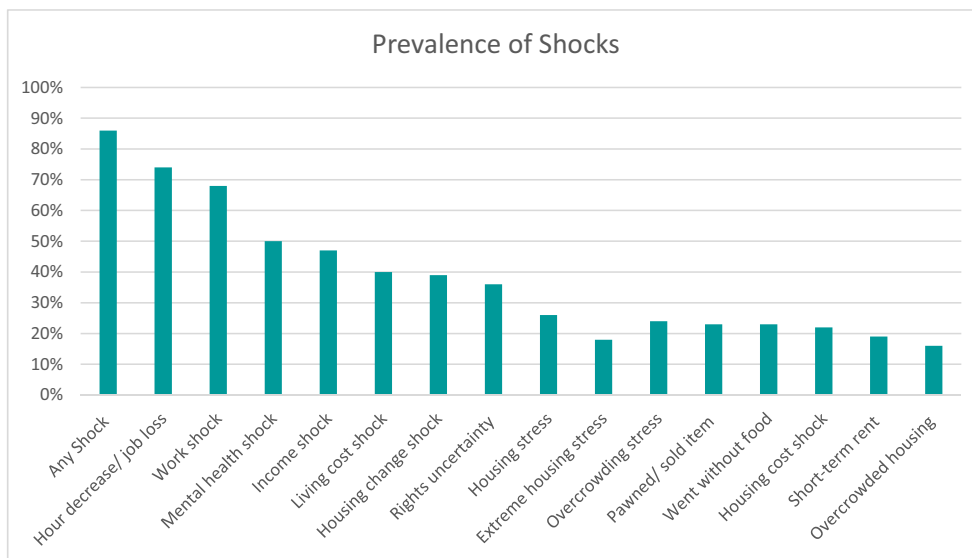


Fig. 2. Prevalence of shocks.

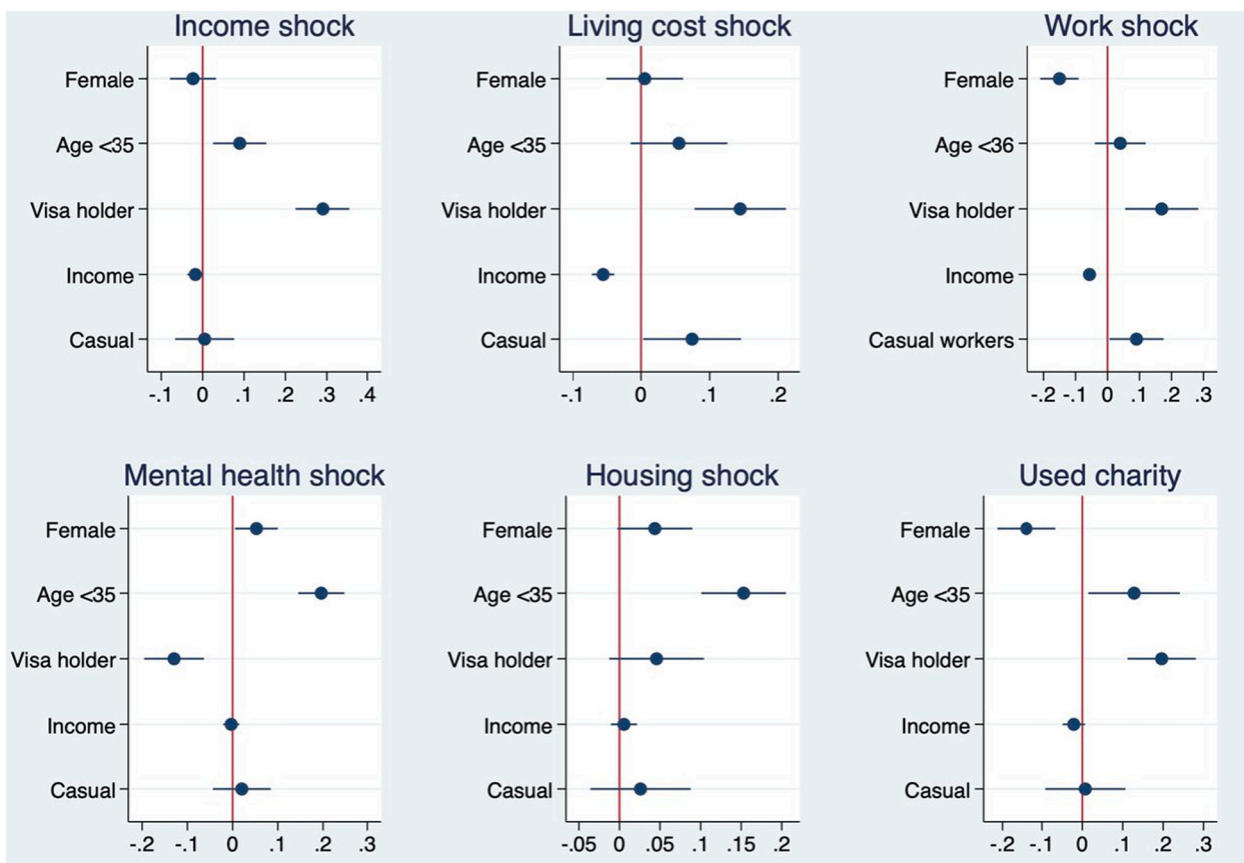


Fig. 3. Logit regressions of impact of individual characteristics on likelihood of experiencing a shock.

(reported in the last row of Table 2), confirm that the proportional odds and parallel lines assumption of the ordered logit model are met.⁵ Tables B1 and B2 of the Appendix report the results of the same regressions, using different specifications: OLS and poisson, respectively.

⁵ The insignificant test statistic of the Brant test provides evidence that the parallel regression assumption has not been violated.

In both specifications, the findings are in line with those presented in Table 2.

5.4. The mediating role of insurances

After having established a relationship between vulnerability and COVID-19 shocks, we investigate the channels that helped to mitigate shocks, focusing on three main types of insurances: individual resources,

Table 2
Characteristics of those affected by multiple COVID-19 driven shocks.

Outcome variable: number of COVID-19-driven shocks								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Young	0.984*** (0.192)	0.971*** (0.194)	0.870*** (0.206)	0.986*** (0.195)	0.964*** (0.183)	0.963*** (0.182)	1.002*** (0.183)	0.988*** (0.264)
Visa holder	0.767*** (0.148)	0.790*** (0.151)		0.807*** (0.151)	0.728*** (0.136)	0.706*** (0.148)	0.546*** (0.141)	0.721*** (0.192)
Income	-0.122*** (0.042)	-0.114*** (0.044)	-0.116** (0.055)	-0.118*** (0.042)	-0.193*** (0.036)			-0.188*** (0.054)
Casual worker	0.346** (0.164)		0.428* (0.227)	0.338** (0.166)		0.568*** (0.164)	0.363** (0.145)	0.442** (0.217)
Female	-0.055 (0.139)	-0.06 (0.140)	0.093 (0.164)	-0.002 (0.142)	-0.116 (0.136)	-0.072 (0.137)	-0.019 (0.134)	-0.003 (0.178)
Part time worker		0.349** (0.158)						
Indigenous			1.260* (0.749)					
Non-binary				1.139** (0.476)				
Unemployed					0.644*** (0.129)			
Education						0.095** (0.038)		
Savings							-0.001*** (0.000)	
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
Postcode FE	N	N	N	N	N	N	N	Y
N	989	989	620	989	989	996	998	989
Wald chi2	324.2	327.6	134.7	327	241.9	294.1	324.1	371.3
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brant test	0.181	0.161	0.315	0.171	0.337	0.308	0.288	0.180

Note: * indicates statistical significance at the 10% level, ** indicates statistical significance at the 5% level, *** indicates statistical significance at the 1% level. The dependent variable measures the number of COVID-19-driven shocks comprising of: work-related shocks (working less hours/job loss); lower income, worse mental health, change in housing arrangement, financial hardship, difficulty in paying rent. Standard errors are clustered at the postcode level.

social support and external support.

Table 3 reports the empirical findings focusing only on the presence of social support. The results point to a strong effect of networks in mitigating COVID-19 shocks: having a support network is associated with a 37.2% decrease in the odds of experiencing shocks (col. 1), and a 14.7% and 29.1% decrease in the odds of having a negative work and income shock (cols 2 and 3, respectively).⁶ Social support is also related to reduced living expenses shock, reduced hardship with rent repayments and reduced likelihood of pawning, using charities and skipping meals (cols. 7–9). On the other hand, we do not find any significant relationship between social support and mental health or changes in housing conditions (cols. 4–5).

Table 4 provides an in-depth analysis of various dimensions of support (monetary and non-monetary) which mitigated COVID-19 negative shocks: specifically, we investigate whether each of the support mechanisms accessed during the pandemic reduced the experience of COVID-19 shocks. As explained in Section 4.3, this measure of effectiveness is based on self-reported satisfaction with the resources accessed. The results, reported in Table 4, suggest that accessing any of the above-mentioned types of financial support systems contributed in mitigating COVID-19 induced hardship. The results are driven by those accessing institutional support (Jobkeeper or JobSeeker, col. 6 and the international students fund, col. 7), personal savings (col. 2) as well as informal financial support (family, col. 5).

Finally, in order to assess which form of insurance mattered most in reducing the number of shocks experienced by an individual, we run a “horserace regression” between three key mediating factors: external support, social support and individual resources (income, education,

⁶ The odds ratio for the ordered logit model are computed by exponentiating the coefficients. For example, in col.1, for a one unit increase in social support the proportional odds ratio of having experienced all shocks is $1 - \exp(-0.466) = 0.372$ lower.

savings, good mental health, low debt), while controlling for age, gender and visa status. The findings, reported in Table 5, suggest that access to external support (Jobkeeper/Jobseeker, international students' relief, rental relief) played an important mitigating role in all specifications. Social support contributes positively when controlling for income and education (cols. 1–2), but its coefficient becomes insignificant when adding the following personal insurances: savings, mental health and debt. In fact, the latter three factors appear to be the most important personal insurances with a mediating effect (cols. 3–6).

6. Discussion

This paper presents a novel contribution to the rapidly growing body of literature examining the impacts of COVID-19 on households. It proposes a conceptual framework for identifying the characteristics driving vulnerability to COVID-19 shocks and a measurement of shock, based on incidence of a variety of disruptive events and a measurement of their severity. This measurement is designed to capture the accumulation of adverse events; a common risk factor for transitions into poverty or homelessness for vulnerable households (Bayudan-Dacuyucy & Lim, 2013; Stone et al., 2015). This research joins other studies in identifying the disproportionate levels of vulnerability to shocks among young people (Churchill, 2020), those in casual employment (Kikuchi et al., 2020) and immigrants (Guadagno, 2020). For example, respondents under 35 were substantially more likely than those over 35 to report struggling to pay for housing and necessary living costs, losing their job or working hours, and suffering from declines in their mental health. Similarly, we find that the strongest impacts in terms of employment were felt by visa-holders, with 87% reporting a substantial reduction in hours worked or job loss.

Interestingly, and in contrast to other research that has predicted higher levels of mental health impact in migrant and international student cohorts in response to COVID-19 (Giorgi et al., 2020), we found

Table 3
The role of social support in mediating COVID-19 driven shocks.

	All shocks	Work	Income	Mental health	Housing	Living cost	Used charity	Pawn/sold	Skipped meals	Rent payment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Social support	-0.466*** (0.127)	-0.159*** (0.070)	-0.344*** (0.121)	0.026 (0.152)	0.076 (0.154)	-0.778*** (0.141)	-0.448** (0.228)	-0.626*** (0.184)	-0.861*** (0.189)	-0.695*** (0.188)
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	979	850	977	978	979	718	925	865	874	876
Brant test	0.254	0.378	0.190	0.245	0.216	0.301	0.267	0.510	0.210	0.190

Note: Ordered logit regressions. The variable “All shocks” measures the number of COVID-19-driven shocks comprising of: work-related shocks (working less hours/job loss); lower income, worse mental health, change in housing arrangement, financial hardship, difficulty in paying rent. Standard errors are clustered at the postcode level. The set of controls include: gender, age, income, visa holders, casual workers.

Table 4
Effectiveness of relief programs.

Outcome variable: number of COVID-19-driven shocks									
	Any program	Savings	House mate	Charity	Family/friend	Job keeper/seeker	Intl. student fund	Rent relief	Super
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Effective support	-0.590*** (0.163)	-0.438** (0.218)	-0.639 (0.601)	-0.793 (1.249)	-0.522* (0.316)	-0.600** (0.237)	-1.322*** (0.483)	-0.431 (0.439)	-0.364 (0.411)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	979	979	925	865	874	876	977	979	850
Brant test	0.278	0.237	0.198	0.212	0.256	0.215	0.189	0.231	0.197

Notes: Ordered logit regressions. * indicates statistical significance at the 10% level, ** indicates statistical significance at the 5% level, *** indicates statistical significance at the 1% level. The dependent variable measures the number of COVID-19-driven shocks comprising of: work-related shocks (working less hours/job loss); lower income, worse mental health, change in housing arrangement, financial hardship, difficulty in paying rent. Standard errors are clustered at the postcode level. All regressions include the following controls: gender, age, income, visa holders, casual workers. Columns (1)–(9) indicate the group of individuals who received support from each specific program.

Table 5
Factors mitigating COVID-19 shocks.

Outcome variable: number of COVID-19-driven shocks						
	(1)	(2)	(3)	(4)	(5)	(6)
Government support	-0.692*** (0.213)	-0.711*** (0.213)	-0.510** (0.227)	-0.668*** (0.223)	-0.597*** (0.213)	-0.461* (0.241)
Social support	-0.310* (0.183)	-0.336* (0.188)	-0.202 (0.178)	-0.165 (0.188)	-0.235 (0.180)	-0.085 (0.185)
Income	-0.108** (0.055)	-0.117** (0.054)	-0.083 (0.055)	-0.045 (0.058)	-0.107* (0.055)	-0.049 (0.059)
Education		0.034 (0.054)				0.069 (0.054)
Savings			-0.001*** (0.000)			-0.001*** (0.000)
Good mental health				-0.473*** (0.093)		-0.387*** (0.094)
Low debt					1.210*** (0.251)	0.861*** (0.245)
Young	0.636** (0.265)	0.695*** (0.252)	0.566** (0.262)	0.650** (0.253)	0.614** (0.250)	0.649*** (0.228)
Visa holder	0.610*** (0.205)	0.561*** (0.216)	0.384* (0.202)	0.892*** (0.216)	0.553*** (0.210)	0.481** (0.226)
Female	-0.054 (0.210)	-0.083 (0.208)	-0.011 (0.205)	-0.153 (0.218)	-0.087 (0.209)	-0.183 (0.210)
N	428	427	428	428	428	428
Brant test	0.256	0.312	0.217	0.194	0.321	0.295

Notes: Ordered logit regressions. * indicates statistical significance at the 10% level, ** indicates statistical significance at the 5% level, *** indicates statistical significance at the 1% level. The dependent variable measures the number of COVID-19-driven shocks comprising of the sum of the following shocks: work-related shocks (working less hours/job loss); lower income, worse mental health, change in housing arrangement, financial hardship, difficulty in paying rent. Standard errors are clustered at the postcode level.

lower risk of mental health deterioration among visa holders and higher proportions of migrants reporting improved mental health following isolation rules. This is despite much higher levels of economic shock for migrants. This may reflect higher levels of mental health resilience among migrants. Writing of the lower levels of depression among migrants in Greece following the Global Financial Crisis, [Stathopoulou](#)

[et al. \(2018\)](#) argued that migrants may have experienced higher levels of turbulence in their countries of origin and therefore be less susceptible to the adverse effects of a variety of economic and social shocks. In the context of the current study, the transition to isolation rules may also have reduced experiences or fear of discrimination in public spaces, particularly for migrants of Asian background who have

disproportionately experienced discrimination and social exclusion in response to COVID-19 (He et al., 2020). Cultural variations in the perception of depression among different ethnic groups may also account for this result.

More broadly, our research illustrates that the loss of income due to the multiple shocks generated by COVID-19 has intensified the experience of precarious living for many group households: this was driven by high levels of housing turbulence as occupants moved to a new house, or as they changed, lost or added other occupants in their homes in response to COVID-19. Moreover, we found that within our sample many are tenuously housed in highly unaffordable and short-term housing arrangements with limited confidence in their ability to negotiate their rights as tenants or occupants. The dramatic employment impact in this cohort (75% experienced a job loss or reduction in hours) is indicative of the precarity of their labor market conditions.

This study also presents a mechanism for understanding the resources or insurances that support vulnerable households during a pandemic, including examining the interactions of personal, social and external resources. We found extremely low access to savings, low median incomes and relatively high debt levels in this group; all evidence of low access to personal insurances. In contrast, our empirical findings highlighted the importance of government support payments in shielding individuals and households from the accumulation and severity of a variety of shocks (Table 4, col. 6). Our findings contrast with other studies that anticipate limited changes to living standards for low-income households receiving additional government payments in response to COVID-19 (Brewer & Gardiner, 2020). Such positive effect was driven by JobKeeper and JobSeeker payments and International Student Relief Funds (Table 3, cols. 6–7). The fact that government support was effective emerges also from the differential incidence rate between employment-related shocks and economic shocks: while 75% of respondents experienced a reduction in hours or a job loss, only 49% reported that their financial situation had become worse since the beginning of the pandemic. This finding is likely to be driven by the fact that the Australian government responded to the pandemic by doubling Government support payments for many unemployed people. Similarly, the initial payments through the JobKeeper program paid a flat rate to companies to keep employees on their payroll, regardless of their income before COVID-19. Hence, for many working part-time, JobKeeper payments would represent an increase in income. These temporary payments are a significant departure from previous welfare policy in Australia, where most recipients of government payments remain below the poverty line (Davidson et al., 2020). While the ‘risk society’ has reduced government involvement in household resilience in recent decades, it appears that government intervention in Victoria in response to COVID-19 has had substantial impacts in supporting vulnerable share households.

We also find substantial importance in social support networks. The survey results show that almost 1 in 5 respondents received financial support from family or friends following COVID-19 and 68% reported that their family had worked hard to support them during COVID-19. Social support did not correlate with housing movements, perhaps indicating the complexity and diversity of reasons for housing movements during a pandemic. Similarly, the equivocal impact of social support on mental health shocks in this study aligns with broader disaster research that has found that social connections can drive positive communal coping for some (Afifi et al., 2012) and may increase the likelihood of experiencing depression among others (Bryant et al., 2017). In the present study, having social support substantially decreased the likelihood of experiencing income and living cost shocks, of skipping meals, pawning goods or being unable to pay rent or mortgage on time. This trend is most prevalent for individuals with low savings and/or high debt. In contrast, for those with savings and/or manageable debt, being able to access personal finances appears to have been a more significant support mechanism in response to COVID-19. The presence of important social support for individuals with limited

personal resources points to the likelihood of inter-generational financial and emotional support occurring in response to COVID-19. Previous research has identified the importance of family ties in managing housing following a shock, including return to the family home after a relationship breakdown or loss of employment (Köppe, 2018) and similar trends appear likely in the current context.

6.1. Takeaway for practice

Our findings highlight a variety of implications for pandemic-informed housing, social and urban policy and research. First, the research revealed high levels of turbulence among share households, with 39% reporting that either they or another member of their household had moved homes between April and June 2020. That figure is in comparison to the 14% of Australians and 35% of Australian renters that move each year on average (Australian Bureau of Statistics, 2016). Our data point to a broad range of reasons for these movements, including caring responsibilities; work opportunities; returning to family homes; moving to reduce housing costs when housemates moved out; leaving to avoid mounting tensions and conflict between housemates; and returning to countries or states of origin before borders closed. These movements, mostly instigated by the pandemic, represent a dramatic pattern of migration among this cohort and additional research is needed to track the short and long-term impacts of these movements. The geographic clustering of share houses, and low-income rental households more generally, is likely to cause clusters of vacant homes and/or clusters of households in high housing stress in the short to medium term. Similarly, given that 16% of respondents were living in overcrowded households and 24% reported feeling stressed by their lack of control over their domestic space, there are clear implications for greater risk of virus transmission in crowded spaces and mental health outcomes for households coping with spatial and interpersonal conflicts. Such challenges are likely to be common to share households internationally.

There are also implications for longer term housing movements. Existing research in Australia has already identified a contemporary pattern of low-income households moving to increasingly disadvantaged households over time (Baker et al., 2016) and COVID-19 may exacerbate this trend. Given the importance of housing pathways in shaping access to education, independence, support and employment, future research should track COVID-19 transitions, particularly among immigrants and young people.

The research also urges urban policy makers and researchers to consider the intersections of vulnerability and access to insurances, particularly within cohorts characterized by high levels of employment insecurity and low personal resources. Our research demonstrated the substantial impact that government payments had on reducing the experience of shocks. As countries globally signal their intentions to reduce support payments, many vulnerable households are likely to struggle to continue to meet living costs after periods of unemployment and significant housing stress. The importance of financial support from family members in this cohort is also relevant to policy makers and is worthy of future research as inter-generational wealth and support is not evenly distributed, further driving divides between advantaged and disadvantaged individuals. Our research highlights the challenges for migrants, who are multiply disadvantaged by low employment security, challenges meeting necessary living costs, limited access to government support payments and likely geographical distance from established social support networks. Internationally, we argue that identifying the factors driving both vulnerability and resilience is key to targeting resources towards those most at risk of falling living standards and also for assessing the effectiveness of various interventions designed to support vulnerable individuals, households and neighborhoods.

7. Conclusion

This research reflects the first phase of a longitudinal study into the changing experiences of share households in Victoria. Ongoing research will continue to track vulnerability, resilience and experience of shocks among members of share houses. While this study has found dramatic employment, housing, mental health and living cost concerns, the volatility of employment outcomes, government policy and public health outcomes due to COVID-19 make it difficult to predict future outcomes. We contribute new knowledge identifying the factors driving vulnerability to COVID-19 shocks (being young, being an immigrant and being casually employed) and the factors supporting resilience in the face of shocks (government support payments, social support networks for those with limited savings and personal savings for higher income individuals). The on-going impact of COVID-19 is re-shaping cities and neighborhoods internationally, not least through emerging experiences of disadvantage and changing government welfare policies and tenancy laws. Given that the accumulation of shocks is a commonly identified pathway to homelessness and poverty (Stone et al., 2015), the tracking of experiences over time is an important tool for understanding and intervening in such pathways. As the world continues to evolve in response to a global pandemic, the variegated experiences of those living precariously will require on-going research, action and advocacy.

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CRediT authorship contribution statement

Katrina Raynor: Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Project administration, Funding acquisition. **Laura Panza:** Conceptualization, Methodology, Software, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.cities.2021.103332>.

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