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Perspective

Cold homes in Australia: Questioning our assumptions about prevalence

Cynthia Faye Barlow [a,*], Lyrian Daniel [a,b], Emma Baker [a]

[a] The Australian Centre for Housing Research, Faculty of Arts, Business, Law and Economics, University of Adelaide, SA 5005, Australia
[b] UniSA Creative, University of South Australia, 5000, Australia

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ABSTRACT

Australia is considered by many to be a warm climate country and hence winter cold and its health effects are often overlooked. The majority of the Australian population live in temperate climate regions, which are heating-dominated and experience cold wintertime conditions. The prevalence of cold in Australian homes has to date been rarely measured or estimated, and the few studies that do are based on proxy data that estimate a low prevalence (around 5 %). This paper tests these proxy measures, using high resolution temperature data on indoor temperature from 100 homes across temperate Australia. The data were assessed using the World Health Organization's Housing and Health guideline for minimum indoor temperature (18 °C), which provides an internationally recognised benchmark for defining cold in homes. Across the sampled homes, 81 % were below 18 °C on average across the whole of winter (June–August 2022). Average winter indoor temperatures were 16.5 ± 2.7 °C across all homes, with no significant difference between locations. These early findings suggest that the problem of unhealthily cold homes in Australia is likely to be significantly more prevalent than previously estimated. Far from affecting 5 % of Australian households, the affected population may be 10 times this value. These initial findings have important implications for how we model health impacts and develop policy. This early release data from a recently commenced large environmental monitoring project is of timely importance. It challenges our understanding of the prevalence of cold housing in Australia context, flagging the pressing need to increase policy attention in advance of winter.

1. Introduction

Cold housing is a factor in wintertime health burden and mortality. Internationally, policy attention and the design of interventions are based on assumptions about the prevalence of cold housing. Warm climate countries, including Australia, are largely perceived to avoid wintertime cold problems [1]. This, however, is challenged by recent research. Houses in temperate climates are often not kept as warm in winter as those in cold climates [2,3]. For example, homes in South Africa (warm-temperate climate) have been observed to reach indoor temperatures as low as 4 °C in winter [4]. Death rates have been estimated to be 20–30 % higher in winter than in summer for Australia [5], and 10 % higher in winter compared to summer in Spain [6], with poor-performing housing implicated in the stark rates. Similarly, in Portugal, higher wintertime mortality (26 % excess winter death rate) [7], compared to the rest of the year, has been attributed to poor housing conditions and lack of protective measures against cold exposure, particularly to a lack of heating [8]. Australian excess winter death rates are high compared to other European countries, which ranged from 8 % for Slovakia to 19 % in Cyprus [7]. Importantly, Hajat and Gasparrini [9] demonstrate that temperatures do not need to be extreme for increased deaths to occur (advocating 19.6 °C minimum mortality temperature). They conclude that cold makes the greatest contribution to annual temperature-related excess deaths and needs to be prioritised for public health planning. Yet, there remains a deficit of research on the prevalence of cold homes across many warmer climate countries.

Beyond the association with excess wintertime deaths, living in a cold home has been shown to adversely affect the mental and physical health of inhabitants, particularly via cardiovascular and respiratory disease [10–13]. The World Health Organization's Housing and Health guidelines recommend 18 °C as a minimum indoor temperature to protect the health of general populations [14]. The health impacts of cold homes have been shown to be exacerbated by housing affordability and the related availability and affordability of heating, with those who

Abbreviations: AHCD, Australian Housing Conditions Dataset; ARHCD, Australian Rental Housing Conditions Dataset; HILDA, Household, Income and Labour Dynamics in Australia; NSW, New South Wales; SA, South Australia; WA, Western Australia; WHO, World Health Organization.

* Corresponding author.
E-mail addresses: cynthia.barlow@adelaide.edu.au (C.F. Barlow), lyrian.daniel@unisa.edu.au (L. Daniel), emma.baker@adelaide.edu.au (E. Baker).

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rent, rather than own their home, being most affected [8,13,15,16]. Housing conditions and affordability have also been well linked to cardiovascular illness, respiratory symptoms, and diabetes, as well as mental illness [15,17–20]. Conversely, living in a warm home brings health benefits, including increased life expectancy [21].

Perhaps due to the poor recognition in Australia of the quality and condition limitations in the housing stock [22], there are few large-scale data sources available to researchers to provide insight into the relative prevalence of cold housing in Australia. Those that are available rely on various proxy measures (self-assessed), rather than direct observations. The Household, Income and Labour Dynamics in Australia (HILDA) survey [23] included a proxy question as part of the Material Deprivation module that asks people if they are unable to keep at least one room adequately warm in the house when it is cold, due to a lack of money. Just over 1 % of the 9638 respondents said that they were unable to [24] keep at least one room adequately warm. The other commonly used data source, is the 2016 Australian Housing Conditions Dataset (AHCD) [25,26], which suggests that 6 % of the 4501 respondents from South Australia (SA), Victoria, and New South Wales (NSW) were unable to keep their homes warm during winter [25]. The more recent 2022 Australian Housing Conditions Dataset (ARHCD), containing in-depth information about 22,500 households across all housing tenures, asks respondents if they are able to "keep comfortably warm in your house during winter?" - 23 % of respondents from Australian temperate regions said that they were unable to keep warm in their home during winter [27]. This varied slightly from state to state (NSW 23 %, Tasmania 24 %, SA 23 %, Victoria 19 %, WA 24 %) [27].

While all self-reported, the data sources cited above represent the best available estimates of cold housing prevalence in Australia to-date. Importantly, we note that each frames cold housing quite differently. The HILDA data for example, provides an insight into cold housing, largely incidentally to its focus on understanding material deprivation. We therefore suggest that the very small prevalence suggested in this survey data may be a result of a tight framing of cold housing (to make just one room of a house adequately warm), and a focus, not just on thermal adequacy, but also on financial capability. The 2016 AHCD bases its measurement on a quite blunt self-perception of the home providing warmth across a winter season, and similarly, the 2022 AHCD, while asking people to reflect on warmth, also relies on self-perception across a season. Because they are based on survey data, these studies are unable to provide a prevalence estimate that can be assessed using international cold housing guidelines (i.e. the WHO Housing and health guidelines) because they do not measure indoor temperature, rather, occupants various perceptions of it. In the absence of large scale indoor temperature data, the true extent of cold housing has been unknown.

In this paper, we seek to provide an initial prevalence estimate that is both objective and aligns with international guidelines. We estimate how many Australian homes are classified as 'cold' under the WHO (18 °C minimum) guideline based on early release data from a large, national environmental home monitoring study. These initial findings have important implications for how we consider and prioritise future research and policy.

2. Methods

Acknowledging that Australia is large nation where less populated climatic zones may have more extreme temperatures, we restrict our analysis to the temperate zones, where the great majority (69 %) of the national population resides [28,29]. Households in the temperate climate zones of NSW, Tasmania, SA, Victoria and WA, were recruited via a mailout targeted across diverse socioeconomic areas, referral, and social media advertising. The primary contact method was via unaddressed mail (62 %), targeted to include a balanced spectrum of household incomes using Australia Post's Campaign Targeter [30]. Additional contacts were made via participant referral (16 %) and Facebook advertising, targeted by geographic location (22 %). Each was sent a TZONE TEMP U 03 digital temperature logger via post.

Participant characteristics were also collected via online survey (Table 1) and reasonably reflect the Australian population. This paper reports on the data from the first 100 homes participating in the study. As this is early data from a larger study, it is anticipated that final study results will better reflect the Australian population. The survey also included questions about typical hours of occupation for the home.

Participants were provided with written placement instructions as well as an instructional video demonstrating logger placement. Each logger (pre-tested for accuracy, and programmed to record temperature at 15 minute intervals) was mounted within a stand in order that participants simply needed to place in the living area, out of direct sunlight, away from heat sources, children and pets. Data for the winter months (June, July August), were converted to a 1-hour averaged temperature for each of the 100 households, and this was assessed against the WHO definition of cold homes.

We note that this sampling method does not guarantee accurate placement and handling of sampling equipment by study participants. However, other citizen science programs have demonstrated that data collected are of comparable quality to studies carried out by qualified researchers [32–34].

3. Results and discussion

The percentage estimates of cold homes, according to the WHO definition (below 18 °C), are presented in Table 2. Wintertime indoor temperatures at the 5th percentile (to remove outliers) were as low as 10.9 °C hourly average for Tasmania, which experiences a cool temperate climate [35]. Average wintertime temperatures across all sampled homes were 16.5 ± 2.7 °C, with median 16.3 °C. Differences between mean temperatures in each state were not statistically

Table 1
Participant characteristics.

Characteristic	Number of participants (total n = 100)	2021 Australian Census [31] (per 100 people)
Tenure		
Mortgage	38	35
Government rental	3	
Private rental	15	30 total rental
Own outright	39	31
Other	3	
Not stated	2	3
Annual household income (income categories were only approximately comparable with ABS data)		
<$31,000	13	11
$31,000–$59,000	10	16
$59,000–$90,000	15	17
$90,000–$125,000	13	14
$125,000–$150,000	8	13
$150,000–$175,000	6	16
$175,000–$200,000	5	5
>$200,000	11	14
Not stated	19	7
Age of respondent		
18–29 years	8	18
30–49 years	41	36
50–64 years	29	24
over 65 years	23	22
Home includes child	24	
Home includes aged person	27	
Gender of respondent		
Female	51	51
Male	48	49
Not stated	1	

Table 2
Wintertime temperature statistics for homes in Australian temperate climates, calculated from hourly average temperatures for each home by overall (Mean °C) and waking occupied hours (WOH) respectively. Each state represents 20 homes, sampled over June, July and August 2022.

	NSW (n = 20)	SA (n = 20)	Tasmania (n = 20)	Victoria (n = 20)	WA (n = 20)	Temperate average (n = 100)
Mean °C	16.8	17.2	15.8	15.7	17.0	16.5
(WOH)	16.7	17.1	15.9	15.7	17.0	16.5
SD	2.0	3.0	3.0	3.3	2.1	2.7
(WOH)	2.1	3.1	3.1	3.3	2.1	2.7
Median	16.4	17.1	15.4	15.5	16.9	16.3
(WOH)	16.4	17.0	15.5	15.6	16.9	16.3
5th percentile	13.9	12.6	11.2	10.9	13.9	12.5
(WOH)	13.8	12.5	11.4	10.8	13.9	12.5
95th percentile	20.3	22.1	21.1	20.6	20.5	20.9
(WOH)	20.4	22.3	21.4	20.6	20.6	21.0
Hours <18 °C	76 %	61 %	77 %	76 %	73 %	73 %
(WOH)	76 %	62 %	73 %	76 %	71 %	72 %
Homes below 18 °C on average over winter	17 (85 %)	13 (65 %)	17 (85 %)	17 (85 %)	17 (85 %)	81 %

significant ($p = 0.051$). On average, homes were cold for 73 % of wintertime occupied hours. All 100 homes sampled recorded temperatures below 18 °C at some point over winter. Data were analysed for all hours, occupied hours only and occupied waking hours only (6 AM to 11 PM, as per Manousakis [36]). Data presented in Table 2 are for occupied hours and waking occupied hours. There was no significant difference in indoor temperatures between these three occupancy scenarios.

Overall, the analysis finds that most homes sampled were cold (<18 °C) for most of the winter period (Fig. 1). This is in stark contrast, for example, to homes studied in Finland, a cold climate country, where indoor winter temperatures were typically between 20 °C and 24 °C [37] and Greenland where they averaged 21.8 °C [38], both countries renowned for their energy efficient homes. By comparison, the UK is notable for having the coldest homes in Europe, a study of 750 homes showed that the lowest mean monthly temperatures, occurring in February, were 18.5 °C [39]. Across the Australian sample represented in this study, winter indoor temperatures averaged just 16.5 °C. This aligns with a recent study of social housing in Australia [40], where 70 % of occupants reported their homes to be very cold or quite cold during cold weather periods and 30 % considered energy unaffordable. In Sansom et al. [40], spring-time indoor temperatures, for waking-hours only, were below 18 °C for 29 % of the time. Importantly, this early data casts doubt on the current, very low estimates of cold homes in Australia.

Our observation of thermal conditions in Australian homes indicate that the proxy estimates currently used in modelling the prevalence and impacts of wintertime cold are unlikely to reflect the true extent of the problem. Our data indicate that this percentage could be significantly higher. Previous small-scale studies of objective temperature in Australian homes have also suggested that 'cold homes' are more prevalent than indicated by available proxy data. Small scale studies conducted in Adelaide (2017 [1] and 2018 [41]) and Melbourne (2018 [42]), totalling 61 households, reported that 50 % and 76 % of homes were below 18 °C on average over winter.

If Australians have colder homes, in general, than elsewhere in the world, this raises the question as to whether this puts them at greater risk, or whether some level of local adaptation to cold indoor conditions is possible. Hitchings [43] notes that many Australians 'ignore' winter, believing it to be short lived and 'pleasant' compared to other parts of the world. This Australian attitude of winter stoicism – also observed among New Zealand households - has led to the construction of homes that give little consideration to winter conditions [5,43], as well as the tendency to underheat homes. In a recent survey of Australian social housing tenants [40], respondents typically only heated one room of the house; only heating bedroom or bathroom areas immediately before use. The same survey detailed other responses to cold including use of clothing and blankets, formal and improvised window coverings; all of which are typically utilised prior to heating; followed by various heating

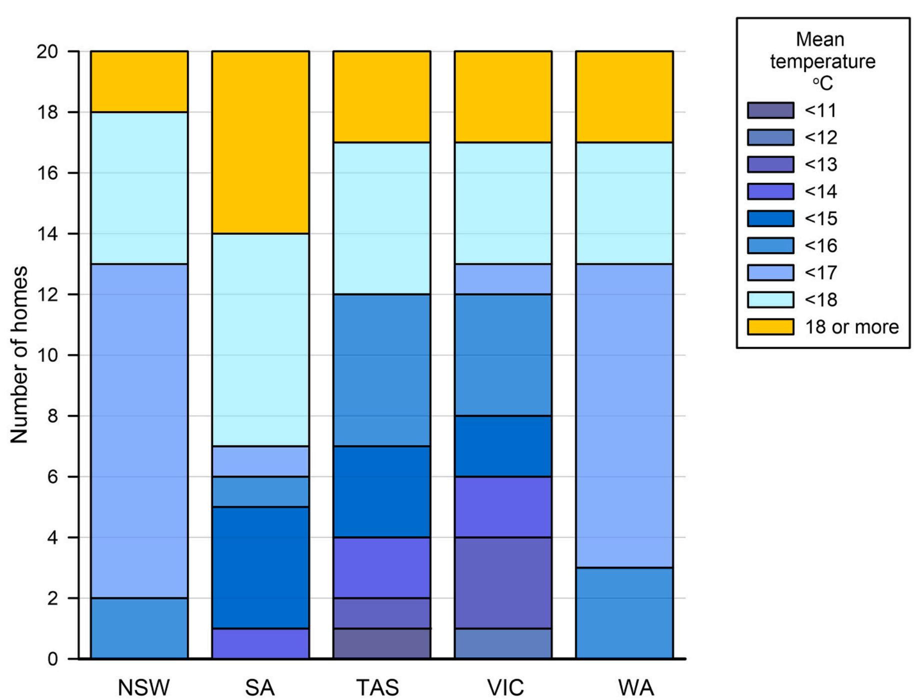

Fig. 1. Mean temperature of each home, June–August 2022, by state.

behaviours [40].

While Australian households have clearly employed a range of means to cope with cold conditions – from acceptance, potential physiological acclimatisation, space heating and adaptive strategies (e.g. clothing, blankets, warm food or beverages), the risk to health from living in conditions below 18 °C remains. This risk is likely to be felt more keenly by individuals with existing health conditions, financial constraints or limited control over their living conditions. For instance, the Australian Bureau of Statistics (ABS) Household Energy Consumption Survey [44] revealed that 30 % of households in the lowest two quintiles experienced energy-related financial stress.

If wintertime cold is a risk factor for adverse health impacts, significant gains in health are possible by addressing wintertime cold in these homes and attaining temperatures of 18 °C [10,12,13,21]. These results also have implications for housing policy, indicating that housing design and conditions in Australia do not provide adequate protection from wintertime cold across the whole community. An analysis of the most affected groups would be beneficial to steer housing policy towards more equitable outcomes for the most vulnerable community members. Obtaining an accurate measure of cold homes is of great importance, considering that complex health modelling, such as Singh et al. [21], health policy and infrastructure planning, depend heavily upon this estimate.

In a period when building codes are being revised, we must take caution in our assumption that homes are currently providing adequate protection from the cold. The data presented here demonstrate a need to better understand this aspect of building performance. Those who own their own homes, and have sufficient means, have more control over their environment and are more able to adapt to cold weather in terms of choice of building materials, design, insulation and heating installation. It must be recognised that while some prefer cooler conditions, for others, particularly those with health or economic vulnerabilities, acceptance of cold indoor conditions is likely to present a very real risk to health and wellbeing.

There is, therefore, a need to consider tenancy legislation and what systems can be put in place to ensure those in both private and government rental properties are protected from the cold. Low-income households may similarly require assistance to effect such changes even in the case of home ownership. We must therefore also think critically about the type of assistance offered to improve energy efficiency and winter warmth, in order to make these programs accessible to those who most need them. This will include appropriate social welfare as well as informed health services that are able to identify individuals most at risk from winter cold.

Variation in wintertime temperatures across homes is affected by factors including building design, building condition, heating affordability and personal preferences [43]. It is therefore necessary to refine our estimate of cold homes in Australia, and other 'warm climate' countries, to study physical temperature across a larger number of homes, of different design, in different locations and socio-economic circumstances.

4. Conclusion

According to the WHO recommendation of 18 °C minimum indoor temperature in winter, 81 of the 100 sampled homes, in Australian temperate climates, were 'cold'. This figure significantly exceeds current estimates for wintertime cold in Australian homes. These data are supported by other small Australian studies, cited above, which also indicate a higher estimate for 'cold homes'. While this is early data from a larger environmental monitoring project, the findings are arresting. While it is not the aim of this present paper to make definitive claims, the findings very clearly indicate the need for greater consideration of the potentially harmful environmental conditions occurring with Australian homes. These studies should be combined with an analysis of cold-related health outcomes to determine those most at risk from cold and hence the most appropriate policy response.

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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.

Data availability

Data will be made available on request.

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