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Understanding the changing thermal comfort requirements and preferences of older Australians

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Abstract: Australia is faced with the challenge of housing and caring for an increasingly ageing population. As the human body ages its sensitivity to changes in the thermal environment diminishes. This paper discusses a recent survey of older people living in Adelaide, South Australia, about the conditions of their living environment, their general health conditions and the ways in which they operate their houses. Selected dwellings are being monitored to record indoor temperatures and humidity while a long term thermal comfort survey of the occupants is being conducted. This paper will discuss preliminary results of this thermal comfort survey for the summer period. The results found that in general the selected occupants perceived their dwellings to be thermally acceptable; however there are some potentially hazardous trends around the use (or not) of heating and cooling. Overall, the thermal comfort surveys in conjunction with the temperature and humidity data indicate a preference among older people for cooler temperatures than typically considered comfortable by the healthy adult population. Balancing these preferences for both temperature and mechanical heating and cooling usage is vital for creating an environment for health and comfort in later life.

Keywords: Thermal comfort; health; ageing population.

1. Introduction

As Australia's population ages, a number of challenges must be overcome to ensure a healthy later life for a large proportion of the population. One of these challenges is that of housing; having enough housing that meets the needs and wants of older people and provides a healthy environment as they age.

As the body ages, changes in the way that it adapts to different thermal conditions begin to appear. Studies into the thermoregulatory responses of older people have shown that sweating starts at higher temperatures than in younger adults, while shivering starts at colder temperatures than in younger adults (Anderson *et al.*, 1996). Both of these responses are also less vigorous than might be expected in younger people. Older people feel the cold more slowly than healthy adults – i.e., it must be a colder temperature before they will report feeling 'cold' than in younger test subjects (Yochihara *et al.*, 1993)

The result of this is a reduced capacity to maintain a healthy body temperature in both hot and cold conditions, potentially leading to hypo- or hyperthermia and associated health problems. Trends toward increased morbidity and mortality amongst older people during periods of hot and cold weather are well established and continue despite public health campaigns aimed at alerting older people to the health risks associated with extremes in weather (reference).

The effect of housing on the health and wellbeing of its occupants is well documented (Evans *et al.*, 2003; Howden-Chapman, 2004; Lawrence, 2004). This effect is multifaceted, and determinants can include physical factors such as cool temperatures, damp and lack of ventilation (Martin *et al.*, 1987; Williamson *et al.*, 1997). Extremes in both heat and cold have led to increases in hospital admissions and mortality of the elderly. Cold and damp conditions lead to exacerbation of respiratory diseases such as asthma (Williamson *et al.*, 1997), and extreme heat can cause renal and cardiovascular problems (Hansen *et al.*, 2008; Nitschke *et al.*, 2011). The degree to which occupants' experience these conditions as opposed to how the conditions themselves affect health is also of interest to researchers. As the perception of temperature and the physiological response to it change with age it is possible that an older person may perceive an environment to be thermally comfortable when in fact it may pose threats to their health. Whilst there are clear correlations between hospital admissions and external temperature and climate conditions, there has been little research on the indoor environment of the dwellings of the elderly, particularly on the effect of the occupants' perceptions of this environment on their health. In the home environment, thermal comfort models (eg ASHRAE, 2013) have been developed to predict the range of conditions most comfortable for occupants, both in air-conditioned and naturally-ventilated modes. Whilst these models have been used to determine the thermal comfort and occupant satisfaction levels of several cohorts, information about how those aged over 65 experience their thermal environment is scarce and whether these models are applicable to this cohort is still questionable.

Through cooperation between architecture and public health researchers, the research aims to examine the relationship between the thermal environment of homes of older people, their thermal comfort perceptions and their health. This paper presents the preliminary results of the study, conducted in Adelaide, South Australia, amongst independently living people aged over 65. The paper will discuss the general opinions of the respondents regarding their housing and health, as well as some detailed thermal comfort data from a small cohort participating in a thermal comfort survey.

2. Background

Whilst older people are particularly susceptible to extremes in heat and cold, there is little known about their experiences of their thermal environment, and indeed there is some controversy in the available research regarding the effect of age on perceptions of thermal comfort. A number of studies have shown that older people in general prefer a lower temperature than would be predicted by the PMD/PPV model of thermal comfort (Collins and Hoinville, 1980; Tsuzuki and Iwata, 2002), which contradicts expectations of a preference for warmer temperatures in those with lower activity levels. Another study found that older adults prefer a temperature within the PMV comfort range (Turnquist and Volmer, 1980). The general conclusion drawn by van Hoof and Hensen (2006) is that older people tend to perceive thermal comfort differently from the young, due to a combination of behavioural factors such as clothing and activity level, and physical factors due to the ageing process. What is not yet clear from the research is what effects this altered perception of thermal comfort has on health. For

instance, an older person may not perceive the environment as being too hot, but the conditions may be hotter or more humid than is healthy for them.

There is however, evidence that the outdoor temperature is connected to health, especially in older people. A number of studies have shown increased health problems during periods of extreme heat and cold, including an increase in hospitalisations, ambulance call outs, and emergency department visits during heatwaves (Mayner *et al.*, 2010; Hansen *et al.*, 2011; Toloo *et al.*, 2014). There is also research that indicates cold weather is likely to increase the risk of falls in older people, especially older women (Lindemann *et al.*, 2014). This is of particular concern for older people who live alone, as 50% of older people are unable to get up after a fall without assistance, and thus these falls can be a cause of accidental hypothermia as well as other serious ongoing health problems(Voermans *et al.*, 2007).

There is very little research available on links between thermal comfort and health, particularly of the elderly. A report produced by the World Health Organisation (WHO) (Goromosov, 1968) concluded that the human body could only compensate for external temperature in a narrow range, given as between 15 and 25 degrees Celsius, with minimal energy expenditure. A further WHO study (WHO Working Group, 1982) showed minimal risk to health of sedentary people, such as the elderly, when housing was kept at a temperature of between 18 and 24 degrees Celsius. Whilst it is an important aspect of thermal comfort, there are other factors that determine whether a person finds their indoor thermal environment comfortable. There have been studies into some of these factors individually, such as humidity and ventilation, but there is little research on all factors collectively, their link to occupant satisfaction, and health.

3. Methodology

This study has been carried out in two stages – a questionnaire and a field study. In the first stage, people in the target age group of 65+ years living independently in Adelaide, South Australia, were asked to complete a survey about their housing and health. Participants for this survey were recruited by contacting targeted local government Home and Community Care (HACC) centres, local church groups, and University of the Third Age chapters. A 'hot desk' set up was also utilized in the local government community centres who assisted in survey distribution to assist those who might have questions about the survey or struggle with the length of the questionnaire. This stage was conducted as a paper questionnaire. This survey included questions about house construction and materials, the kind of heating and cooling installed and how this was used, the ability of the occupants to use various passive heating and cooling as well as mechanical systems, and questions about general health as well as specific symptoms during hot and cold weather. These symptoms included headaches, joint pain, dizziness, anxiety, respiratory and circulatory problems and fatigue. General demographic questions such as age, sex, income and country of origin were also included, as well as a request for the approximate yearly gas and electricity expenditure. Areas of the Adelaide metropolitan region identified as having higher vulnerability to heatwaves as determined by the heat related vulnerability index (Loughnan *et al.*, 2013) were targeted for participation.

Participants of the survey were subsequently invited to join the second stage of the study which aimed to investigate the thermal conditions in their homes and possible relationship with their health. This field study involved the installation of unobtrusive indoor data loggers in the participants' living and bed rooms to record air temperature, relative humidity and globe temperature every 15 minutes. Whilst these loggers were installed in the houses the participants were asked to regularly fill out a comfort vote survey based on section 7 of ASHRAE standard 55-2013. This is a short survey including the ASHRAE 7-

point thermal sensation vote, McIntyres's three point preference scale, as well as questions regarding the acceptability of the current conditions, clothing being worn, factors influencing their thermal comfort (for example, doors and windows being open, fans and cooling or heating operating) and the participants activity level immediately prior to completing the survey. In addition, the survey also asked whether the participants experienced heat or cold related symptoms in the 24-hours prior to the time they responded. The answers to these surveys were then matched with the data from the loggers to determine what conditions the participants find thermally comfortable and acceptable. Data were also analysed to investigate the relationship between the thermal condition of the space, the participants' thermal requirements and preferences, and their health condition.

4. General Survey Results

At the time this paper was being prepared, 59 surveys had been completed. The study is continuing and more participants are still being recruited. Out of those who have responded, females made up 74.5% (n=41) of respondents with 25.5% being male (n=14), with 4 respondents failing to indicate their gender. The majority of the respondents were aged between 65 and 80 (n=44), with only a small number (n=14) aged 81 years or older, and one participant failing to indicate their age bracket. Over 70% (n=41) were on either a full or part government pension, which accounts for the modal income being between $20,001 and $40,000. Despite having a slightly lower household income than the median reported by the ABS, household expenditure on electricity and gas was roughly equal to the national household average (Australian Bureau of Statistics, 2012) at approximately $32 per week.

Of the survey respondents, 4 noted not having any cooling installed, whilst all participants had some form of heating in their home. When asked about their heating or cooling use, 33% of respondents reported avoiding using their heating and/or cooling despite feeling uncomfortable. The majority (78%) of these respondents reported either not being able to afford the usage or not wanting to spend money on gas or electricity as their reasons for avoidance. Other reasons given included health concerns and a desire to 'save the environment'. One respondent reported that their air conditioner didn't work.

Most respondents reported only using their heating and cooling in response to their own comfort needs, with 'only when I feel too hot/cold' (45 and 53% of responses respectively) and 'only when it gets hot/cold inside' (29 and 25% of responses respectively) being the top responses. Very few (<5%) used their heating and cooling around the clock to create a constant thermal environment. The modal thermostat temperatures were 23 degrees in summer and 22 degrees in winter. Use of heating or cooling in the evenings before bed was also quite common, especially in the winter months with a third of respondents reporting this practice. Despite the pattern of mechanical heating and cooling usage, a majority of respondents reported their houses were 'always' or 'mostly' comfortable during both winter and summer.

5. Preliminary field study results

5.1. Participants and their houses

Of the 59 survey respondents, 23 were interested in joining the field study. Of these, 11 have had loggers installed in their homes so far but only six of these households have data reported in this paper due to the timing of installation and subsequent collection of data. The households represented in this paper include five two-person households and two single person households. Despite the option for two members to complete comfort votes, in these six households so far all votes have been completed by

one participant only, with four females and two males completing comfort votes. All participants reported either 'good' or 'very good' health, although all respondents reported being on medications for chronic health conditions.

All participants lived in detached houses of either double brick (n=5) or brick veneer (n=1) type construction. All were long term residents with length of residence ranging from 13 – 48 years. All houses had some form of mechanical cooling and heating installed; however, three of those reported avoiding cooler use at least occasionally. Of the six houses, three had insulation in the ceiling and walls, two had insulation in the ceiling only and 1 had no insulation. All had external and internal window treatments on at least some windows. Five of the houses had ceiling fans installed in the main bedroom and the living area, with two houses having additional ceiling fans in the kitchen and other bedrooms. All houses had at least some windows which were able to be opened.

The monitoring period reported in this paper was 09/02/2015 – 25/05/2015. This encompassed both hot summer weather and some unseasonably cool autumn weather. Participants' houses were on average 2 degrees warmer than the average daily outside air temperature. On the hottest day during the logging period (average outside temperature of 34 degrees, maximum temperature of 41.6 degrees, low of 26.5 degrees) the houses were on average 7.1 degrees cooler than the average outdoor temperature, and on the coldest day (average outside temperature 10.3 degrees, low of 4.8 degrees, high of 15.7 degrees) on average the houses were 5.3 degrees warmer than outside air temperature. At their coolest period, the houses were 5 degrees cooler, and at their warmest 6.5 degrees warmer than the outdoor temperature.

5.2. Thermal Comfort Votes

A total of 452 thermal comfort votes were received from the six participants from whom data was collected. Of these votes, 40% were completed at conditions the participants felt were 'just right' (neutral vote of 4 out of 7-point scale), with an additional 37% occurring during conditions considered 'slightly warm' or 'slightly cool', 17% when conditions were 'cool', 5% when 'cold', and less than 1% each at 'warm' and 'hot'. Average thermal sensation vote (TSV) was found to increase with indoor temperature. Figure 1 shows the average thermal sensation vote for every 1 ^{o}C indoor temperature interval. Using the linear regression equation of TSV = 0.1897 Ti + 0.5287, an average neutral temperature would be reached at 23.9 degrees.

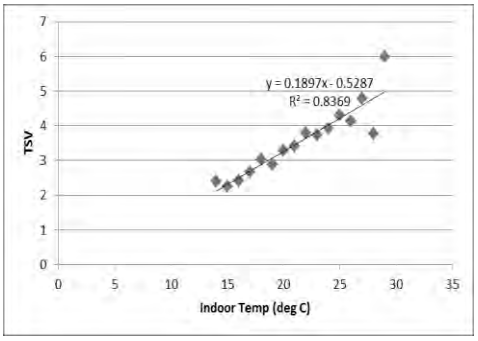

Figure 1: Average thermal sensation votes (TSV) compared with indoor temperature.

At the extremes of thermal sensation vote, some interesting trends have been observed. When reporting 'warm' or 'hot' conditions, participants were more likely to indicate a preference for change (75% and 100% respectively) than they were when they considered the conditions 'cool' or 'cold' (54 and 59% respectively). Even when voted 'slightly warm' more participants expressed a desire for change (57%) than when reporting feeling 'slightly cool' (24%). This indicates a preference for cooler conditions rather than warmer, and also a greater acceptability of cooler temperatures than warmer temperatures. It is worth noting, however, that there were a greater number of cooler days than warm days during the monitoring period, despite the fact that it was conducted during later part of summer to autumn, and therefore there were fewer thermal comfort votes during which people stated feeling 'warm' or 'hot' (see Figure 2).

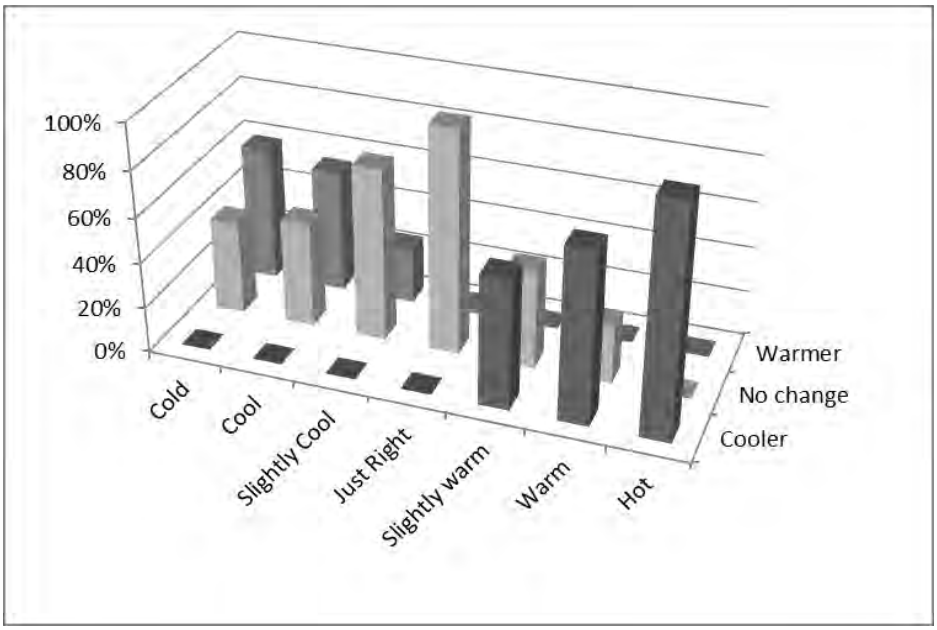

Figure 2: Preference for change during sensations of cold through to hot.

Participants were more likely to operate cooling during hot weather than they were to operate heating during cold weather. The largest percentage of responses who answered that yes, they had heating operating was 44% when the daily average was only 11 degrees. In contrast, at temperatures about 28 degrees and above 50% or more of respondents had cooling operating, with 100% having cooling operating at daily average temperatures of 31 and 33 degrees. This tends to once again indicate that cooler temperatures are more acceptable (therefore not requiring mechanical change) than warmer temperatures for the older people in this cohort.

This preference is confirmed when the thermal comfort vote data is entered into the Adaptive Thermal Comfort model. A larger number (43%) of neutral thermal sensation votes (slightly warm, just right, slightly cool) than expected are clustered below the usual 80% acceptability limits, indicating a preference for cooler conditions. When the 90% acceptability limits are examined, 60% of the votes fall below this line (see Figure 3).

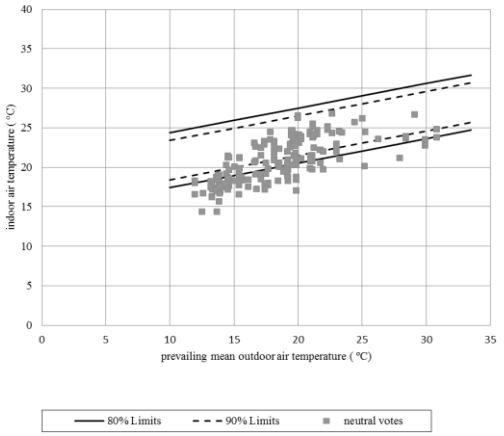

Figure 3: Neutral TSVs of the cohort compared with the acceptability limits of the general population proposed by the adaptive thermal comfort model.

When the indoor air temperatures and prevailing mean outdoor temperature are examined at times when participants indicated no desire for change in their thermal comfort levels, there are once again more votes clustered around the cooler end of the spectrum (42% lower than 80% acceptability, 59% lower than 90% acceptability) than expected (see figure 4).

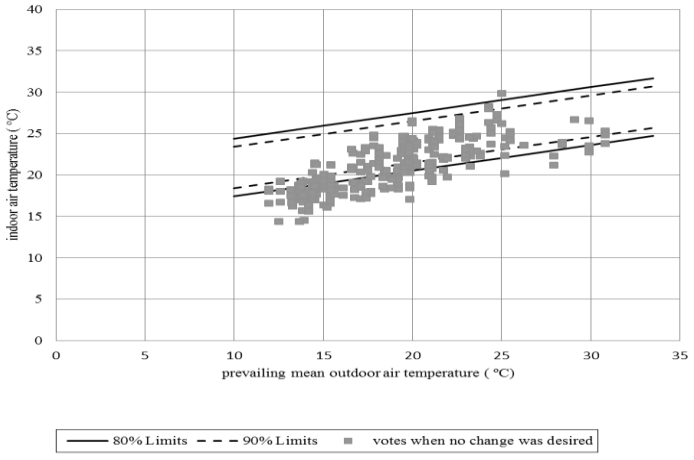

Figure 4: Conditions at which no preference for change was indicated as compared with the adaptive thermal comfort model acceptability limits.

These results exclude votes at the highest activity levels and the lowest and highest clothing ranges, meaning these preferences were not due to increased activity level or heavy clothing. This reduces the effect that adaptive behaviours may have on the results.

6. Discussion

6.1. General Survey

Results from the general survey indicate that the older people in this cohort do not consider their thermal needs as being any different from the general population. Heating and cooling was used in response to their own comfort, rather than in a way that creates a more consistent environment. Whilst this is reasonable for the general population, if there are indeed age-related changes in thermoregulation and temperature sensitivity taking place, this pattern of heating and cooling use may not be appropriate. Whilst many did not shy away from using their heating and cooling, concern must be raised about those who do avoid their usage when they are uncomfortable. This is especially true of those who are concerned about the financial impact of using these devices. Whilst frugality and resilience are common attributes amongst the older population (Hughes et al 2008, Abrahamson et al 2009), with increasing electricity prices there is concern that those with lower incomes may be more at risk during extreme heat and cold.

A further concern is the trend of many older people to keep the thermostat on their heating and cooling at the same temperature year round. For those concerned about the price of electricity, a thermostat set at 22 or 23 degrees in the winter may be having a dramatic impact on their energy usage. Estimates published by the Australian Government suggest every extra degree can impact heating and cooling energy use by 5-10% (Milne *et al.*, 2010). As long as the thermal needs of the older population can be met at lower temperatures, these should be considered, especially by those wishing to reduce their electricity bills.

6.2. Thermal Comfort Field Study

Overall the results from the field study show a trend toward the preferences of older people for cooler temperatures. There are a number of reasons that these older people's preferences may fall outside of expected norms. These include behavioural and attitudinal factors as well as changes in physiology which occur in later life. At this stage, however, any reasoning as to which factors are specifically at play amongst this cohort is pure conjecture, and future research is needed to determine which attitudinal or physiological factors have a greater influence over the preferences and perceptions of thermal comfort amongst older people.

In a recent study (Tod *et al.*, 2012) of attitudes toward cold in older people in the UK, particular values emerged which may be relevant to the results seen in this study. Firstly, amongst some older people, there was an idea that central heating could be detrimental to health. Rooms which were too warm were considered 'bad for you' and led people to live in colder conditions than they might otherwise. Secondly, there was an attitude of resilience and not seeing a need to change behaviours that had been acceptable all their lives. This is quite possibly linked to the well-established fact that people often don't see themselves as being 'old' (Abrahamson *et al.*, 2009) and therefore dissociating from the specific needs that come with age. The results of this thermal comfort study show cooler indoor conditions to be preferred, rather than simply being 'put up with', however the degree to which the two attitudes are related is complicated and warrants further investigation. Whilst attitudes of

resilience and stoicism may influence a person's preference for particular conditions, the possibility of physiological factors being at play cannot be excluded. The participants in this study all but one reported good health, however, the fact that they are of an older age may mean various changes in physiological thermoregulation can occur. A lack of adequate thermal sensitivity in older people may potentially compromise health and wellbeing and may become a public health issue warranting help for older people to understand how best to manage their health in these conditions.

The current methodology does not allow for differences between physiological and attitudinal responses and further investigation is required once more participants have been identified and recruited. Of particular importance is whether the personal preferences of older people for these cooler temperatures are leading to a greater number of health problems for this population. Whilst a question relating to hot and cold symptoms was included in the thermal comfort vote survey in this study, there is so far insufficient data to determine whether a link between thermal comfort and health exists in this cohort. If so, there may be a need for strategies that can be implemented to address the thermal conditions of houses to create healthy indoor environments. Finding the balance between how older people prefer to feel and what is best for their long term health is the difficult but necessary task that is faced when dealing with an increasingly ageing population both now and in the future.

7. Conclusion

Overall, this study finds a high degree of satisfaction with the thermal conditions in their home amongst the older cohort examined. The older people studied accepted and preferred much cooler temperatures than what would be expected in a healthy younger adult population as predicted by the thermal comfort standard such as ASHRAE 55. Whether this has to do with personal behaviours and attitudes or a general change in physiological perception of the cold is not able to be determined in this study at this stage, nor are any potential health impacts of this preference. Ultimately, a balance between the preferences of the older people concerned as well as the relationship between thermal environment and health will need to be struck in order to provide the best housing solutions for older people.

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