PACIFIC RIM PROPERTY RESEARCH JOURNAL
2020, VOL. 26, NO. 1, 1–17
https://doi.org/10.1080/14445921.2019.1707949

Home is where the health is: what indoor environment quality delivers a "healthy" home?

Rochelle Ade and Michael Rehm

Department of Property, University of Auckland Business School, Auckland, New Zealand

ABSTRACT
This study uses critical discourse analysis to review the belief structure surrounding cold and damp housing in New Zealand (NZ) finding that a strong belief structure exists in the NZ psyche that "cold and damp" housing is linked to poor health outcomes. This belief structure has led to recent changes to NZ law to ensure healthy rental housing is provided via the Healthy Homes Guarantee Act. This law utilises a healthy minimum temperature threshold of 18°C as set by the World Health Organisation (WHO). A review of the literature finds limited evidential basis for this minimum temperature threshold, concluding that there is no academic consensus on what indoor environment quality (IEQ) would be required to deliver a healthy home. Until future research fills this knowledge void the current temperature guidelines (18°C to 24°C) could be carefully utilised in conjunction with measures of relative humidity (RH 40% to 60%) and thermal comfort.

ARTICLE HISTORY
Received 14 August 2019
Accepted 19 December 2019

KEYWORDS
Indoor environment quality; temperature; relative humidity; housing

Introduction

It is frequently stated that the quality of housing affects the health of the population, with "cold and damp" homes postulated as a key cause of illness in many publications (Howden-Chapman et al., 2007; Milner & Wilkinson, 2017; Preval, Keall, Telfar-Barnard, Grimes, & Howden-Chapman, 2017; Rangiwhetu, Pierse, Viggers, & Howden-Chapman, 2018; Telfar-Barnard et al., 2017). This claim is so prevalent that it has become an accepted truth that is disseminated in the literature with statements like "The association between living or working in a damp building and health effects such as cough, wheeze, allergies, and asthma is well established" (Sundell, 2004) and in the popular media with attention grabbing titles like "The cost of cold, damp homes is too high" (Watson, 2019), "Mould, sweet mould: inside New Zealand's damp housing crisis" (Donnel, 2018) and "New Zealand homes: Damp, cold and mouldy"(Millar, 2017).

However, a perfect storm can occur in housing research. The contextual "cold and damp" houses tend to be rental houses, rather than owner occupied dwellings (Witten et al., 2017, p. 15) and the tenants of these dwellings are often from lower socio-economic groups (Witten et al., 2017, p. 23) who experience both housing and work insecurity (Chisholm, Howden-Chapman, & Fougere, 2017). This insecurity has been shown to lead to mental stress, which in itself can lead to poor health outcomes and increased illness (Bentley et al.,

CONTACT Rochelle Ade chelleade@yahoo.com

2016; Bills, West, & Hargrove, 2019). Lower socio-economic demographics are also more likely to live in overcrowded residences or participate in bed-sharing, either for cultural or economic reasons (Milne & Kearns, 1999). Overcrowding, regardless of the dwelling it occurs in, can cause illness due to the close proximity of people to each other, and the increased ease of transmission (McNicholas, Lennon, Crampton, & Howden-Chapman, 2000; Tin et al., 2016). Thus, if someone contracts an illness at work, school or day care, it can easily spread to others in the home due to increased contact points. With these confounding factors can we be certain that it "cold and damp" housing that is the problem?

This paper uses critical discourse analysis, based on the empirical methods of Norman Fairclough (Fairclough, 2007, 2013; Wodak & Fairclough, 2013) to evaluate the lore of cold/damp housing and poor health. The paper then conducts a review of the literature to determine if it is possible to set a definition of the required indoor environment quality for a "healthy" home.

The lore of "cold and damp" housing

The discourse on "cold and damp" housing is strong, with a prevalent belief that cold and damp housing begets poor health. This belief structure now forms a part of the everyday psyche of New Zealanders supported by popular media headlines such as "The cost of cold, damp homes is too high" (Watson, 2019) or "Mould, sweet mould: inside New Zealand's damp housing crisis" (Donnel, 2018). The vernacular is so strong that some reporters have drawn parallels between New Zealand Housing and "hell" (MacAndrew, 2018) or claimed that damp, overcrowded homes are a bigger threat to kids than car crashes (Johnston, 2017).

New Zealand (NZ) politicians also subscribe to this belief structure, with then Housing and Urban Development Minister Phil Twyford stating that NZ rental homes are cold, damp and mouldy and cause respiratory illness, toxic reactions, and allergies (New Zealand Parliament Hansard, 2018). This belief structure is so strong that the current Labour government of NZ has enacted a piece of "healthy home" legislation. Called the Residential Tenancies (Healthy Homes Standards) Regulations (2019) its purpose is to ensure that every rental home in New Zealand meets minimum standards of heating, insulation, and ventilation, also addressing issues of moisture ingress and drainage and draught stopping. This legislation aims "to make rental properties warmer and drier" (Twyford, 2019) on the reasoning that this will help improve occupant health.

Minister Twyford stated in the debate for this legislation that "This issue of healthy homes is so important. Otago University's most recent calculation is that New Zealand is hospitalising 50,000 children every year primarily because of cold, damp, and mouldy homes, and the toxic cocktail of poverty and overcrowding in poor quality homes. An estimated 15 children a year are dying needless deaths because of the poor quality of New Zealand housing"(New Zealand Parliament Hansard, 2016).

While it is clear that many believe that "cold and damp" renders a dwelling "unhealthy", what is less clear in this discourse is what constitutes a "healthy" home. Twyford stated in parliament that "the World Health Organization recommends a minimum indoor temperature of 18 degrees" (New Zealand Parliament Hansard, 2019) and this temperature underpins the new Healthy Home Standards. However, what is the basis of this 18°C temperature threshold? And is this minimum temperature all that is required for a “healthy” house?

The world health organisation

In the literature, it is now common to see statements such as “The World Health Organization (WHO) recommends a minimum indoor temperature of 18°C, and below 16°C warns of health implications”(Rangiwhetu et al., 2018) used with no further discussion or investigation on the subject. However, where did this minimum temperature threshold come from?

The WHO recently published a new report titled “Housing and Health Guidelines” (World Health Organization, 2018). This report states (on page xvii of the executive summary) that “For countries with temperate or colder climates, 18°C has been proposed as a safe and well-balanced indoor temperature to protect the health of general populations during cold seasons”.

However, later in the same report, it states that the categorical cut-offpoint at 18°C was chosen based on the conclusions of a previous WHO working group on indoor environment finding that “there is no demonstrable risk to human health of healthy sedentary people living in air temperature of between 18 and 24°C” (World Health Organization [WHO], 2018, p. 46). **BUT** that the evidential basis for this can no longer be traced (Barnard, Howden-Chapman, Clarke, & Ludolph, 2018).

The previous working group is referenced as the 1987 Health Impact of Low Indoor Temperatures report (World Health Organization [WHO], 1987). However, this report states “Although the incidence of the common cold increases in winter, cold winter temperature does not in itself appear to be the cause. Isolated communities in cold climates may be completely free from colds and upper respiratory tract infections for the whole of the winter, but epidemics occur when first contact is made with visitors” (WHO, 1987, p. 10). In addition, this report does not declare a healthy temperature of 18°C; instead, it references a suite of measures which when used in conjunction with temperature actually constitute thermal comfort, stating “indoor temperature of between 18 and 24° when there is **also** an air movement of less than 0.2 m/s, a relative humidity of 50% and a mean radiant temperature within 2°C of air temperature” (WHO, 1987, p. 1).

The 1987 WHO report recommendations are themselves referenced to two earlier WHO publications the first a 1982 report from a working group title “Health aspects related to indoor air quality: Report on a WHO working group” and the second a 1979 expert committee report title “Public Health aspects of housing: First report of the expert committee”. However, both references appear to be erroneous with the “Health aspects related to indoor air quality: Report on a WHO working group report” published in 1979 and the “First report on public health aspects of housing” published in 1961.

The 1961 report states in section 2.5.1 that a healthy residential environment is one in which the occupant is comfortable. This report references three centres of research who suggest comfort can be achieved at (i) 18°C to 22°C with a relative humidity of greater than 30% and an air movement not exceeding 0.1 m/s (France) (ii) 18°C to 22°C (USSR) and (iii) 18°C as the minimum operative temperature for normally vigorous persons wearing normal clothing and rest.

All of these working groups and reports lead back to a 1961 report called Homes for Today and Tomorrow, commonly called the Parker Morris report. This report was commissioned by the Central Housing Advisory Committee UK to consider the standards of design and equipment to family dwellings. Page 57 of this report states that better heating is key to the design of the home whilst page 58 concludes that the minimum installation provision should be capable of heating the areas used for work and circulation to 55°F (13°C) and the living/dining area to 65°F (18°C) when the outside temperature is 30°F (−1°C) (Parker Morris Committee, 1961). This report contains no medical or epidemiological studies and is primarily a design manual for housing.

This conflicting WHO information is further confused by their 2012 review of thermal comfort guidelines that references a 1968 WHO report by Goromosov (titled "The Physiological Basis of Health Standards for Dwellings") who examined the evidence for the human body's powers of thermal regulation, concluding that the human body can only compensate for a relatively small temperature range of 15°C to 25°C. The 2012 WHO report states that it is not clear is why there was a change from 15°C to 25°C temperature range in the WHO documents from the late sixties to a new 18°C to 24°C range in documents published in the eighties; however, the authors of the 2012 report believed that the latter range was supported by evidence and has been generally adopted as the thermal comfort range necessary to protect health (Ormandy & Ezratty, 2012).

It, therefore, appears as though the WHO has experienced substantial confusion in relation to what constitutes a "healthy" IEQ for housing and this had led to conflicting guidelines being published over the years with an initial focus on thermal comfort that was then reduced to a focus solely on temperature.

Literature review

Minimum temperature threshold ("too cold")

In 2018 the WHO published an evidential review that sought to determine if there was any basis for the temperature threshold of 18°C (Barnard et al., 2018) researchers undertaking this review identified six studies that assessed the association between indoor temperature and blood pressure (Table 1) as well as four studies that investigated the effects of indoor cold on respiratory health (Table 2).

However, none of these studies sets a temperature threshold at which ill health effects were determined and the authors of the WHO review limited their conclusions to a "moderate" certainty that warming a cold house (**perhaps** to a minimum indoor temperature of 18°C) would reduce the risk of respiratory and cardiovascular mortality and morbidity.

Another series of frequently quoted temperature thresholds are those by the Marmot Review (Marmot, Geddes, Bloomer, Allen, & Goldblatt, 2011) that state (i) temperatures below 16 degrees appear to impair respiratory functions (ii) temperatures below 12 degrees place strain on the cardiovascular system and (iii) temperatures below 6 degrees place people at risk of hypothermia. These claims appear to be cited to a 1986 study by Collins. However, the Collins study states below 16°C, resistance to respiratory infections **may** be diminished and that at temperatures below 12°C, cold extremities and slight lowering of core temperature **can** induce short term increases in blood pressure. There is no mention of 6°C with the exception of "Significant blood pressure rises were observed

Table 1. Summary of cardiovascular morbidity and mortality studies.

Study	Finding
(Saeki, Keigo, Obayashi, & Kurumatani, 2015; Saeki. et al., 2013)	Higher blood pressure in people living in colder homes (Japan)
(Saeki, Keigo et al., 2015)	For adults over 60 years of age decreases of 1°C in indoor temperatures were significantly associated with increased blood pressure levels (Japan)
(Shiue, & Ivy, 2016; Shiue, & Shiue, 2014)	People in housing heated to less than 18°C had a greater risk of high blood pressure. This risk increased if temperatures were below 16°C (Scotland)
(Bruce, Elford, Wannamethee, & Shaper, 1991)	A decrease in systolic and diastolic blood pressure of 0.5 mmHg per 1°C increase in room temperature (Britain)

Table 2. Summary of Respiratory morbidity and mortality studies.

Study	Finding
(Osman et al., 2008)	Patients with Chronic Obstructive Pulmonary Disease (COPD) had better health status with more hours of indoor temperature at and above 21°C
(Pierse et al., 2013)	Children with asthma had a small but significant increase in lung function every 1°C increase in room temperature above the threshold of 9°C. Bedroom exposure was shown to have stronger association with asthmatic children's lung function than living room exposure
(Mu et al., 2017)	Adults with COPD, reported reduced respiratory problems with an indoor temperature at 18.2°C regardless of whether indoor humidity was low, moderate or high.
(Ross, Collins, & Sanders, 1990)	Children with and without upper respiratory tract infections showed no consistent associations with indoor temperature

in the elderly at temperatures of 6°C, 9°C and 12°C but not at 15°C, suggesting that 15°C would be a minimum level at which the older person should live at home" (Collins, 1986).

The supporting evidence for the highly utilised 18°C minimum temperature threshold (as well as the other referenced temperatures) therefore appears to be minimal with no studies demonstrating a clear link to adverse health effects below this temperature. One highly cited (431 at last count) insulation retrofit study by Howden-Chapman et al. (2007) documented an increase in mean temperature from 13.6°C to 14.2°C. Even though the improvement is well below the stated 18°C minimum threshold for occupant health the study documented significant improvements in self-rated health, wheezing and absenteeism from school and work. Howden Chapman postulates that the improvement in health outcomes may not be due to maintaining higher average temperatures, but instead to reduced exposure to very low temperatures.

Maximum temperature threshold ("too hot")

Heat is a natural hazard and high temperatures have the potential to compromise the human body's ability to maintain thermoregulation and consequently and thus can adversely affect health (Head et al., 2018). A recent review of the literature by the WHO (Head et al., 2018) rather surprisingly determined that no evidence was found which related indoor temperature to health outcomes in older people or to infants and children. They did find a body of evidence that identified that people over 65 years, particularly those living in nursing and care homes, as particularly vulnerable during a heat wave (Dhainaut, Claessens, Ginsburg, & Riou, 2003; Hajat, O'Connor, & Kosatsky, 2010; Klenk, Becker, & Rapp, 2010). Although these studies were based on outdoor temperatures, Head *et al.* state that it seems likely that many of the participants will have spent a lot of their time indoors and will, therefore, have been exposed to high indoor temperatures.

Other research, not covered in the recent WHO evidential review by Head *et al.*, also determines that very young children and the elderly, are particularly vulnerable to heat-related deaths (McGeehin & Mirabelli, 2001; Xu et al., 2012; Zivin & Shrader, 2016) with sudden infant death syndrome linked to high heat (Stanton, Scott, & Downham, 1980). For children, the mortality rate (from exposure to extreme heat) is estimated to be 50 to 100 percent higher than for adults (Sherbakov, Malig, Guirguis, Gershunov, & Basu, 2018).

High temperatures do not only affect infant and elderly mortality rates, but they have also been linked to increased hospital admissions and diseases. Xu et al. (2012) determined that the incidences of hand, foot and mouth disease, renal disease, fever and electrolyte imbalance among children increased significantly for high outdoor temperatures. These findings have been echoed in California where higher outdoor temperatures have been linked to increased hospital admissions for acute renal failure, appendicitis, dehydration, ischemic stroke, mental health, non-infectious enteritis, and primary diabetes (2018). Whilst in New South Wales, Australia, Lam found that high outdoor temperatures were positively and significantly associated with emergency presentations for gastroenteritis among children younger than six years old (Lam, 2007).

However, while high outdoors temperatures are linked in the literature to adverse health outcomes there is no definitive research that documents support the WHO "healthy" threshold of 24°C. The authors of the recent WHO report (Head et al., 2018) specifically highlighted the need for more longitudinal studies on the impact of indoor heat and health and concluded that given the current literature, they did not consider it to be feasible to define indoor thresholds on a widespread or national basis.

This finding is supported by a recent review of the literature by Kenny, Flouris, Yagouti, and Notley (2019) who found no studies that systematically validate the WHO upper-temperature threshold of 24°C for different heat-vulnerable groups (i.e. children, older adults, individuals with chronic health conditions, people living at home alone, and deprived individuals). In fact, they concluded that there has been little in the way of strong scientific evidence to support the WHO recommendations, also attributing the origin of these guidelines to the 1968 Gorsomov authored WHO Public Health Report titled "The Physiological Basis of Health Standards for Dwellings".

Therefore, while the WHO temperature range of 18°C to 24°C for dwellings is frequently referred to and acknowledged as the range with which health is optimally protected, there is little evidential support for this guideline.

Damp

Adverse health effects associated with building dampness and other moisture problems have been reported for over 2000 years ago. In the days of the Israelites, buildings that were affected by dampness were classified as "contaminated houses", and such buildings were not fit to be hospitable (Leviticus 14: 33–48). However, as noted by prominent researcher Howden Chapman "it is not possible to define a damp building in health relevant terms, or to specify which agents in damp buildings have detrimental effects on health" (Howden-Chapman et al., 2007).

Different types of dampness can be found in homes, such as condensation on window panes or visible mould growth, and researchers use a variety of mechanisms to assess dampness in buildings. This can range from independent dampness assessments from industry professionals such as building surveyors or self-reported measures of dampness from building occupants. Regardless of who is asked to report the dampness consistent measures are utilised across the literature, these being:

(1) Visible mould
(2) Damp spots
(3) A stale odour
(4) Wetness or flooding under foundations or crawl spaces

The WHO (World Health Organization, 2018, p. 40) states that dampness or mould is associated with a range of adverse health effects, including asthma, respiratory infections and symptoms, dyspnoea, hypersensitivity pneumonitis and allergic alveolitis, referencing this statement to a literature review by Mendell, Mirer, Cheung, Tong, and Douwes (2011). However, Mendell *et al.* note that whilst it is plausible that microbial exposures may play a causal role in health, the evidence reviewed also suggested that moderate exposures to certain microbial agents (especially at early ages) may help prevent allergies and allergic asthma.

Table 3 summarises that some of the studies identified that specifically research and link "damp" housing with adverse health outcomes. None of these studies determines a threshold of dampness exposure that causes ill health, which is in line with the WHO report (2018) that concludes relationships between dampness, microbial exposure and health effects cannot be quantified precisely, so no quantitative health-based guideline values or thresholds can be recommended for acceptable levels of contamination with micro-organisms. Instead, they recommend that dampness and mould-related problems be prevented.

Dampness is also frequently linked to humidity in the literature with research papers titled "Damp housing and childhood asthma; respiratory effects of indoor air temperature and relative humidity"(Strachan & Sanders, 1989) or statements like "Damp or humid indoor air encourages mould growth" common (Agyekum, Salgin, & Danso, 2017).

As the WHO (2018) notes human health is not affected by humidity levels per se, instead health effects relating to humidity are primarily caused by the growth and spread of biotic agents under different humidities.

Humidity

Humidity is linked with anomalous mortality and morbidity levels through various mechanisms. Humidity can directly affect humans and their ability to self-regulate temperature, especially in extreme conditions (Davis, McGregor, & Enfield, 2016). In addition, levels of humidity or "damp" can cause growth and spread of biotic agents (Baughman & Arens, 1996).

For humidity, there are three different terms of reference. Absolute humidity (AH) is the measure of water vapour (moisture) in the air, regardless of temperature and is expressed as grams of moisture per cubic meter of air (g/m^3). Relative humidity (RH) also measures water vapour, but relative to the temperature of the air. RH is therefore expressed as the amount of water vapour in the air as a percentage of the total amount that could be held at its current temperature. Finally, specific humidity refers to the weight of water vapour

Table 3. Summary of damp housing studies.

Study	Findings
(Venn et al., 2003)	Indoor damp increased both the risk and severity of childhood wheezing illness
(Kilpelainen, Terho, Helenius, & Koskenvuo, 2001)	Positive association between home dampness (mould/damp/water stains in 15% of homes) for first year university students and current asthma, allergic rhinitis, and atopic dermatitis as well as common colds (Finland)
(Koskinen, Husman, Meklin, & Nevalainen, 1999)	Exposure to moisture was significantly associated with sinusitis, acute bronchitis, nocturnal cough, nocturnal dyspnoea and sore throat, and the exposed inhabitants had significantly more episodes of common cold and tonsillitis in adults. Exposure to mould was significantly associated with common cold, cough without phlegm, nocturnal cough, sore throat, rhinitis, fatigue and difficulties in concentration in adults. (Finland)
(Platt, Martin, Hunt, & Lewis, 1989)	Damp and mouldy living conditions had an adverse effect on symptomatic health, particularly among children. Children living in damp and mouldy dwellings had a greater prevalence of respiratory symptoms (wheeze, sore throat, runny nose) and headaches and fever compared with those living in dry. Adult respondents living in damp and mouldy dwellings were more likely to report nausea, vomiting, constipation, blocked nose, breathlessness, backache, aching joints, fainting, and bad nerves than respondents living in dry dwellings.
(Strachan & Sanders, 1989)	In a questionnaire survey of a random sample of 1000 children aged 7 years, a significantly greater proportion of those living in homes reported as damp were affected by wheeze, day cough, night cough, and chesty colds. However no correlation was found between RH and the same health effects. The authors noted that whilst the results ran counter to the widely held belief that indoor temperature and humidity are important determinants of respiratory ill health, they do not directly exclude effects due to mites or moulds, whose survival is determined by the humidity of their respective microenvironments.

contained in a unit weight (amount) of air, expressed as grams of water vapour per kilogram of air (g/kg). Absolute and specific humidity are similar in concept and application.

Relative humidity

In the context of RH, a frequently cited literature review is that of Sterling (1985). This study resulted in the oft-used Sterling Chart (Figure 1) that graphically recommends a range of 40% to 60% RH.

The WHO states that at air temperatures below 16°C, RH > 65% can impose hazards to human health, particularly from respiratory and arthritic diseases and allergic reactions to moulds, fungi, house dust mites and allergens from domestic animals (World Health Organisation, 1991, p. 17). It is therefore important to understand how these items, and thus human health can be affected by different humidity levels.

Mould

Though moulds are non-communicable, the spores of some species, in high concentrations can be toxic to humans. Mould fungal spores, mainly from genera penicillium, Cladosporium, aspergillus and alternaria found in dwellings have been associated with diseases such as alveolitis, aspergillosis, bronchitis, toxic pneumonitis, rhinoconjunctivitis, cancer, chronic fatigue syndrome, asthma, bronchitis, gastro-intestinal ailments, depression, Crohns disease and multiple sclerosis (Howieson, 2017). Mould growth occurs at the confluence of humidity, temperature and the availability of nutrients, with the availability of moisture normally the critical factor determining whether mould will grow in a dwelling. Moulds extract moisture from the substrate they are growing on which in turn extracts moisture from the surrounding air. Mould can grow on hygroscopic materials such as wood and leather at a relative humidity as low as 70% and a relative humidity of above 70% is

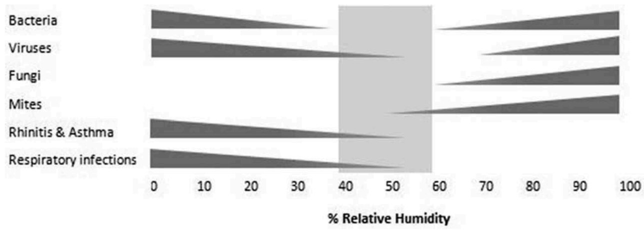

Figure 1. Sterling chart.

quoted (BSI, 1989) as the critical condition for mould growth. For common wall coverings such as painted plaster or wallpaper the critical surface relative humidity for mould growth is 80% and if this RH is maintained for a period of several weeks then mould will grow. However, conditions within dwellings are rarely stable with RH varying constantly. In addition, micro-climates frequently occur in buildings creating situations where average room conditions are below the critical levels when mould should flourish but where there are specific microenvironments (such as junctions between walls/floors and aluminium window joinery) where moulds can and do thrive (Cunningham, 1999; Oreszczyn & Pretlove, 2000).

Dust mites

Humid indoor environments also enable the development of mites, especially house dust mites (HDM), which are a trigger for asthma. HDM are microscopic, spiderlike insects of the arachnid family which feed on dead skin that sloughs from the human body. Dust mites absorb water from the air to survive and require a humid indoor environment with humidity levels ranging between 50% and 75% RH as well as an ideal indoor temperature ranging between 15°C and 30°C (Cunningham, 1999; 1998).

Respiratory illness, bacteria & virus

The WHO state that the role of RH is not clear in relation to respiratory illness (WHO, 2018, p. 18). This is also shown by Shorter et al. (2018) who also found no association between indoor climate (average temperature, relative humidity, absolute humidity, dew point, or building moisture content) and new-onset wheezing in children.

However, humidity levels greatly affect the survival rates of bacteria and viruses. Airborne legionella are capable of surviving over greater distances when the relative humidity is 65% or greater whilst low RH conditions favour survival and transmission for some influenza virus, which also includes viruses like RS virus, human rhinovirus, and avian influenza virus (Ikäheimo et al., 2016). However, there is a long-standing dispute about indoor air humidity and associated health effects (Wolkoff, 2018)

One reason for this dispute is the challenge of relating AH, RH and temperature to each other and health outcomes. As RH varies as a function of both water vapour content (AH) and air temperature, it can be challenging to make inferences about how either relates to the dependent variable. RH also varies diurnally and seasonally, and the use of mean RH does not necessarily represent the average moisture content of the air since temperature diurnality and seasonality are also variable. Debry *et al.* believe that these complexities may account for some of the contradictions in the existing epidemiological literature regarding how RH influences health outcomes (Derby & Pasch, 2017). Other researchers find the common use of RH in most climate and health studies troubling given the confounding influence of temperature (Davis et al., 2016).

Over the past decade, there has been an increasing trend to apply AH rather than RH as a parameter for comparison and identification of health associations. Shaman *et al.* were amongst the first to show that the survival and transmission potential of influenza viruses are inversely associated with AH (and not RH) in wintertime (Shaman & Kohn, 2009) with others confirming a link between low AH and virus transmission (Barreca & Shimshack, 2012; Koep et al., 2013; Shaman, Pitzer, Viboud, Grenfell, & Lipsitch, 2010; Wiemken et al., 2017). However, these findings have been recently challenged by Prussin et al. (2018) who note that it is challenging to disentangle AH, RH and temperature and discuss one measure in isolation and find that RH was the most important factor in controlling virus infectivity in droplets.

In terms of AH, only two thresholds are established in the literature. The first is a threshold of 7 g/kg at which dust mites will proliferate (Korsgaard, 1998) whilst the second is a recommendation by the European Standard CEN/TC 156 that absolute humidity stays below a threshold value of 12 g/kg (Comite'Europe'en de Normalisation, 2007, p. 38).

Policy

The Healthy Homes Guarantee Act's purpose is to ensure that every rental home in New Zealand meets minimum standards of heating, insulation, and ventilation "to make rental properties warmer and drier" (Twyford, 2019) on the reasoning that this will help improve occupant health. A minimum temperature threshold of 18°C has been set with a fixed heating source to be provided in the living room of rental housing, capable of heating that room to that temperature. The NZ government provided a calculator associated with this legislation typically sizes this heating source as a heat pump. This presents two problems. Firstly social housing tenants have a documented tendency to suffer fuel poverty, making it likely that these tenants are relying on the home's thermal envelope to regulate the indoor environment. If this thermal envelope fails to deliver climate-appropriate mitigation then these tenants, even if provided with an active heating device, may not be able to afford its operation.

Secondly, heat pumps are space conditioning devices that are capable of both active heating *and* cooling. Recently researchers have begun to focus attention on the potential for highly insulated thermal envelopes to overheat (Gupta & Kapsali, 2016; McLeod, Hopfe, & Kwan, 2013; Mitchell & Natarajan, 2019; Sameni, Gaterell, Montazami, & Ahmed, 2015; Toledo, Cropper, & Wright, 2016). The retrofitting of existing dwellings with insulation, combined with space heating devices that are also capable of active cooling, may provide significant unintended consequences.

The use of a heat pump to provide cooling during the summer months increases energy use and electricity demand at the worst possible time (i.e. during the hot summer months when levels in hydro-electric dams are low) thus requiring the use of coal and gas electrical plants to satisfy such "peak" demand. A significant irony thus results with the NZ government proclaiming sustainability goals in the form of legislation, such as the Climate Change Response (Zero Carbon) Amendment Bill (2019) and the Building Act

2004 plus aspirational goals of the Energy Efficiency and Conservation Authority (EECA) (see Burgess, 2011) but undermining these goals with legislation that requires the installation of heat pumps. The irony thickens when refrigerant leakage from air source heat pumps is considered. Research by Johnson (2011) concludes that when operational and end of life refrigerant leakage is considered in the context of life cycle analysis, the carbon footprint of heat pumps worsens such that it becomes an analogous performer to gaseous fuels.

The use and stipulation by the NZ government of the WHO (unsupported) 18°C minimum temperature threshold, therefore, appears to be driving the market towards unsustainable outcomes, which if fully implemented could worsen housing's environmental footprint, whilst not providing any demonstrable benefit to the occupants.

Conclusions

The discourse analysis indicates that a strong belief structure on "cold and damp" housing has pervaded the psyche of the NZ, culminating in government legalisation predicated on the ability of a dwelling to achieve a minimum temperature of 18°C at all times in the living room. This government legislation is promoted as delivering warmer, drier, and thus healthier, rental properties. However, it is not clear how a "healthy" home is defined in terms of IEQ.

In 2007 Bonnefoy declaimed that there was no commonly agreed upon definition of "healthy housing", that there were major gaps in the knowledge on how housing conditions may affect health, and limited knowledge on which mitigation strategies may show the best results (Bonnefoy, 2007). This situation has not changed demonstrably with this review of the available literature finding a sparsity of research that connects "cold and damp" housing with occupant ill health.

Many confounding factors occur in housing research. There is a documented tendency for cold and damp houses to be rental houses. Tenants of rental dwellings also often experience both housing and work insecurity which can lead to mental stress and poor health outcomes. Rental housing is also more likely to be overcrowded which can cause illness due to the close proximity of people to each other, and the increased ease of transmission for illnesses contracted elsewhere, i.e. work, school or day care. Few studies attempt to concurrently review day time and night time abodes. How then can it be determined that it is a "cold and damp" house that is causing illness when perhaps it could be a "cold and damp" school or workplace? Furthermore, if a house is overcrowded it could be the use of the dwelling rather than the structure of the dwelling that is causing poor health outcomes.

This review of the literature has determined that there is currently no academic consensus on what IEQ will provide healthy housing. The 18°C to 24°C temperature range is not strongly supported by research, with the WHO itself stating there is only a moderate linkage between a minimum temperature of 18°C and improved health outcomes. At best the existing literature demonstrates a connection between extremely low and high indoor temperatures in homes and increased rates of illness, with children and the elderly particularly vulnerable. No guidance is provided by the WHO around dampness or humidity other than a recommendation that dampness and mould-related problems be prevented. However, the literature indicates that an RH range of 40% to 60% will mitigate the proliferation of most biotic and non-biotic agents that cause poor health.

Despite this knowledge void local and regional governments, as well as green building councils, have issued legislation and green building rating tools that aim and claim to deliver "healthy housing". The issuance of WHO guidelines using a temperature range that is not strongly supported by health research has resulted in legislation that requires the provision of fixed heating devices, encouraging people to use these to heat their living rooms to an 18°C temperature. The very people targeted to use these heating devices are renters who frequently experience fuel poverty. The strong discourse provided to this vulnerable sector of society is that if they do not heat their dwellings to 18°C they and their children will suffer from poor health. Not being able to afford to operate these heating devices may lead to additional mental stress and anguish, itself resulting in poor health outcomes. However, it is possible that the minimum temperature threshold for improved health may, in fact, be lower than 18°C. It might even be that thermal comfort is more important than raw temperatures and that RH and air exchange rates need to be considered.

The current specific focus on minimum temperature thresholds is concerning as in a world that is warming due to climate change is it "cold and damp" or "hot and humid" that poses the greater risk to human health?

In the absence of academic consensus the WHO guidelines of a temperature range of 18°C to 24°C could potentially be carefully utilised (in conjunction with the 40% to 60% RH identified in the literature); however, an immediate priority should be the call to action made by the WHO itself for more studies that interrogate the specifics causes of poor health in housing. In particular, the identification of a minimum interior temperature threshold should be made an immediate priority as Howden Chapman (2007) showed that improved health can be achieved a much lower temperature than 18°C.

The NZ government should pay particular attention to the findings of this analysis. The aims of the Healthy Home Standards are laudable; however, their myopic viewpoint on cold and damp ignores other, equally important issues such as overheating and carbon footprints of heating sources. The use of a temperature threshold (18°C) that is not supported by academic evidence of improved health outcomes has driven a legislative requirement for the installation of heat pumps throughout nearly all rental housing in NZ. These heat pumps have a significant life cycle carbon footprint and bring the Healthy Home Standards into direct conflict with the new Climate Change Response (Zero Carbon) Amendment Bill.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This study was supported by funding from the Building Research Levy Building Research Association of New Zealand (BRANZ) [LG0644].

ORCID

Rochelle Ade http://orcid.org/0000-0002-5894-1941
Michael Rehm http://orcid.org/0000-0002-9800-6405

References

Agyekum, K., Salgin, B., & Danso, A. (2017). The health impacts of damp housing conditions: Lessons for inhabitants living in damp tropical buildings. Paper presented at the International conference on infrastructure development in Africa, Kumasi, Ghana.

Barnard, L. T., Howden-Chapman, P., Clarke, M., & Ludolph, R., & World Health Organization. (2018). *WHO housing and health guidelines: Web Annex B: Report of the systematic review on the effect of indoor cold on health.*

Barreca, A. I., & Shimshack, J. P. (2012). Absolute humidity, temperature, and influenza mortality: 30 years of county-level evidence from the united states. *American Journal of Epidemiology*, *176* (suppl_7), S114–S122.

Baughman, A., & Arens, E. A. (1996). *Indoor humidity and human health–Part I: Literature review of health effects of humidity-influenced indoor pollutants*. Berkeley, CA: Center for the Built Environment, University of California.

Bentley, R. J., Pevalin, D., Baker, E., Mason, K., Reeves, A., & Beer, A. (2016). Housing affordability, tenure and mental health in Australia and the united kingdom: A comparative panel analysis. *Housing Studies*, *31*(2), 208–222.

Bills, K. L., West, S. M., & Hargrove, J. (2019). Housing cost burden and maternal stress among very low income mothers. *Journal of Sociology and Social Welfare*, *46*, 73.

Bonnefoy, X. (2007). Inadequate housing and health: An overview. *International Journal of Environment and Pollution*, *30*(3–4), 411–429.

Bruce, N., Elford, J., Wannamethee, G., & Shaper, A. G. (1991). The contribution of environmental temperature and humidity to geographic variations in blood pressure. *Journal of Hypertension*, *9* (9), 851–858.

BS 5250. (1989). *British standard code of practice for control of condensation in buildings*. British Standards Institution.

Burgess, J. (2011). *Sustainability of the New Zealand Housing Stock*. BRANZ study report SR 253. Retrieved from http://www.branz.co.nz/cms_show_download.php?id=6aa4ded75413c78597a8c430dee930dd8e5df209

Chisholm, E., Howden-Chapman, P., & Fougere, G. (2017). Renting in new zealand: Perspectives from tenant advocates. *Kōtuitui: New Zealand Journal of Social Sciences Online*, *12*(1), 95–110.

Climate Change Response (Zero Carbon) Amendment Bill. (2019). Retrieved from http://www.legislation.govt.nz/bill/government/2019/0136/latest/LMS183736.html

Collins, K. (1986). Low indoor temperatures and morbidity in the elderly. *Age and Ageing*, *15*(4), 212–220.

Comite'Europe'en de Normalisation, C. (2007). *Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics*. En 15251.

Committee, P. M., Ministry of Housing and Local Government Ed. (1961). *Homes for today and tomorrow*. London: HM Stationary Office.

Cunningham, M. (1998). Direct measurements of temperature and humidity in dust mite microhabitats. *Clinical and Experimental Allergy*, *28*(9), 1104–1112.

Cunningham, M. J. (1999). Modelling of some dwelling internal microclimates. *Building and Environment*, *34*(5), 523–536.

Davis, R. E., McGregor, G. R., & Enfield, K. B. (2016). Humidity: A review and primer on atmospheric moisture and human health. *Environmental Research*, *144*, 106–116.

Derby, M. M., & Pasch, R. M. (2017). Effects of low humidity on health, comfort & IEQ. *Ashrae J*, *59*, 44–51.

Dhainaut, J., Claessens, Y., Ginsburg, C., & Riou, B. (2003). Unprecedented heat-related deaths during the 2003 heat wave in paris: Consequences on emergency departments. *Critical Care*, *8*(1), 1.

Donnel, E. (2018). Mould, sweet mould: Inside New Zealand's damp housing crisis. Retrieved from https://thespinoff.co.nz/society/22-08-2018/mould-sweet-mould-inside-new-zealands-damp-housing-crisis/

Fairclough, N. (2007). *Discourse and contemporary social change* (Vol. 54). Bern: Peter Lang.

Fairclough, N. (2013). *Critical discourse analysis: The critical study of language*. Abingdon, UK: Routledge.

Gupta, R., & Kapsali, M. (2016). Empirical assessment of indoor air quality and overheating in low-carbon social housing dwellings in England, UK. *Advances in Building Energy Research*, *10*(1), 46–68.

Hajat, S., O'Connor, M., & Kosatsky, T. (2010). Health effects of hot weather: From awareness of risk factors to effective health protection. *The Lancet*, *375*(9717), 856–863.

Head, K., Clarke, M., Bailey, M., Livinski, A., Ludolph, R., & Singh, A. (2018). *Report of the systematic review on the effect of indoor heat on health. WHO housing and health guidelines*. World Health Organization.

Howden-Chapman, P., Matheson, A., Crane, J., Viggers, H., Cunningham, M., & Blakely, D. G. (2007). Effect of insulating existing houses on health inequality: Cluster randomised study in the community. *BMJ (Clinical Research Ed.)*, *334*(7591), 460. doi:bmj.39070.573032.80 [pii].

Howieson, S. (2017). The great Scottish housing disaster: The impacts of feudalism, modernism, energy efficiency and vapour barriers on indoor air quality, asthma and public health. *Sustainability*, *10*(1), 18.

Ikäheimo, T., Jaakkola, K., Jokelainen, J., Saukkoriipi, A., Roivainen, M., & Juvonen, J. J. (2016). A decrease in temperature and humidity precedes human rhinovirus infections in a cold climate. *Viruses*, *8*(9), 244.

Johnson, E. P. (2011). Air-source heat pump carbon footprints: HFC impacts and comparison to other heat sources. *Energy Policy*, *39*(3), 1369–1381.

Johnston, K. (2017). Damp, overcrowded homes bigger threat to kids than car crashes. Retrieved from https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11913397

Kenny, G. P., Flouris, A. D., Yagouti, A., & Notley, S. R. (2019). Towards establishing evidence-based guidelines on maximum indoor temperatures during hot weather in temperate continental climates. *Temperature*, *6*(1), 11–36.

Kilpelainen, M., Terho, E. O., Helenius, H., & Koskenvuo, M. (2001). Home dampness, current allergic diseases, and respiratory infections among young adults. *Thorax*, *56*(6), 462–467. doi:10.1136/thorax.56.6.462

Klenk, J., Becker, C., & Rapp, K. (2010). Heat-related mortality in residents of nursing homes. *Age and Ageing*, *39*(2), 245–252.

Koep, T. H., Enders, F. T., Pierret, C., Ekker, S. C., Krageschmidt, D., Neff, K. L., . . . Huskins, W. C. (2013). Predictors of indoor absolute humidity and estimated effects on influenza virus survival in grade schools. *BMC Infectious Diseases*, *13*(1), 71.

Korsgaard, J. (1998). Epidemiology of house-dust mites. *Allergy*, *53*, 36–40.

Koskinen, O. M., Husman, T. M., Meklin, T. M., & Nevalainen, A. I. (1999). The relationship between moisture or mould observations in houses and the state of health of their occupants. *The European Respiratory Journal*, *14*(6), 1363–1367.

Lam, L. T. (2007). The association between climatic factors and childhood illnesses presented to hospital emergency among young children. *International Journal of Environmental Health Research*, *17*(1), 1–8.

MacAndrew, R. (2018). Raising kids in a damp home: One woman's battle to get out of her housing NZ hell. Retrieved from https://www.stuff.co.nz/dominion-post/news/106831962/raising-kids-in-a-damp-home-one-womans-battle-to-get-out-of-her-housing-nz-hell

Marmot, M., Geddes, I., Bloomer, E., Allen, J., & Goldblatt, P. (2011). *The health impacts of cold homes and fuel poverty*. London: Friends of the Earth & the Marmot Review Team.

McGeehin, M. A., & Mirabelli, M. (2001). The potential impacts of climate variability and change on temperature-related morbidity and mortality in the united states. *Environmental Health Perspectives*, *109*(Suppl 2), 185–189.

McLeod, R. S., Hopfe, C. J., & Kwan, A. (2013). An investigation into future performance and overheating risks in passivhaus dwellings. *Building and Environment*, *70*, 189–209.

McNicholas, A., Lennon, D., Crampton, P., & Howden-Chapman, P. (2000). Overcrowding and infectious diseases-when will we learn the lessons of our past? *New Zealand Medical Journal*, *113* (1121), 453.

Mendell, M. J., Mirer, A. G., Cheung, K., Tong, M., & Douwes, J. (2011). Respiratory and allergic health effects of dampness, mold, and dampness-related agents: A review of the epidemiologic evidence. *Environmental Health Perspectives*, *119*(6), 748–756.

Millar, C. (2017). New zealand homes: Damp, cold and mouldy. Retrieved from https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11897319

Milne, K., & Kearns, R. (1999). Housing status and health implications for pacific peoples in New Zealand. *Pacific Health Dialog*, *6*(1), 80–86.

Milner, J., & Wilkinson, P. (2017). Commentary: Effects of home energy efficiency and heating interventions on cold-related health. *Epidemiology*, *28*(1), 86–89.

Mitchell, R., & Natarajan, S. (2019). Overheating risk in passivhaus dwellings. *Building Services Engineering Research and Technology*, *40*, 4. doi:10.1177/0143624419842006

Mu, Z., Chen, P., Geng, F., Ren, L., Gu, W., Ma, J., & Li, Q. (2017). Synergistic effects of temperature and humidity on the symptoms of COPD patients. *International Journal of Biometeorology*, *61*(11), 1919–1925.

New Zealand Parliament Hansard. (2016). *Hansard debates.*

New Zealand Parliament Hansard. (2018). *Housing rental minimum standards.*

New Zealand Parliament Hansard. (2019). *10. question no. 10—Housing and urban development.*

Oreszczyn, T., & Pretlove, S. (2000). Mould index. Cutting the Cost of Cold. E.& FN Spon. *London*, *122–133,* 125.

Ormandy, D., & Ezratty, V. (2012). Health and thermal comfort: From WHO guidance to housing strategies. *Energy Policy*, *49*, 116–121.

Osman, L. M., Ayres, J. G., Garden, C., Reglitz, K., Lyon, J., & Douglas, J. G. (2008). Home warmth and health status of copd patients. *European Journal of Public Health*, *18*(4), 399–405.

Pierse, N., Arnold, R., Keall, M., Howden-Chapman, P., Crane, J., Cunningham, M., & Heating Housing and Health Group. (2013). Modelling the effects of low indoor temperatures on the lung function of children with asthma. *Journal of Epidemiology and Community Health*, *67*(11), 918–925. doi:10.1136/jech-2013-202632

Platt, S. D., Martin, C. J., Hunt, S. M., & Lewis, C. W. (1989). Damp housing, mould growth, and symptomatic health state. *BMJ (Clinical Research Ed.)*, *298*(6689), 1673–1678. doi:10.1136/bmj.298.6689.1673

Preval, N., Keall, M., Telfar-Barnard, L., Grimes, A., & Howden-Chapman, P. (2017). Impact of improved insulation and heating on mortality risk of older cohort members with prior cardiovascular or respiratory hospitalisations. *BMJ Open*, *7*, 11.

Prussin, A. J., 2nd, Schwake, D. O., Lin, K., Gallagher, D. L., Buttling, L., & Marr, L. C. (2018). Survival of the enveloped virus Phi6 in droplets as a function of relative humidity, absolute humidity, and temperature. *Applied and Environmental Microbiology*, *84*(12), Print 2018 Jun 15. doi:e00551-18 [pii]. doi:10.1128/AEM.00551-18

Rangiwhetu, L., Pierse, N., Viggers, H., & Howden-Chapman, P. (2018). Cold new zealand council housing getting an upgrade. *Policy Quarterly*, *14*, 2.

Residential Tenancies (Healthy Homes Standards) regulations. (2019). Retrieved from http://www.legislation.govt.nz/regulation/public/2019/0088/latest/whole.html

Ross, A., Collins, M., & Sanders, C. (1990). Upper respiratory tract infection in children, domestic temperatures, and humidity. *Journal of Epidemiology and Community Health*, *44*(2), 142–146. doi:10.1136/jech.44.2.142

Saeki, K., Obayashi, K., Iwamoto, J., Tanaka, Y., Tanaka, N., Takata, S., ... Kurumatani, N. (2013). Influence of room heating on ambulatory blood pressure in winter: A randomised controlled

study. *Journal of Epidemiology and Community Health*, *67*(6), 484–490. doi:10.1136/jech-2012-201883
Saeki, K., Obayashi, K., & Kurumatani, N. (2015). Short-term effects of instruction in home heating on indoor temperature and blood pressure in elderly people: A randomized controlled trial. *Journal of Hypertension*, *33*(11), 2338–2343.
Sameni, S. M. T., Gaterell, M., Montazami, A., & Ahmed, A. (2015). Overheating investigation in UK social housing flats built to the passivhaus standard. *Building and Environment*, *92*, 222–235.
Shaman, J., & Kohn, M. (2009). Absolute humidity modulates influenza survival, transmission, and seasonality. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(9), 3243–3248.
Shaman, J., Pitzer, V. E., Viboud, C., Grenfell, B. T., & Lipsitch, M. (2010). Absolute humidity and the seasonal onset of influenza in the continental united states. *PLoS Biology*, *8*(2), e1000316.
Sherbakov, T., Malig, B., Guirguis, K., Gershunov, A., & Basu, R. (2018). Ambient temperature and added heat wave effects on hospitalizations in california from 1999 to 2009. *Environmental Research*, *160*, 83–90.
Shiue, I. (2016). Cold homes are associated with poor biomarkers and less blood pressure check-up: English longitudinal study of ageing, 2012–2013. *Environmental Science and Pollution Research*, *23*(7), 7055–7059.
Shiue, I., & Shiue, M. (2014). Indoor temperature below 18 degrees C accounts for 9% population attributable risk for high blood pressure in scotland. *International Journal of Cardiology*, *171*(1), e1–2. doi:10.1016/j.ijcard.2013.11.040
Shorter, C., Crane, J., Pierse, N., Barnes, P., Kang, J., & Wickens, H. A. (2018). Indoor visible mold and mold odor are associated with new-onset childhood wheeze in a dose-dependent manner. *Indoor Air*, *28*(1), 6–15.
Stanton, A., Scott, D., & Downham, M. (1980). Is overheating a factor in some unexpected infant deaths? *The Lancet*, *315*(8177), 1054–1057.
Sterling, E., Arundel, A., & Sterling, T. (1985). Criteria for human exposure to humidity in occupied buildings. *ASHRAE Transactions*, *91*(1B), 611–622.
Strachan, D. P., & Sanders, C. H. (1989). Damp housing and childhood asthma; respiratory effects of indoor air temperature and relative humidity. *Journal of Epidemiology and Community Health*, *43*(1), 7–14.
Sundell, J. (2004). On the history of indoor air quality and health. *Indoor Air*, *14*(s7), 51–58.
Telfar-Barnard, L., Bennett, J., Howden-Chapman, P., Jacobs, D., Ormandy, D., & Cutler-Welsh, K. M. (2017). Measuring the effect of housing quality interventions: The case of the New Zealand "rental warrant of fitness". *International Journal of Environmental Research and Public Health*, *14*(11), 1352.
Tin, S. T., Woodward, A., Saraf, R., Berry, S., Carr, P. A., Morton, S. M., & Grant, C. C. (2016). Internal living environment and respiratory disease in children: Findings from the growing up in New Zealand longitudinal child cohort study. *Environmental Health*, *15*(1), 120.
Toledo, L., Cropper, P., & Wright, A. J. (2016). Unintended consequences of sustainable architecture: Evaluating overheating risks in new dwellings. Paper presented at the Paper Presented at the 32nd International Passive and Low Energy Architecture (PLEA) Conference.
Twyford, P. (2019). *Standards to make homes warm and dry released*. Retrieved from https://www.beehive.govt.nz/release/standards-make-homes-warm-and-dry-released
Venn, A. J., Cooper, M., Antoniak, M., Laughlin, C., Britton, J., & Lewis, S. A. (2003). Effects of volatile organic compounds, damp, and other environmental exposures in the home on wheezing illness in children. *Thorax*, *58*(11), 955–960. doi:10.1136/thorax.58.11.955
Watson, A. (2019). The cost of cold, damp homes is too high. Retrieved from https://www.stuff.co.nz/business/opinion-analysis/112001047/the-cost-of-cold-damp-homes-is-too-high
Wiemken, T. L., Mattingly, W. A., Furmanek, S. P., Guinn, B. E., English, C. L., Carrico, R., … Ramirez, J. A. (2017). Impact of temperature relative humidity and absolute humidity on the incidence of hospitalizations for lower respiratory tract infections due to influenza, rhinovirus, and

respiratory syncytial virus: Results from community-acquired pneumonia organization (CAPO) international cohort study. *The University of Louisville Journal of Respiratory Infections*, *1*(3), 7.

Witten, K., Wall, M., Carroll, P., Telfar-Barnard, L., Huckle, T., & Scott, K. (2017). *The New Zealand rental sector*. (No. ER222). BRANZ.

Wodak, R., & Fairclough, N. (2013). *Critical discourse analysis*. London: Sage.

Wolkoff, P. (2018). Indoor air humidity, air quality, and health–An overview. *International Journal of Hygiene and Environmental Health*, *221*(3), 376–390.

World Health Organisation. (1991). *Indoor environment: Health aspects of air quality, Thermal environment, light and noise*. (No. WHO/ENE/RUD/90.2).

World Health Organization. (1987). *Health impact of low indoor temperatures*. Author.

World Health Organization. (2018). *WHO housing and health guidelines*. Geneva: WHO. (CC BY-NC-SA 3.0 IGO).

Xu, Z., Etzel, R. A., Su, H., Huang, C., Guo, Y., & Tong, S. (2012). Impact of ambient temperature on children's health: A systematic review. *Environmental Research*, *117*, 120–131.

Zivin, J. G., & Shrader, J. (2016). Temperature extremes, health, and human capital. *The Future of Children*, *26*(1), 31–50.