Health Impact Assessment:

Review of Environment Canterbury's Air Plan

Potential effects of wood burner restrictions on wood burning households in Christchurch

Report and Recommendations

September 2014

Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha

Canterbury District Health Board
Te Poari Hauora ō Waitaha

Acknowledgements

This report is the culmination of many months of work during 2013-2014 by the Health Impact Assessment project team. The project team and contributing authors included Emma Kenagy, Malcolm Walker, Matt Willoughby, Bruce Waddleton, Dr Nadia Bartholomew, and Dr Alistair Humphrey from the Canterbury District Health Board; Carmel Rowlands and Nadeine Dommisse from Environment Canterbury; and Emily Wilton from Environet Ltd.

The authors would also like to acknowledge the attendees at the Stakeholder Workshop in May 2014 for giving their time and expertise to this process. The recommendations in this report were developed based on discussions that took place during this workshop.

Published in November 2014 by the

Canterbury District Health Board

PO Box 1475, Christchurch 8140, New Zealand

ISBN 978-0-473-30677-9

Reference this document as:

Canterbury District Health Board. Health Impact Assessment: Review of Environment Canterbury's Air Plan, Potential effects of wood burner restrictions on wood burning households in Christchurch. Canterbury District Health Board, 2014

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Executive Summary

There are a range of health impacts associated with low household temperatures, particularly for vulnerable population groups such as the elderly, infants and young children, low income households, and people with chronic illness. The introduction of either a ban on the use of wood burners or further restrictions on wood burners could exacerbate these affects for some wood burning households.

Wood burning is one of the most affordable commonly-available forms of heating in New Zealand, second only to heat pumps in terms of operating costs when compared to the cost of purchasing firewood (Wilton, 2013a). Nearly 24,000 Christchurch households currently use wood for heating, and up to 29% of these are rental households. Most wood burning households are middle or upper income earners. Despite this, 33% of domestic firewood was collected in 2013, making it the most affordable heating method for many households (Wilton, 2013a).

Heat pumps are a recommended alternative for those moving away from wood burners due to comparable operating costs. Unfortunately, the high capital cost to install a heat pump means that for many households this heating method is less accessible than other forms of electric or gas heating, which are inexpensive to purchase but up to three times more expensive to operate (Wilton, 2013a). Renters are particularly vulnerable in this context, as they have little control over the heating appliances available to them and level of insulation in the home. Approximately 28,000 (22%) households in Christchurch are currently living in fuel poverty and half of these are rental households (Wilton, 2014a). It is estimate that a ban on wood burner use would cause fuel poverty levels to increase, reinforcing the important role wood burners currently have as an affordable heating method.

Importantly, heating method is one of many factors that play a role in winter warmth and wellbeing. The level of insulation in homes has a significant impact on heating affordability, regardless of heating type (Wilton, 2014a). While there has been an improvement in household insulation in Christchurch since 2005, illustrated by an increase in households reporting all types of house insulation of around 20%, nearly 25% of the housing stock has only one or fewer types of insulation (Wilton, 2013a). Limited insulation in many dwellings may make all forms of heating more costly.

A primary recommendation of the HIA is that a collaborative inter-agency approach is needed to develop and deliver supporting measures, such as targeted heating and insulation subsidies and awareness campaigns, to mitigate possible adverse health impacts of further wood burner restriction in the future. This will ensure that improved air quality and warm homes are mutually-achievable aims.

Background

Chapter 3: Air Quality of the Environment Canterbury Regional Council's Natural Resources Regional Plan, commonly referred to as the Air Plan, is currently under review. The primary aim of the Air Plan review is to assess the effectiveness of the current approach to managing air quality in Canterbury, and to recommend changes to the Plan that will ensure that air quality continues to improve to support healthy communities. A key part of the review is to investigate progress towards meeting national targets for particulate matter (PM_{10}) prescribed in the National Environmental Standards for Air Quality (NESAQ), in polluted air sheds. Christchurch is a designated polluted air shed and has had regulation in place for managing air quality since 2002 when the first Air Plan was formally notified. Approximately 67% of PM_{10} emissions in Christchurch are from wood burning appliances, primarily from the use of conventional wood burners for domestic home heating during winter (Environment Canterbury, 2014).

Context for the HIA

The human health impacts from PM_{10}/$PM_{2.5}$ emissions have been established at both a national and international level. Research undertaken by the World Health Organisation (WHO) continues to

support measures taken to reduce PM_{10}/$PM_{2.5}$. In particular, the WHO has developed a guideline that PM_{10} concentrations should not exceed 50 micrograms in any 24-hour period, and recommends that countries not currently meeting this guideline undertake immediate action to reduce emissions. In New Zealand, the NESAQ establishes the statutory framework for air quality based on the WHO guidelines. The NESAQ requires that Regional Councils put in place measures to achieve the specified air quality standards and PM_{10} targets. The primary mechanism to achieve this in Canterbury is the Air Plan.

A policy-level Health Impact Assessment (HIA) approach was used to support the review of the Air Plan. The project team acknowledged existing evidence of the impacts of air pollution on health, a summary of which is provided in a separate report titled *Health impacts of particulate: a literature review* (Wilton, 2014b). The HIA instead focused on a gap in available information relating to the potential health impacts that could occur for households having to make changes due to further wood burner restrictions. There was concern that further restriction or prohibition of wood burner use would result in households not being able to afford to heat their homes to minimum temperatures recommended for health.

Proposed Air Plan Changes

Significant improvement has been made in reducing emissions from wood burning in Christchurch, and improvements to air quality are visibly noticeable. However further improvement is required to meet the NESAQ PM_{10} targets. Air quality monitoring suggests that implementation of the existing Air Plan measures is unlikely to meet the NESAQ, and that additional measures will be required, including a mix of non-regulatory and regulatory options.

The current Air Plan already requires older more polluting wood burners to be upgraded after fifteen years to meet current emission standards. Additional requirements to upgrade wood burners, or phase-out wood burners completely, would result in a larger number of households having to either replace wood burners with a lower emitting appliance, or convert to another form of heating. A key aim of this study was to determine the potential health impacts of any additional requirements under the Air Plan from the perspective of households required to implement the change.

Approach

Policy-level HIA is a formal process that recognises and assesses the impact of decisions made in sectors outside of health on population health and wellbeing. The Air Plan HIA followed a structured approach consisting of the following stages:

- Screening – to determine if the HIA should proceed as part of the Air Plan review process
- Scoping – to map out the scope of the issue and boundaries of the HIA
- Appraisal – information and data collection to assess the potential impacts of the proposed policy and develop recommendations
- Reporting – presentation of the assessment findings and recommendations at the conclusion of the appraisal process.

The HIA on wood burning households was jointly planned and led by the Canterbury District Health Board (CDHB) and Environment Canterbury Regional Council. The project team was made up of members of the Policy Team and Health Protection Team in the Community and Public Health service of the CDHB, a Principal Planner from Environment Canterbury, and a scientific consultant specialising in energy and air quality from Environed Ltd.

Planning began in mid-2013 and approval was received for the HIA to proceed following a screening meeting in July. The project team was formed and undertook a scoping workshop in August 2013 to define the parameters and objectives of the HIA, identify populations likely to be effected, and develop key questions to be answered during the appraisal process.

Scope

It is often not feasible or practical to consider all of the potential health impacts associated with a particular policy. For this reason, a scoping process was undertaken to determine the focus and boundaries of the HIA. This HIA focuses specifically on the potential health impacts of proposed changes to the Air Plan on wood burning households in Christchurch. Although specific policy proposals were not yet available at the initiation of the HIA, the assessment focused on the scenario in which wood burner use was either further restricted or prohibited for domestic heating during winter. Complete prohibition of wood burner use was considered as a 'worst case' scenario.

As discussed earlier, the scope was limited to assessing the health implications of potential restrictions on wood burners from the perspective of householders who might be affected. It is intended that the findings of this HIA be considered alongside other information on the wider population effects of poor air quality, such as that summarised in *Health impacts of particulate: a literature review* (Wilton, 2014b).

Aim and Objectives

The aim of the HIA is to inform the review of Environment Canterbury's Air Plan with regard to the potential health effects on the wood burning population from any further restriction on the use of wood burners for domestic home heating during winter.

The HIA objectives are:

1. To outline the potential health effects on wood burning households that may be required to replace their wood burners with a lower emitting wood burner appliance or change their current home heating method from wood burning to a non-solid fuel alternative.

2. To develop recommendations based on these findings for mitigating potential negative health effects in consultation with key stakeholders.

Key Questions and Appraisal Process

Five key question areas were identified during the scoping workshop to assist with developing the approach for achieving the objectives of the HIA:

1. Who will be affected by any changes to wood burner regulations in the Air Plan (who is currently using wood burners in Christchurch)? Which population groups are most at risk?
2. What are the potential health impacts for these population groups? What are the relevant health determinants and equity issues?
3. If wood burner use is restricted or prohibited in the future, what are the alternative heating options and associated costs? Which options are people likely to choose?
4. What factors, apart from wood burner use, need to be taken into account and what role could they play in exacerbating or mitigating the health effects relating to home heating changes?

5. For what proportion of the affected population would changes to home heating result in a less healthy home? How might this affect those most at risk?

The appraisal process outlined below was designed to provide answers to these questions:

Appraisal stage	**Timeframes**
Heating Options and Costs Review (Appendix 2) This review considered the range of domestic heating appliances available to New Zealand households and assessed each appliance in terms of capital cost to purchase and install, and operating costs.	August 2013
2013 Heating and Household Survey (Appendix 1) The survey revealed the distribution of heating types used in Christchurch households, and provided detailed information on the characteristics of wood burning households, including age, ethnicity, household income, and health status.	Sept-Nov 2013
Literature review on heating, housing and health (Appendix 3) This focused on the impacts of cold homes on human health, in terms of the consequences for households if unable to heat homes to minimum temperatures for health. The literature review also identified the members of population most vulnerable to living in cold homes.	Nov-Dec 2013
Fuel Poverty Impact Analysis (Appendix 4) This analysis quantified the impact of wood burner prohibition on health by using information from the Heating Options and Costs Review and Heating and Household Survey to estimate the current level of fuel poverty in Christchurch and impact of wood burner prohibition on fuel poverty levels.	Feb-March 2014
Stakeholder Workshop Representatives of stakeholder organisations that work with or represent vulnerable population groups were brought together to review the HIA findings, consider the impacts of policy scenarios within the larger context of winter warmth and health, and produce recommendations to minimise the impact of the adverse health effects on wood burning households.	May 2014

Findings

1. Who will be affected?

This HIA focuses on changes to the Air Plan which may affect the way that people living in Christchurch heat their homes, and the impact this could have on the health and wellbeing of occupants. The population likely to be directly affected by any changes are those living in dwellings with wood burners as the primary method of home heating, including renters and those who own their own homes.

The 2013 Heating and Household Data survey estimated that 23,900 households, representing 19% of the total number of dwellings in Christchurch, are currently using wood burners, around 1000 households are using open fires or multi fuel burners and a further 3410 are using pellet fires to heat the main living area of their homes (Wilton, 2013a). This gives a total of around 28,300 households using wood for space heating in the main living area of their home. This estimate was reinforced by the 2013 census result of 30,100 who use wood for space heating anywhere in their home (Wilton, 2013). Census data indicates approximately 6700 households (22%) using wood for home heating were renting and the remaining dwellings were owner occupied (Wilton, 2013a).

The 2013 Heating and Household Survey report (Wilton, 2013a) (Appendix 1) provides a detailed breakdown of wood burner using households by ethnicity, income and employment status, age, and household type. This provides a picture of the overall population of interest and more detailed information about sub-groups of this population that may be most affected by home heating changes. A key finding of the survey is that most wood burning households are middle or upper income earners, with 64% of households reporting an annual income over $52,000 and 40% reporting over $77,000 (Wilton, 2013a).

Which population groups are most at risk?

This question was answered in part by the findings of the literature review (Appendix 3), supported by information from the Heating and Household Data survey (Wilton, 2013a) (Appendix 1) to define how the key population groups are represented in the wood burner user population. The following populations groups were identified during the scoping process due to their increased vulnerability to adverse health effects associated with home heating:

- Elderly
- Families with young children
- People with chronic illness
- Low income and unemployed
- Māori and Pacific

The 2013 Heating and Household Survey report demonstrates how these groups are represented in the wood burner user population:

Elderly

- 29% of wood burner users are 60 years or older, representing 37% of all people aged 60 years+ surveyed
- 16% of households using a wood burner are retirees – representing 12% of all people retired

Families with young children

- 36% of families with school-aged children used wood burners for heating the main living area of their home.

Low income and unemployed

- 21% of wood burner households have an annual income of less than $52,000 and 13% of wood burner households earn less than $33,000
- 4% of wood burner households reported their employment status as ‘unemployed’

People with chronic Illness

- 22% of wood burner households had at least one occupant with chronic respiratory illness
- 15% of wood burner households had at least one occupant with mental health issues
- 8% of wood burner households had at least one occupant with cardiopulmonary illness.

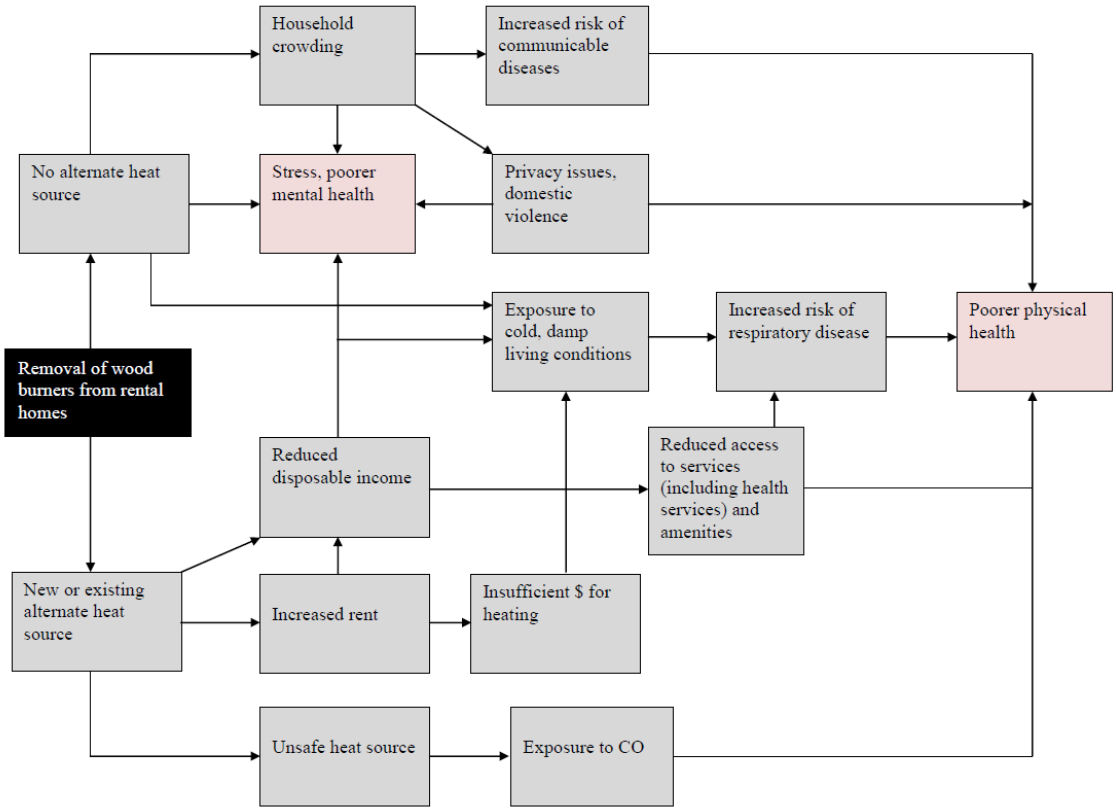
Māori and Pacific

- 3% of wood burner users are of Māori descent
- Just under 2% of wood burner users are Pacific households

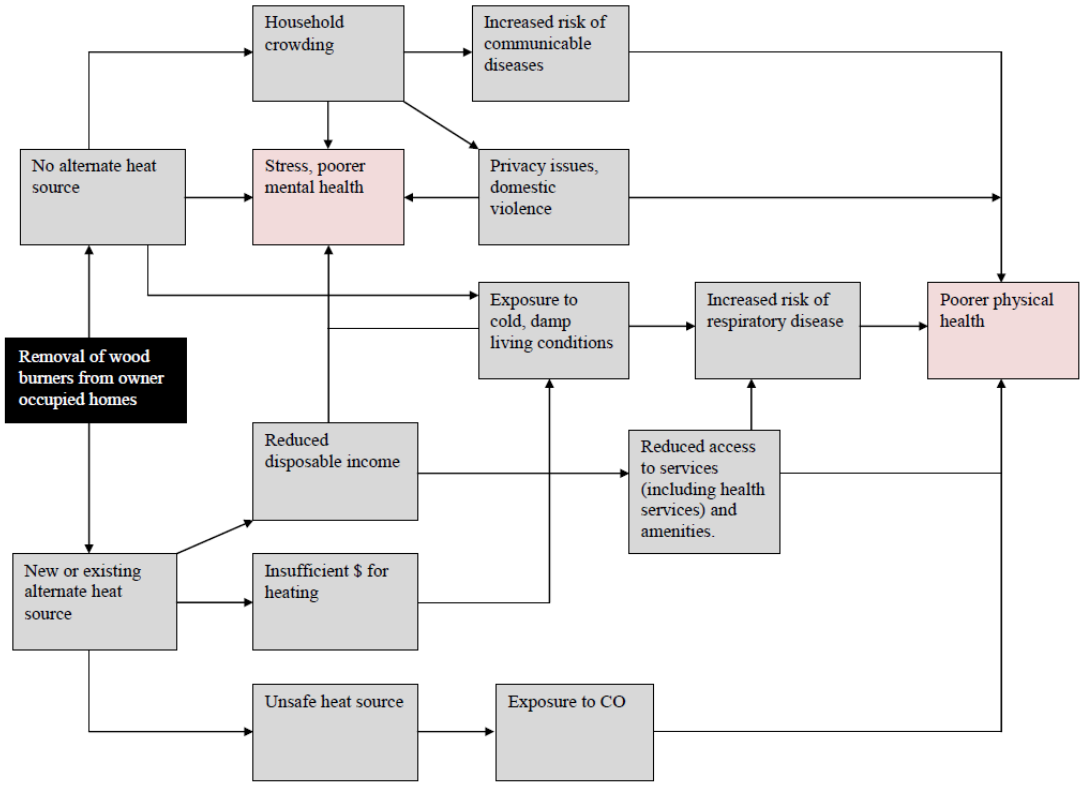
2. What are the potential health outcomes?

Causal pathways were developed during the scoping stage to layout the potential health effects of wood burner restriction on occupant health for renters and owner-occupiers of dwellings currently heated by wood burning. The pathways consider both direct and indirect impacts of the restriction or prohibition of wood burners on physical and mental health and wellbeing, as well as wider determinants of health, such as access to education and employment, and affordability of other essential requirements and services, including health services. The pathways provided initial guidance for the selecting Literature Review search terms and additional questions for the Heating and Household Data survey.

Causal pathway for renters



Causal pathway for owner-occupiers



Summary of Health Impacts

The literature review delved deeper into the evidence behind these issues to provide an overview of the factors contributing to indoor winter temperatures and wellbeing. The direct impacts of cold homes relate to respiratory health, cardiovascular health, mental health and wellbeing, crowding, communicable diseases, and social functioning within the home. Indirect impacts relate to the wider determinants of heath, such as food security, education and employment, and access to health and other important services. Each of these topics is described in greater detail in the summaries below.

Temperature thresholds for health

A 1968 World Health Organisation (WHO) report concluded that the human body can only compensate for a relatively small temperature range of approximately 15^0 C to 24^0 C. The 1982 WHO working group found that for indoor temperatures between 18^0 C and 24^0 C there was minimal risk to the health of sedentary people, such as the elderly (Ormandy & Ezratty, 2012). Temperatures below 16°C, particularly in the presence of high humidity, are associated with adverse health consequences and temperatures below 12°C are a health risk for vulnerable groups. Cold homes have both direct and indirect effects on health.

In New Zealand, households often fail to meet the WHO recommendations of heating homes to at least 18^0C (Isaacs et al., 2010).

Respiratory health

Respiratory health can be compromised by exposure to cold temperatures. These detrimental health impacts are particularly prevalent in the most vulnerable groups of society such as the elderly, children and individuals with existing respiratory conditions.

Cold air affects the normal protective function of the respiratory tract, with increased bronchoconstriction, mucus production and reduced mucus clearance (Marmot Review Team, 2011). Research shows that drops in outdoor temperature below 14°C are associated with increased hospital admissions and deaths from respiratory and cardiovascular disease (Allen, Leckie, Millar, & Brauer, 2009). However, indoor temperatures may be more important to consider because people spend 80% of their time inside (Free, Howden-Chapman, Pierse, & Viggers, 2010). Conditions associated with cold homes, such as damp and mould, may also be important factors that need to be considered when addressing the effects of cold homes on respiratory health effects. The Marmot Team found that around 33% of Excess Winter Deaths are attributable to respiratory disease, reinforcing the important relationship between cold homes and respiratory health.

Asthma is a respiratory condition that is particularly affected by cold homes. There are a number of studies which investigate the effects of cold indoor temperatures on individuals with pre-existing respiratory conditions, such as asthma (Somerville, Mackenzie, Owen, & Miles, 2000) (Keall et al., 2012). Approximately 25% of children in New Zealand report symptoms of asthma and therefore a large majority may be affected. Cold temperatures, damp, mould and pollutants have been found to aggravate the symptoms of asthma (P. Howden-Chapman et al., 2008). Changes in temperature are associated with small reductions in lung function caused by reflex bronchoconstriction or by impairing immunological defenses to respiratory infections (Pierse et al., 2013).

The respiratory health of older adults can also be compromised. A large scale study which looked at residents aged over 65 years in the London Borough of Newham, calculated excess winter morbidity based on emergency hospital episodes for all respiratory diagnosis codes, and ranked this against a Fuel Poverty Index (FPI) (Team, 2011). The FPI was shown to be a predictor of excess winter morbidity, thus supporting evidence of a relationship between energy-efficient housing and winter respiratory disease among older adults.

Cardiovascular health

Living in a cold home may also have an impact on cardiovascular health. Literature suggests that there are strong links between the thermal quality of housing, and therefore house temperature, and cardiovascular health outcomes. By changing the thermal quality of a house to an optimal level from a non-optimal level, researchers have seen an improvement in cardiovascular health outcomes (C. R. Lloyd, Callau, Bishop, & Smith, 2008).

New Zealand-specific research based on 1996-2000 health data suggests that 47% of all excess mortality was attributed to diseases of the circulatory system. Whilst this may not solely be related to household temperatures, the association between thermal quality of housing and cardiovascular health affects suggests that there is a risk and that this risk is exacerbated during the winter months (Davie, Baker, Hales, & Carlin, 2007). Some studies suggest that there is also a link between the temperature of a room and blood pressure (Saeki et al., 2013). The World Health Organisation determined in their research that below the zone of thermal comfort, cold-related disease may take many forms. Cardiovascular reflexes can be initiated by cold air on the face or hands that can result in changes in heart rate and blood pressure and consequently increased cardiovascular strain (World Health Organization, 1987).

Mental health and wellbeing

Living in cold homes may adversely affect mental health and wellbeing in a number of ways. Research suggests that children living in sub-standard housing, including cold homes, were more likely suffer from mental health illnesses including anxiety and depression (Marmot Review Team, 2011). Inconsistencies between the size of housing, type of heating, and the specific requirements of

occupants have been linked with poorer mental health and wellbeing outcomes (Gibson, Thomson, Kearns, & Petticrew, 2011). Issues around self esteem, stress, and the cost of heating, lack of motivation to maintain the house and lack of control around modifications to the house as a tenant are common (Saeki, et al., 2013). In addition the financial pressure of maintaining an optimal thermal environment from heating a home has been associated with poorer mental health outcomes (P. Howden-Chapman, Crane, Chapman, & Fougere, 2011). Conversely the physical improvement of the thermal environment in a home has been linked with improved mental wellbeing and self esteem (Kearns, Petticrew, Mason, & Whitley, 2008).

Cold household temperatures can also affect social functioning. Families have reported spending more quality time in the home when the strain of a cold home is removed, with positive changes in children's education, play and enthusiasm for attending school also being observed (Free, et al., 2010).

Household crowding

Household crowding can occur in cold homes for a number of reasons. If families do not use heating, or heat only one area of the house, then they may congregate in one room for warmth. In addition, if low income families are unable to pay fuel bills they may decide to live together to reduce costs. Household crowding relates to a number of wider issues including communicable disease transmission, violence, and mental health.

Household crowding is an important risk factor for close contact infectious diseases (Baker, McDonald, Zhang, & Howden Chapman, 2013). Those living in crowded households have been found to have increased odds of diseases such as gastroenteritis, tuberculosis, pneumonia and meningococcal disease (Baker, et al., 2013). Maori and Pacific children are disproportionately exposed to household crowding and associated infectious disease burden (Baker, et al., 2013).

Household crowding can also produce opportunities for conflict and frustration, resulting in an atmosphere where individuals are more likely to be aggressive (Regoeczi, 2003).

What are the relevant determinants and equity issues?

Food security

High heating costs and fuel poverty may also have an impact on a household's ability to afford other basic necessities. A US study published in 2006 found an association between food insecurity and seasonally high heating and cooling costs, particularly for the elderly and those with low incomes (Nord & Kantor, 2006). Another study similarly found that a drop in winter temperature corresponded to decreased expenditure on food and reduced calorie intake for low-income households to offset winter heating costs (Bhattacharya, DeLeire, Haider, & Currie, 2003).

Cook et al. found that children living in households with energy insecurity were more likely to experience household and child food insecurity, hospitalisation, and caregiver report of child fair/poor health (Cook et al., 2008). Severe energy insecurity was also associated with significant developmental concerns**.**

Employment and Education

Adults suffering from health conditions due to a cold house will have to take time off work. In addition if they have children, they may be unable to go to work when their children are unwell. Studies have

found that following interventions that enable a house to be kept warmer, fewer adults require days off work (P. Howden-Chapman et al., 2007).

Similarly, children with health issues such as asthma are more likely to have more days off school (P. Howden-Chapman, et al., 2008). Absenteeism in the US has been found to have a significant inverse relationship with standardised test scores (Free, et al., 2010). Overcrowding can also lead to poorer educational attainment, as crowding has found to both reduce the probability of completing high school and has a negative impact on the number of schooling years completed (Lubell & Brennan, 2007) and drop-out rates (Office of the Deputy Prime Minister, 2004).

Access to health services

In New Zealand co-payments are required to access primary health care. For those that are in fuel poverty, this may mean that they will delay or defer accessing primary health care due to less residual income available during the winter months when they are heating their home. Jatrana and Crampton found that cost remains an issue for deferring primary care in New Zealand and a substantial proportion of people defer visits because they cannot afford the cost of the visit or the prescription fees (Jatrana & Crampton, 2009). The New Zealand Health Survey 2011/12 found that 14% of people experienced unmet need when accessing a general practice due to cost and 7% were unable to access an after hours service due to cost. Jatrana et al also found that 6.4% reported deferring prescriptions due to cost (Jatrana, Crampton, & Norris, 2011). Maori, Pacific peoples and those in the lowest tertiles were most likely to put off buying prescription medications.

Delayed medical treatment can have clinical implications. These include poor clinical outcomes, decline in health status, higher rates of problems in those with chronic illness, increased rates of complications, poor prognosis and longer hospital stays (Jatrana & Crampton, 2009).

3. What are the alternative heating options and associated costs?

This question addresses the need to understand the alternative heating options currently available in Christchurch for those who use wood burners to heat their homes. The costs were determined both in terms of capital outlay to purchase and install the heating appliance, and ongoing operational costs.

Home heating options for Christchurch households replacing wood burners include the following outlined in the table below (Wilton, 2013b):

Pellet fires - high capital cost, average operating cost Pellet burners appear similar to conventional wood burners and are available in free standing or inbuilt models. Pellet burners are fired by specifically designed wood pellets that are mechanically fed into the fire via a hopper. Good levels of heating efficiency can be achieved with pellet fires, through the ability to adjust the rate that pellets are consumed, control room temperature through a thermostat and using timers to turn the heating appliance on and off. The approximate heat output for pellet burners ranges from 10 to 30 kilowatts (kW). Space heating efficiencies range from 65% to 88%. Pellet burners are a more expensive heating option than wood burners and cost around 14-20 cents per kWh compared with around 6 c/kWh for modern wood burners.
Heat pumps - average capital cost, low operating cost, good temperature control A heat pump works by extracting heat in the air from outside a house and bringing it inside. Through the use of refrigerant gas, heat pumps shift more heat than the electrical energy consumed in the operation of them (www.consumer.org.nz). This makes them a highly efficient form of heating that can

produce up to five times as much energy in optimal operating conditions (EECA, 2009). Heat pumps are thermostatically controlled to bring the temperature of a room to a certain level and maintain it within one to two degrees of that temperature. Prices typically range from around $2500 to $7000 installed.

Flued gas heaters - high capital cost, high operating cost

Flued gas heaters can be flame effect and appear similar to an enclosed burner, space heaters, or central heating units. Flame effect heaters tend to have a lower efficiency than gas space or central heating units (Wilton & Baynes, 2009). In New Zealand gas is available either through the reticulated natural gas network that covers parts of the North Island, through bottled LPG, and in some areas, through piped LPG. Although some areas of Christchurch have piped LPG the majority rely on bottled LPG.

During recent years the use of gas heaters has become less popular, mainly due to the large increase in gas prices (Wilton & Baynes, 2009). Flued gas heaters do not appear to be popular choices in Christchurch, for example the Christchurch 'Clean Heat' project has only had a three percent uptake in gas heating (pers. comm., Mike Gaudin, Environment Canterbury, 2009). Wilton et al., (2010) suggest that flued gas is unlikely to be a popular choice amongst the general population and that potential sectors of the community that may be interested in switching to gas heating include high income homeowners who still want the aesthetic value of flame fires and can afford to pay higher fuel costs.

Diesel burners - high capital cost, high operating cost

Diesel burners are not a particularly popular heating method with less than 1% of household in Christchurch used that method (Wilton, 2013b). The capital cost of diesel fired burners tend to be more expensive than most wood burners and pellet fires, and cost around $4200 installed in 2009 (pers. comm., Smiths City, 2009). Anecdotal evidence suggests that in recent years the demand for diesel heaters has declined as the price of diesel has increased.

Diesel fired burners were included in the Canterbury 'Clean Heat' project, but were not included as a heating option for EECA projects. Diesel burners only account for 0.2 % of conversion to clean heat under the Environment Canterbury 'Clean Heat' project.

Unflued gas heaters - low capital cost, high operating cost

Historically unflued gas heaters were a low capital cost and low operating cost option. Increases in the cost of LPG since 2005 make this option less attractive than other low capital cost electrical options. Some households may still choose this heating option as awareness of the relative costs of heating methods is likely to be low.

Other electric options - low capital cost, high operating cost

Other electric heater types include radiant, convector, fan, under floor, and night store heaters. These are all high cost options in terms of on-going operation.

The main advantages of radiant, convector and fan electric heating include low capital costs and the convenience of quickly heating a small room or particular area. The disadvantages of these heating methods are the increasing cost of electricity, increased demand on the electricity network, and the limited way they many of them can be operated. Many only have a on or off setting, although basic thermostatic controls have become more prevalent in recent years.

Electric underfloor heating is a heating option for new homes but is not really an option for a wood burner replacement as retrofitting is not cost effective. The main advantage of underfloor heating is that it provides a warm, comfortable radiant heat. Underfloor heating tends to be expensive to install and operating costs are high

Night store heaters operate by storing heat from night rate electricity and release it during the day. They are most advantageous for households that are occupied during the day and in locations where there is a cheaper night rate for electricity. Apart from vulnerability to price increases, one of the main disadvantages is that they have to be run all of the time, which can mean that they are heating areas

during the day when there is enough warmth outside to heat the house without requiring heat from the night store heater. Historically the differential between day and night rates was greater making this option more financially attractive than it is currently.

Wood burners (replacement burners only) - high capital cost, low operating cost

Wood burners are only a heating choice for Christchurch householders as a replacement method for an existing solid fuel heating method. All wood burners installed in the Christchurch Clean Air Zones must meet the standard of 1.0g/kg when tested to NZS 4013, and have a thermal efficiency of at least 65%.

Wood burners are a popular heating option particularly in larger and older less well-insulated dwellings where more heat is required. Wood burners typically have heat outputs in the range of 4-18kW and efficiencies of 65-77%. Many households that use wood burners in their main living area also use other heating methods for other areas of the dwelling.

4. What other factors need to be taken into account, and what role could they play in exacerbating or mitigating the adverse health effects related to wood burner restrictions?

The relationship between home heating, or overall winter warmth, and health is influenced by many factors. One objective of the appraisal process was to explore this complex relationship and identify important factors that need to be considered during the policy-making process in order to protect the health of those potentially affected by changes. In addition to informing important decisions about wood burner restriction or prohibition made during the Air Plan review, it was felt by the project team that these issues need be taken into account when developing recommendations for mitigating any potential adverse health effects identified by the HIA. The following information has been summarised from the literature review, incorporating relevant findings from the Housing and Heating Survey Report and discussion in the stakeholder workshop.

Fuel poverty and fuel insecurity

Fuel poverty is generally defined as the situation when a household must spend more than 10% of its income on household energy requirements in order to heat the dwelling to a satisfactory temperature (O'Sullivan, Howden-Chapman, & Fougere, 2011). The World Health Organisation recommends minimum temperatures of 18°C for bedrooms and 21°C for living areas (World Health Organization, 2007).

In 2008, it was estimated that 25% of New Zealand's households were in fuel poverty, up from 10-14% in 2001 (B. Lloyd, Bishop, & Callau, 2007). The South Island is more severely affected and the potential rate of fuel poverty in Christchurch was most recently estimated to be 40% (Philippa Howden-Chapman et al., 2012). A limitation of this estimate is the assumption that electricity is the only fuel used for heating, making room for a more accurate analysis that considers other common fuel types, such as solid fuel and gas.

Analysis of the Heating and Household Data survey findings combined with census data estimated that 28,000 (22%) of households in Christchurch are likely to already to be in fuel poverty based on the household energy requirements to achieve a minimum temperatures of 18^0 C in living areas and 16^0 C in bedrooms (Wilton, 2014a). Approximately half of those in fuel poverty are renters and half owner-occupiers. Although fuel poverty is often associated with low levels of income, households with a relatively high income may still be in fuel poverty if fuel costs are high and the dwelling thermally inefficient (Philippa Howden-Chapman, et al., 2012). Wilton (2014a) found households earning as much as $80,000 per year could be in fuel poverty if living in a large uninsulated house and relying on a high cost heating method such as electric fan, oil column or radiant heater.

From a health perspective, fuel poverty is thought to be a contributing factor to New Zealand's high rates of excess winter mortality, which is estimated to be 1600 excess deaths per year during winter with young children and elderly people being most affected (Philippa Howden-Chapman, et al., 2012). In New Zealand, for children less than five years old, mortality associated with respiratory disease was 2.5 times higher in winter than expected (Free, et al., 2010). A similar pattern is seen for excess winter morbidity, with excess hospitalisations in winter for children less than five years old. Older people bear the majority of the burden of excess winter mortality. The majority of excess winter deaths in the UK occur in those aged over 75 years of age (P. Howden-Chapman, Signal, & Crane, 1999).

Howden-Chapman et al. identify the three main factors that exacerbate fuel poverty in New Zealand to be thermal efficiency of housing, income inequality, and increasing electricity costs (Philippa Howden-Chapman, et al., 2012). Thermal efficiency and electricity costs are discussed in more detail below.

Thermal efficiency of housing

The indoor temperature of a house is related to the thermal efficiency of the house, and it has been found that improving the thermal efficiency of houses can help to reduce fuel poverty (B. Lloyd, et al., 2007). This is as a result of savings on fuel costs and being able to heat the house to a higher temperature and for longer at the same cost.

House characteristics that determine thermal efficiency include property age, insulation, wall type and heating system (O'Sullivan, 2008). Insulation standards in New Zealand have been comparatively low. The earliest regulation for ceiling insulation was introduced in 1978. There are a number of houses that still have limited insulation in New Zealand today. It is thought that the historical low cost of electricity in New Zealand has contributed to the poor thermal housing standards (B. Lloyd, 2006).

Insulation subsidies are available for many households, which has led to significant improvements in home insulation levels in recent years.

Insulation Levels in Christchurch: 2005 and 2013

The Heating and Household Data Survey (Appendix 1) provides a comparison of insulation levels in Christchurch when the survey was first conducted on 2005 (Wilton, 2005) and following the survey update in October 2013, as presented in Table 1 (Wilton, 2013a):

> [The data] suggests a significant improvement in household insulation in Christchurch since 2005, illustrated by an increase in households reporting all types of house insulation of around 20%. In addition the proportion of households reporting no insulation has decreased from 18% in 2005 to 5% in 2013. While this is a significant improvement, it is worth noting that almost one quarter of the housing stock has only one or fewer types of insulation i.e., none or just ceiling insulation. However, this reduces to just 10% of households for those using wood burners for home heating.

- **Table 1: Insulation types and amounts**

Insulation type	2005 %	2013 %	Degree of insulation	2005 all	2013 all
Ceiling	62%	87%	No insulation	18%	5%
Underfloor	19%	39%	Just one type	28%	17%
Wall	34%	54%	Two types	21%	29%
Cylinder wrap	23%	26%	Three types	13%	24%
Double glazing	14%	39%	Four types	9%	16%
None	18%	5%	Five types	2%	7%
Don't know	11%	3%	Don't know	11%	5%
Other	0%	2%			

A previous summary of the 2005 survey results indicated that the most poorly insulated homes in Christchurch were those using open fires for domestic home heating, with the majority of households using this heating method having no insulation (52%). Improvements in insulations since 2005 appear to have occurred across a range of heating methods.

- **Table 2: Amount of insulation by heating type**

Insulation level	Electric		Gas		Wood burner	
	2005	2013	2005	2013	2005	2013
One type	28%	17%	35%	9%	29%	17%
Two types	22%	29%	19%	26%	25%	32%
Three types	13%	23%	16%	32%	18%	29%
Four types	6%	17%	8%	23%	14%	12%
Five types	3%	6%	0%	9%	0%	6%
None or don't know	29%	5%	22%	0%	14%	4%

Electricity costs

The cost of electricity is another important driver for fuel poverty. Most households in New Zealand use electricity to heat their homes and 75% of New Zealand's domestic energy use is in the form of electricity (Philippa Howden-Chapman, et al., 2012)—much higher than OECD norms. Due to the reliance of New Zealand households on electricity for household heating, New Zealanders pay more per kilowatt hour (kWh) of domestic energy than people from other countries. To buy a gigajoule of electrical energy in New Zealand costs 1.5 times as much as a gigajoule of natural gas energy of in Italy. Deregulation of the electricity market has led to the steady increase of residential electricity prices by 71% between 1990 and 2008 (O'Sullivan, et al., 2011). In addition, those on low incomes or those that have fallen into debt are often encouraged to use prepayment systems. Unfortunately prepayment metering is often more expensive than other payment options and may increase the likelihood of fuel poverty (Philippa Howden-Chapman, et al., 2012).

Source of Firewood

Another important consideration highlighted by the Heating and Household Data survey is the source of firewood for wood burner users, which relates to the affordability of wood as a fuel source (Wilton, 2013a). Approximately 33% of wood used in Christchurch is obtained free of charge. 7,600 homes using wood earn less than $50,000 and 50% of the wood used by these households has been obtained free of charge, making wood burning the most affordable of all heating methods. It is noted that the availability of free firewood varies from year to year, and there were several storm events in 2013, which likely contributed to the amount of free firewood available,

Table 3: Source of fire wood

Firewood	Wood burner 2005	Wood burner 2013
Bought	75%	67%
Self-collected	25%	33%

5. For what proportion of wood burning households might these proposed changes result in a less healthy home?

The project team sought to determine if it would be possible to produce an overall estimate of the magnitude of potential health impacts on wood burning households associated with restricting or prohibiting wood burner use in Christchurch. Due to the complex nature of the issues considered as part of the HIA, it became apparent that it would not be possible to produce a quantitative estimate that takes into account all of the potential health impacts depicted in the causal pathways and outlined in the literature review. It was, however, possible to provide an updated estimate of the current level of fuel poverty in Christchurch, as well as the impact that prohibiting wood burners would have on the level of fuel poverty. Fuel poverty is thought to be a contributing factor to New Zealand's high rates of excess winter mortality (Philippa Howden-Chapman, et al., 2012), as discussed earlier in this report.

As stated previously, it is estimated that 28,000 (22%) of households in Christchurch are likely to already to be in fuel poverty, around half of which are renters and half owner-occupiers (Wilton, 2014a). Additional analysis revealed that a further 7,500 households, including 2,500 renting households, currently using wood are likely to end up in fuel poverty if the use of wood burners were prohibited and these households switched to high-cost electrical heating (Wilton, 2014a). Nearly 2300 of the households likely to go into fuel poverty had at least one person with either chronic respiratory illness or cardiopulmonary disease. The findings are based on the income threshold for fuel poverty, minimum temperatures for home heating 16^0 C for bedrooms and 18^0 C for living areas, income levels from the Census data, and health statistics. The temperature thresholds used are lower than the WHO recommendation of 18^0 C and 21^0 C respectively, making these conservative estimates.

The total operation costs of replacement heating for these homes is estimated to be around $3 million (average of $400 per house) per year if a heat pump is installed. This increases to $12 million (or average of $1620 per house) per year for other forms of electric heating such as fan, oil or convection.

Summary of key findings

- There are a range of health effects that arise from household temperature below the recommended minimum temperatures for health.
- Introduction of either a ban on the use of wood burners or further restrictions on wood burners could exacerbate these effects for wood burning households.
- Specific areas of concern are:
    - Low income wood burning households
    - Households who may fall within fuel poverty thresholds due to increased heating costs
    - Households with members who have pre-existing health conditions that could be worsened by cold indoor temperatures
    - Rental households, who have less control over housing quality and heating appliances available for use
- The magnitude of effect on wood burning households will be dependent both on the timing of changes and the introduction of appropriate mitigation measures, as set out in the recommendations below.

Recommendations

1. A cross-sectoral response is needed to identify specific mitigation measures required to address the issues described above. Responsibility for these mitigations will likely fall across a range of organisations/agencies and roles.

2. The appropriate mechanism for this cross-sectoral response requires further investigation and discussion with key organisations and agencies, however the approach should incorporate and expand upon current initiatives, including the following:

    - Support and incentives made available for households to replace an existing wood burner with a heat pump, as this appliance is the recommended alternative in terms of operating costs and effectiveness.
    - Community level information campaigns and one-on-one education to inform people of alternative heating options, the importance of insulation, support and subsidies available, and how to correctly use their heating appliance.
    - Additional targeted support through health and social service providers for those with chronic respiratory and cardiac illness, the elderly, families with young children, and low-income households.

3. Separate consideration for renters is recommended as these households may have limited control over heating appliances, insulation, and general housing conditions, making them particularly vulnerable to regulatory changes relating to wood burner use. The following should be considered:

    - Support and incentives for landlords to insulate rental properties and install heating appliances that provide affordable heat.
    - Agreement from social housing providers to insulate dwellings to minimum standard and provide an affordable heat appliance, such as a heat pump.
    - Support for the continued development and introduction of the Rental Warrant of Fitness programme, to ensure property owners achieve minimum standards for the condition of rental properties.

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Appendices (attached)

Appendix 1. Heating and household survey report

Appendix 2. Heating choices and costs report

Appendix 3. Literature review

Appendix 4. Assessing the impact of prohibiting wood burner use on fuel poverty levels in Christchurch