Health and safety implications of improved housing quality

2nd Built Environment Research Symposium
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New Zealand
Outline

• We spend most time in our homes
• Housing trials on insulation & heating show causal relationships with health
• Generalisation to Warm Up NZ insulation & heating fund
• Community housing studies in progress
  – WHEZ study – heat as medicine
  – HIPI study – repairs to injury hazards
• Assessing housing quality in relation to health and safety
  – Injury index
  – Respiratory Health Index
  – A housing Warrant of Fitness?
Effect of insulating existing houses on health inequality: cluster randomised study in the community

Philippa Howden-Chapman, professor and director, Anna Matheson, PhD student, Julian Crane, professor and codirector, Helen Viggers, data analyst, Malcolm Cunningham, principal analyst, Tony Blakely, professor, Chris Cunningham, professor, Alistair Woodward, professor, Kay Saville-Smith, director, Des O'Dea, lecturer, Martin Kennedy, adviser, Michael Baker, senior lecturer and codirector, Nick Waipara, scientist, Ralph Chapman, associate professor, Gabrielle Davie, biostatistician

ABSTRACT
Objective To determine whether insulating existing houses increases indoor temperatures and improves occupants' health and wellbeing.
Design Community based, cluster, single blinded randomised study.

INTRODUCTION
The quality of housing affects the health of the population. Improvements to housing could potentially prevent ill health, especially in sections of the population exposed to substandard housing. Several reviews of social interventions, and housing interventions in par-
Insulated houses: significant results

- Bedroom temperatures increased
- Decreased relative humidity
- Energy use (all sources) reduced by 19%
- Bedroom temps below 10°C for 1.7 fewer hours each day
- Reduced odds (halved):
  - fair or poor self-rated health
  - Wheezing
  - Children taking a day off school
  - Adults taking a day off work fewer visits to GPs
  - hospital admissions, trend but not statistically significant
Valuing the health gains, and energy and CO2 emissions savings, suggests that total benefits in “present value” (discounted) terms are one and a half to two times the magnitude of the cost of retrofitting insulation.
LPG heaters – poor person’s heater

- Third of NZ households have UFGHs
- Releases multiple combustion products indoors, including Nitrogen Dioxide (NO₂)
- Exposure to NO₂ can reduce immunity to lung infections & increase the severity and duration of a flu episode
- NO₂ inflames the lining of the lungs, which can cause problems such as wheezing, coughing, colds, flu and bronchitis.
- NO₂ increases health risks from particulates
Effects of improved home heating on asthma in community dwelling children: randomised controlled trial

Philippa Howden-Chapman, professor and director,1 Nevil Pierse, statistician,1 Sarah Nicholls, programme manager,1 Julie Gillespie-Bennett, PhD student,1 Helen Viggers, research fellow,1 Malcolm Cunningham, principal physicist,2 Robyn Phipps, director,3 Mikael Boulic, PhD student,3 Pär Fjällström, postdoctoral student,3 Sarah Free, MPH student,1 Ralph Chapman, associate professor and director of environmental studies,4 Bob Lloyd, associate professor and director,5 Kristin Wickens, senior research fellow,6 David Shields, research assistant,1 Michael Baker, associate professor and codirector,1 Chris Cunningham, professor,7 Alistair Woodward, professor and head,8 Chris Bullen, associate director of clinical trials unit,8 Julian Crane, professor and codirector1

ABSTRACT
Objective To assess whether non-polluting, more effective home heating (heat pump, wood pellet burner, flued gas) has a positive effect on the health of children with asthma.

C to 1.64°C and in the child’s bedroom of 0.57°C (0.05°C to 1.08°C). Lower levels of nitrogen dioxide were measured in the living rooms of the intervention households than in those of the control households.
Housing Heating and Health Study

- Randomised community trial
- Retrofitted insulation & sustainable heating in 409 households with asthmatic children
- Aims
  - Increase temperature to WHO minimum 18°C
  - Lower relative humidity
  - Reduce NO₂
  - Reduce symptoms of children with asthma


Previous:

- X electric heaters (2kW)
- X unflued gas heaters (4kW)

Replaced with:

- √ 320 heat pumps (4-7kW)
- √ 55 wood pellet burners (10kW)
- √ 11 flued gas heaters


Intervention

Results in intervention group

• Average temperature rose to almost 18°C
• 67% reduction in NO₂
• Overall fewer reports of lower & upper respiratory track infections
• Reduced asthma symptoms
• Fewer school absences
• Reduction in dry cough
• Reduction in sleep disturbed by wheeze
Sources of nitrogen dioxide (NO$_2$) in New Zealand homes: findings from a community randomized controlled trial of heater substitutions

Abstract Houses in New Zealand have inadequate space heating and a third of households use unflued gas heaters. As part of a large community intervention trial to improve space heating, we replaced ineffective heaters with more effective, non-polluting heaters. This paper assesses the contribution of heating and household factors to indoor NO$_2$ in almost 350 homes and reports on the reduction in NO$_2$ levels due to heater replacement. Homes using unflued gas heaters had more than three times the level of NO$_2$ in living rooms [geometric mean ratio (GMR) = 3.35, 95% CI: 2.83–3.96, $P < 0.001$] than homes without unflued gas heaters, whereas homes using gas stove-tops had significantly elevated living room NO$_2$ levels (GMR = 1.42, 95% CI: 1.05–1.93, $P = 0.02$). Homes with heat pumps, flued gas heating, or enclosed wood burners had significantly lower levels of NO$_2$ in living areas and bedrooms. In homes that used unflued gas heaters as their main form of heating at baseline, the intervention was associated with a two-third (67%) reduction in NO$_2$ levels in living rooms, when compared with homes that continued to use unflued gas heaters. Reducing the use of unflued gas heating would substantially lower NO$_2$ exposure in New Zealand homes.


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The respiratory health effects of nitrogen dioxide in children with asthma

J. Gillespie-Bennett*, N. Pierse*, K. Wickens#, J. Crane#, P. Howden-Chapman* and and. the Housing, Heating and Health Study Research Team*
More effective home heating reduces school absences for children with asthma

S Free, P Howden-Chapman, N Piere, H Viggers, the Housing, Heating and Health Study Research Team*

Figure 3 Days absent from school during winter 2006.

New heaters reduced school absences 1.9 days (average 21%)
Cost-benefit analysis 1.09:1

Ratio of benefits to costs 1.09:1 over 12 year life-span of heater

- purchase and installation cost of heaters
- time off work/school
- care-giving
- health services
- pharmaceutical use
Is your home one of the 900,000 houses with sub-standard insulation?

You could get 1/3 off the cost to upgrade.
Warm Up NZ: Heat Smart Programme

• 100,000 houses in first 2 years of programme
• $320 million, **not** targeted to low income
• Quasi-experimental study, detailed anonymised matching of first 46,655 houses
• Small but significant drop in metered energy
• Significant health benefits in reduced pharmaceutical usage, length of hospitalisation, avoidable mortality for over 65s
• Benefit/cost ratio 3.9:1

http://www.motu.org.nz/news-media/detail/reports_on_warm_up_new_zealand_heat_smart_now_available
## Effect of treatment on mortality rates in people aged 65+ hospitalised with circulatory illness prior to treatment month

<table>
<thead>
<tr>
<th></th>
<th>Hospitalised before treatment month (numbers)</th>
<th>Deaths after treatment month (numbers)</th>
<th>Mortality rate per 1000 people per year</th>
<th>RR (95% CI) p-value</th>
<th>Hazard Ratio (HR) calculated using Cox proportional hazards model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Treatment</strong></td>
<td>958</td>
<td>51</td>
<td>69.8 (51.2-88.3)</td>
<td>0.62 (0.45-0.84)</td>
<td>0.61 (0.45-0.81) p=0.002</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>2231</td>
<td>184</td>
<td>112.7 (97.2-128.2)</td>
<td>p=0.002</td>
<td></td>
</tr>
</tbody>
</table>
Warm Homes for Elder New Zealanders (WHEZ)

- 522 people over 55 with COPD
- Intervention $500 electricity voucher
- Heat as medicine
- Whanganui, Palmerston North, Wellington & Christchurch
- Community partnerships with asthma societies, outpatient respiratory clinics
- Half participants’ homes colder than they would like and they have shivered inside
Crowding link to infectious diseases

• When only one room heated, people crowd together
• Probable link to increasing rate of infectious diseases in New Zealand

Increasing incidence of serious infectious diseases and inequalities in New Zealand: a national epidemiological study

Michael G. Baker, Lucy Telfar Barnard, Amanda Kvatsvig, Ayesha Verral, Jane Zhang, Michael Keall, Nick Wilson, Teresa Wall, Philippa Howden-Chapman

Summary
Background Although the burden of infectious diseases seems to be decreasing in developed countries, few national studies have measured the total incidence of these diseases. We aimed to develop and apply a robust systematic method for monitoring the epidemiology of serious infectious diseases.
The Healthy Housing Index (HHI) questionnaire

- Developed to suit NZ conditions - Collaboration between *He Kainga Oranga* and BRANZ
- Checklist of hazards (degree of hazard) in house
- Inspectors trained but use less expert judgement than the English Housing Health and Safety Rating System
- Reflects likelihood that occupants will suffer sickness or injury due to housing factors

*Assessing housing quality and its impact on health, safety and sustainability*

Michael Keall,¹ Michael G Baker,¹ Philippa Howden-Chapman,¹ Malcolm Cunningham,² David Ormandy³

Research using the HHI

• Based on expert opinion, formed indices for:
  – Injury
  – Respiratory hazards
• These indices show an increase in the level of hazards presented by the house
• Validated using cross-sectional studies
• Subsequently used in research to control for relevant housing factors
• The HHI is a valid policy tool for improving health via improved housing quality as measured by the HHI
<table>
<thead>
<tr>
<th>Section</th>
<th>Present</th>
<th>Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.12 Landings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.12.1 Are there landings?</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>9.12.2 Landing balustrade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not present</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Less than 1000mm height</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Openings greater than 100mm</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Insufficient strength</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Disrepair</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>9.13 Stair lighting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequately lit</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>No light switch at top of stairs</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>No light switch at bottom of stairs</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>9.14 Stair Hazards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mirrors or glass doors etc.</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Steps between kitchen &amp; dining spaces</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Steps between bedrooms &amp; toilets</td>
<td>Y</td>
<td>N</td>
</tr>
</tbody>
</table>
Injury hazards included in the Healthy Home Index:

- Bathroom floor uneven/slippery/sloped.
- Shower/bath with slippery surface.
- Inadequate space around bath/shower.
- In rest of house (apart from bathroom) floor uneven/slippery/sloped.
- Unsafe electrical wiring.
- Hot water thermostat temperature set to >60° or measured >55° at tap.
- Internal stairs present
  - Stair handrail in disrepair/too high or too low/not continuous.
  - Landing balustrade in disrepair/too low/too wide openings/insufficient strength.
  - Stair risers uneven/too low/too high.
  - Stairs slippery.
  - Stairs not adequately lit.
  - Stairs too steep.
  - Stair treads too wide or narrow or uneven.
- Steps between bedroom and toilet.
- Insecure carpet on steps.
- Steps between kitchen and dining area.
- Mirrors or glass doors adjacent to stairs.
- No storage area in each of bathroom/kitchen/laundry available protected from young children.
- Outdoor pathway poorly lit/slippery/too steep/uneven/window opens onto pathway in hazardous way.
- Handrail on external steps in poor condition.
- Handrail on external steps needed but not provided.
- External steps structurally unsafe.
- External steps treads and risers of different heights.
- External steps flights of less than three steps grouped together.
- External steps with missing treads.
- External steps necessary (steep pathway).
- External steps slippery.
- External steps poorly lit/difficult to see.
HHI Inspection in progress
Healthy Housing Index

Applications - current and future

HHI Version 1 – Pilot tested on 102 houses, Hutt Valley, 2004

HHI Version 2 – 1,000 houses, ACC/Better Homes Taranaki, 2007-8

HHI Version 2 – 250 Maori households in Nelson/Marlborough

HHI Version 2 – Used to assess Christchurch City Council housing, 2007-8

HHI Version 2
– discussions underway with several agencies – to be used for study of Aboriginal housing in Australia
– HRC randomised controlled community trial of home hazard remediation


Validating the injury hazards index

- Sample of 100 consenting households in Hutt Valley
- HHI used to evaluate house
- Linked ACC records for home injury to people in house
- Looked at associations between risk of injury and level of hazards of the home
- ACC reported injury to person during 2 years prior to house inspection
- 22% increase in odds with each additional hazard (95% CI: 6% to 41%)
- Increases to 26% when age, gender and NZ Dep quintile included in model
Percent of sampled people that had ACC reported accident by quartiles of injury hazards in house

Number of hazards

Percentage of houses

Formulating a home safety intervention that might work

- subjects: a total of 1,612 occupants of 961 households in Taranaki
- text descriptions of participants’ 1,328 medically treated home injuries over 4 years
- further information on injuries from telephone interviews
- HHI home inspection by trained inspectors to identify numbers and types of injury hazards
- attitudes to repairs (small sub-sample)
## Classification from text descriptions

<table>
<thead>
<tr>
<th>Text description</th>
<th>Potentially associated with home environment</th>
<th>Injury coded as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>While lifting baby, a sudden severe low back pain</td>
<td>No</td>
<td>Lifting</td>
</tr>
<tr>
<td>Pulling out tree and branch went into left eye</td>
<td>No</td>
<td>Gardening</td>
</tr>
<tr>
<td>Threw himself backwards onto concrete in a tantrum</td>
<td>No</td>
<td>Other</td>
</tr>
<tr>
<td>Climbing on couch fell off back</td>
<td>No</td>
<td>Other</td>
</tr>
<tr>
<td>Lifting concrete into drive way and felt sharp pain</td>
<td>No</td>
<td>Home maintenance</td>
</tr>
<tr>
<td>Rising out of chair and twisted right knee</td>
<td>No</td>
<td>Other</td>
</tr>
<tr>
<td>Wrenched left shoulder getting item from cupboard</td>
<td>Yes</td>
<td>Other</td>
</tr>
<tr>
<td>Tripped and fell on steps</td>
<td>Yes</td>
<td>Slip/trip/fall</td>
</tr>
</tbody>
</table>

Implications and future research

- The dose-response relationship from a cross-sectional study: increasing number of hazards associated with increased injury rate
- This suggests that addressing home injury hazards may be effective in reducing home injury rates
- But... there are many potential confounders that could also explain the relationship found
- We formed a set of potential repairs based on where and how home injuries occur, and common home injury hazards that might be implicated
- In the Home Injury Prevention Intervention (HIPI) study, we recruited 800 households, made repairs to (randomised) half of these two years ago, with repairs to remainder about to be made early next year
Some common remediations made as part of the HIPI study
Respiratory hazards index

- ASTHMA study (analysis funded by the Asthma and Respiratory Foundation of New Zealand)
- 1000 households in Taranaki
- Owner-occupied, built before 1980
- Data collected from August 2007 to September 2008


Keall et al. Environmental Health 2012, 11:33
http://www.ehjournal.net/content/11/1/33

A measure for quantifying the impact of housing quality on respiratory health: a cross-sectional study

Michael D Keall¹*, Julian Crane², Michael G Baker¹, Kristin Wickens², Philippa Howden-Chapman¹ and Malcolm Cunningham³

Diagram of study

**Behavioural factors**
- Crowding
- Smoking

**Causal chain**
- Damp, cold conditions
- Presence of contaminants (mould, bacteria, dust mites, NO2)
- Respiratory symptoms

**Means of measurement**
- Presence of insulation, degree of shade, feels damp, unflued gas heating
- Musty smell, presence of mould (in or under house), unflued gas heating
- Self-report (recall over 12 month period)


<table>
<thead>
<tr>
<th>Feature assessed</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>feels a little damp</td>
<td>182</td>
<td>23%</td>
</tr>
<tr>
<td>feels quite damp</td>
<td>32</td>
<td>4%</td>
</tr>
<tr>
<td>in shade - partial</td>
<td>389</td>
<td>51%</td>
</tr>
<tr>
<td>in shade - substantial</td>
<td>82</td>
<td>11%</td>
</tr>
<tr>
<td>house smells musty</td>
<td>37</td>
<td>5%</td>
</tr>
<tr>
<td>any mould in bedrooms/living rooms</td>
<td>39</td>
<td>5%</td>
</tr>
<tr>
<td>unflued gas heater in any bedrooms/living rooms</td>
<td>212</td>
<td>27%</td>
</tr>
<tr>
<td>fungi/mould on joists or bearers</td>
<td>22</td>
<td>4%</td>
</tr>
<tr>
<td>minor leaks in roof</td>
<td>114</td>
<td>13%</td>
</tr>
<tr>
<td>major leaks in roof</td>
<td>26</td>
<td>3%</td>
</tr>
<tr>
<td>ponding of water under house</td>
<td>32</td>
<td>4%</td>
</tr>
<tr>
<td>no floor insulation</td>
<td>527</td>
<td>88%</td>
</tr>
<tr>
<td>no ceiling insulation</td>
<td>799</td>
<td>100%</td>
</tr>
<tr>
<td>no wall insulation</td>
<td>799</td>
<td>100%</td>
</tr>
</tbody>
</table>
Ratings of houses by the Respiratory Hazard Index (0 = least hazardous)

<table>
<thead>
<tr>
<th>Respiratory hazard index</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>156</td>
<td>8%</td>
</tr>
<tr>
<td>1</td>
<td>511</td>
<td>25%</td>
</tr>
<tr>
<td>2</td>
<td>689</td>
<td>34%</td>
</tr>
<tr>
<td>3</td>
<td>398</td>
<td>20%</td>
</tr>
<tr>
<td>4</td>
<td>195</td>
<td>10%</td>
</tr>
<tr>
<td>5 plus</td>
<td>91</td>
<td>4%</td>
</tr>
</tbody>
</table>
Risk of wheezing or whistling in the chest during the past 12 months by the housing respiratory hazard index


Risk of asthma attack during the past 12 months by the housing respiratory hazard index

Summary of results of ASTHMA study

• Limited by being an observational study
• But with strength of having independent assessment of housing quality
• We developed a Respiratory Health Index based on research and expert opinion
• Showed statistically significant increase in respiratory symptoms as housing quality deteriorated
• If we could improve the worst houses to be as good as the best, the rate of respiratory symptoms might halve in these houses
### Expert Advisory Group on Solutions to Child Poverty

**Solutions to Child Poverty in New Zealand**

**Issues and Options Paper for Consultation**

28 August 2012

<table>
<thead>
<tr>
<th>Priority issues for children in poverty</th>
<th>Short-term actions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Housing</strong></td>
<td><strong>Warrant of fitness for rental properties</strong></td>
</tr>
<tr>
<td>Many children live in poor quality and overcrowded houses (particularly Māori and Pasifika children) and suffer serious health conditions because of this</td>
<td>- Set a basic standard for rental properties (such as houses must have heating and insulation, sanitation, and be safe). Help landlords to meet the standards by introducing tax breaks for renovations and repairs.</td>
</tr>
<tr>
<td>Options provide opportunities to:</td>
<td>- Accommodation Supplement (AS) and Income Related Rents (IRR)</td>
</tr>
<tr>
<td>- reduce over-crowding</td>
<td>- AS and IRR are housing subsidies – about $2 billion paid out each year. They need to be reviewed and refocused to work better for low-income families and whānau</td>
</tr>
<tr>
<td>- improve the quality of housing, particularly rental properties</td>
<td></td>
</tr>
<tr>
<td>- increase the number of social houses and other affordable housing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Housing and critical infrastructure</td>
</tr>
<tr>
<td></td>
<td>- Include Housing as a priority in the National Infrastructure Plan and make finding solutions to the poor quality, and severe undersupply of affordable housing, a priority</td>
</tr>
</tbody>
</table>
Conclusion

• He Kainga Oranga / Housing and Health Research Programme examines and clarifies the links between Housing and Health

• Associations between poor housing and ill health are well known

• But the links that make up the causal chain have until recently been poorly understood

• We conduct policy-relevant research, supported by cost-benefit analyses, to highlight initiatives that will fundamentally improve health and safety via improved housing