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**THE INDOOR ENVIRONMENTAL BENEFITS FROM
REPLACING UNFLUED GAS AND PORTABLE ELECTRIC
HEATERS WITH HIGHER CAPACITY NON INDOOR
POLLUTING HEATERS:
AN INTERVENTIONAL FIELD STUDY**

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*To my Tad-Kozh who left for his last
Journey at the beginning of this project and
to my daughter Moana who arrived at the end of this project.*

Abstract

A two year intervention study investigated the relationship between domestic heaters and indoor environment of children with asthma. The main objectives of this project were to investigate the changes to the measured indoor environmental parameters, when a higher capacity non indoor polluting replacement heater was installed and to examine if this intervention was sufficient to provide the households with a healthy indoor environment.

Baseline monitoring was carried out in the living rooms and child's bedrooms of 33 homes including the real time measurement of four gaseous key pollutants, room temperature, relative humidity (RH) and usage of the original heater (unflued gas heater (UGH) or portable electric heater) for up to one week. Airborne fungi level and fungi level from the floor dust were measured and a visual inspection of fungi was undertaken. The suitability of the wall environment for fungi development was estimated via a fungal detector and correlated to wall psychrometric conditions (temperature, RH). The different fungi assessment methods were compared. The measurements were repeated in 36 homes, following the replacement of the UGH or portable electric heater with a higher capacity non indoor polluting heater such as flued gas heater, wood pellet burner or heat pump in the intervention homes. Of these homes, 27 were monitored for both winters.

Excessive levels of pollutants were found when the UGH was operated, even for short periods. Acceptable air quality levels were achieved for all replacement heater homes. The study showed that the replacement heaters were operated for longer periods than the heaters they replaced. The homes with the replacement heaters installed were warmer and dryer and had less mould than the homes with UGHs. The replacement heater also had a positive impact on the wall psychrometric conditions with reduced water availability for mould to grow.

Replacing the UGH with a higher capacity non indoor air polluting heater reduced the asthmatic children's exposure to harmful indoor environment. Unvented gas heating appliances should be more regulated and ideally should not be operated in homes.

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List of Abbreviations

ASHRAE: American Society of Heating, Refrigerating and Air conditioning Engineers

BRANZ: Building Research Association of New Zealand

CL: chemiluminescence analyser

CO: carbon monoxide

CO₂: carbon dioxide

DG18: dichloran 18% glycerol agar

EECA: Energy Efficiency and Conservation Authority

FGH: flued gas heater

HCHO: formaldehyde

HDD: Heating Degree Day

HEEP: Household Energy End-Use Project

HHH: Housing, Heating and Health study

HP: inverter heat pump

IAQ: Indoor Air Quality

IEA: International Energy Agency

IEM: Intensive Environmental Monitoring

ISO: International Organization for Standardization

LPG: Liquefied Petroleum Gas

MEA: Malt Extract Agar

NO₂: nitrogen dioxide

NZ: New Zealand

NZBC: New Zealand Building Code

NZS: New Zealand Standard

OECD: Organisation for Economic Co-operation and Development

RH: relative humidity

UGH: unflued gas heater

VP: water vapour pressure

WB: wood burner

WHO: World Health Organisation

WPB: wood pellet burner

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List of Papers

Preliminary results of the present IEM study have been published in the following papers. These papers are listed by date of publication and are presented in the Appendix Part.

- I. **Boulic, M.**, Phipps, R.A., Cunningham, M., Cleland, D. J., and Fjällström, P. R. (2006). Too dry and too cold for mould germination in New Zealand dwellings? *In Proceedings of the 10th Annual Environmental Postgraduate Conference, Australia's Largest Postgraduate Environmental Conference, Sydney, Australia*, 34-39.
- II. Phipps, R.A., Cunningham, M., Fjällström, P.R., **Boulic, M.**, Howden-Chapman, P., Crane, J., Baker, M., Viggers, H., Robinson, J.A., Nicholls, S., Lloyd, B., and Chapman, R. (2006). Not just hot air: Methods and preliminary results for the intensive monitoring of emissions and by-products from two types of domestic heaters. *In Proceedings of Healthy Buildings 2006, de Oliveira Fernandes, Gameiro da Silva, and Rosado Pinto (Eds.), Lisboa, Portugal*, 399-402.
- III. **Boulic, M.**, Phipps, R.A., Cunningham, M., Cleland, D.J., and Fjällström, P.R. (2007). Too dry and too cold for mould germination in New Zealand dwellings? *International Journal of Global Environmental Issues*, 7(4), 330-340.
- IV. **Boulic, M.**, Fjällström, P.R., Phipps, R.A., Cunningham, M., Cleland, D.J., Howden-Chapman, P., Chapman, R., and Viggers, H. (2007). Cold homes in New Zealand - low heater capacity, or low heater use? *In International Council for Research and Innovation in Building and Construction. Auckland, New Zealand*. 1-8.
- V. **Boulic, M.**, Fjällström, P.R., Phipps, R.A., Cunningham, M., Cleland, D.J., Pierse, N., Howden-Chapman, P., Chapman, R., and Viggers, H. (2008). Cold

homes in New Zealand - Does increasing the heater capacity improve indoor temperatures? *Clean Air and Environmental Quality Journal*, 42(3), 22-30.

VI. **Boulic, M.**, Phipps, R.A., Cunningham, M., Cleland, D.J., and Fjällström, P.R. (2009). Did replacing unflued gas heaters with inverter heat pumps decrease the indoor potential for mould growth? *In Do damp and mould matter? Health impacts of leaky homes, Howden-Chapman, Bennett, and Siebers (Eds.) Wellington, New Zealand.* 100-113.

VII. **Boulic, M.**, Phipps, R.A., Fjällström, P.R., Cunningham, M., Cleland, D.J., and Howden-Chapman, P. (2009). Stop "heating the birds": Well being at home and heating options. *In Massey University Centre for Energy Research Energy Post Graduate Conference, Palmerston North, New Zealand.* 1-6.

Further papers have been published from the parent Housing, Heating and Health (HHH) Study.

VIII. Howden Chapman, P., Pierse, N., Nicholls, S., Gillespie Bennett, J., Viggers, H., Cunningham, M., Phipps, R.A., **Boulic, M.**, Fjällström, P., Free, S., Chapman, R., Lloyd, B., Wickens, K., Shields, D., Baker, M., Cunningham, C., Woodward, A., Bullen, C., and Crane, J. (2008). Effects of improved home heating on asthma in community dwelling children: Randomised controlled trial. *British Medical Journal (BMJ)*, 337, 1-9.

IX. Gillespie-Bennett, J., Pierse, N., Wickens, K., Crane, J., Nicholls, S., Shields, D., **Boulic, M.**, Viggers, H., Baker, M., Woodward, A., Howden-Chapman, P., and the Housing, Heating, and Health Team. (2008). Sources of nitrogen dioxide (NO₂) in New Zealand homes: findings from a community randomized controlled trial of heater substitutions. *Indoor Air*, 18(6), 521-528.

X. Free, S., Howden-Chapman, P., Pierse, N., Viggers, H., Nicholls, S., Bennett, J., Cunningham, M., Phipps, R.A., **Boulic, M.**, Fjällström, P., Chapman, R., Shields, D., Lloyd, B., Wickens, K., Cunningham, C., Woodward, A., Baker,

M., Bullen, C., and Crane, J. (2009). More effective home heating reduces school absences for children with asthma. *Journal of Epidemiology and Community Health*, 64, 379-386.

XI. Preval, N., Chapman, R., Pierse, N., Howden-Chapman, P., Nicholls, S., Gillespie-Bennett, J., Viggers, H., Cunningham, M., Phipps, R.A., **Boulic, M.**, Fjällström, P., Free, S., Lloyd, B., Wickens, K., Shields D., Baker, M., Cunningham, C., Woodward, A., Bullen, C., and Crane, J. (2010) Evaluating energy, health and carbon co-benefits from improved domestic space heating: A randomised community trial. *Energy Policy Journal*, 38, 3965-3972.

My contribution to the papers

From this IEM study, four conference papers, two journal articles and one book chapter were published.

For all papers, from the section “List of Papers (I to VII)”, I carried out the fieldwork, with the assistance of Dr Pär Fjällström, I analysed the data and I wrote the first draft of each paper. The co-authors did comment on the draft, except Paper II which was written by Associate Professor Phipps.

I presented the results from Paper I, Paper IV and Paper VII, as principle researcher at conferences.

Paper I “Too dry and too cold for mould germination in New Zealand dwellings” that I presented, as principle researcher, at *the 10th Annual Environmental Postgraduate Conference in Sydney, Australia* was one of the eight papers selected (out of 42 papers presented) to be published in the *International Journal of Global Environmental Issues* (Paper III).

I was invited to the Auckland and Wellington sessions of the 12th Public Health Summer School *"The impact of the Leaky Buildings on health"*, organised by the University of Otago, to co-present with A/Prof Robyn Phipps the Paper VI results.