Indoor conditions and mould growth in New Zealand homes

Many New Zealand homes have mould growth in bedrooms and bathrooms due to inadequate heating and/or ventilation. During winter in 2016 and 2017, BRANZ monitored the indoor temperature and relative humidity at 88 homes across New Zealand and found bedrooms were often colder and damper than generally considered healthy. Excessively high mould spore counts were observed in several homes. Occupants were also asked about their perception of cold and damp problems and how they heat and ventilate their homes.

The temperature and relative humidity[1] inside homes are important for ensuring the comfort and health of the occupants. Cold temperatures and excessive levels of moisture are problematic because they can result in mould growth, which can impact the respiratory health of the occupants and also cause deterioration in building materials.

BRANZ collected information from two sets of homes over the winters of 2016 and 2017 to learn more about the living conditions in New Zealand housing (Table 1).

In 2016, the temperature and relative humidity in bedrooms and bathrooms were monitored in 64 homes across New Zealand. These houses were a subset of the dwellings visited during the 2015 House Condition Survey undertaken by BRANZ every 5 years since 1994. This survey involves a detailed visual assessment of the dwelling, recording data on how homes are maintained, the conditions people are living in and the extent and severity of mould visible in all rooms of the house. The 64 homes monitored were also sent a short questionnaire about the occupants' ventilation habits (use of extractor fans and opening windows), how they perceive the warmth and comfort in their main living area and bedrooms and any problems including damp and mould.

During winter in 2017, BRANZ carried out a more detailed study at a further 25 homes of members of a local marae in the Wellington region. Living areas were monitored as well as bedrooms and bathrooms, and 24 households were interviewed about their heating and ventilation habits, comfort and any problems experienced during winter. Visible mould was again recorded, and additional air samples were taken to collect mould spores and identify the presence of individual mould species. In some houses, dust samples were collected to see if this method could detect the presence of fungal and bacterial byproducts (known as metabolites).

Conditions observed in New Zealand homes during winter 2016 and 2017

Temperature

The monitoring showed that the temperature

[1] Relative humidity is the measured moisture in the air as a percentage of the highest possible level of moisture in air at that temperature.

variability in the bedrooms is large. The minimum indoor temperature recommended by the World Health Organization is 18°C. Most of the bedrooms monitored in this study were below healthy temperatures for more than 70% of the time (Table 2). The lowest temperatures were reached in the early morning hours as most bedrooms were not heated during the night. Heating of bedrooms mainly occurred in the evening, but this may have been by heat transport from other parts of the building rather than direct heat input in the bedroom.

Relative humidity

The median relative humidity measured in bedrooms during the 2016 and 2017 studies was 64% over the full day and 65% during the night only. This means that, for 50% of the time, the bedrooms were damp enough to need ventilation and/or heating to reduce the air moisture levels (Figure 1). Indoor moisture should not exceed 65% relative humidity to reduce the likelihood of mould growth.

Presence of mould, bacteria, spores and their metabolites

High levels of mould were found most often in bedrooms. This could be caused by high moisture levels in the rooms. Moisture levels can be exacerbated by a lack of heating and/or ventilation. However, some New Zealand houses simply do not have enough thermal insulation to prevent mould growth, even with adequate heating and ventilation.

As occupants spend many hours in the bedroom, the observed levels are of concern and could have some health implications. This study used four techniques to determine the exposure of the occupants to mould and bacteria - direct observation of visible mould (Table 3), airborne sampling onto a microscope slide (Table 4), viable spore count onto an agar plate and an experiment to test whether measurements could be made from samples of the floor dust.

Table 1. Measurements and surveys carried out at homes for 6 months during 2016 and 2017.

STUDY YEAR	2016	2017
Location	Auckland, Wellington, upper South Island, Dunedin	Wellington region
Number of homes surveyed	64	25
Number of bedrooms monitored	151	58
TEMPERATURE AND RELATIVE HUMIDITY MEASUREMENTS		
Number of sensors	309 in 64 homes	132 in 24 homes
Rooms monitored	Bedrooms and bathrooms	Bedrooms, bathrooms, living areas and kitchens (utility rooms excluded)
OTHER OBSERVATIONS		
Sampling	Observed mould (mould index determined)	Observed mould, air samples and dust samples
Surveys of occupants	Self-completed questionnaire (all 64 returned)	In-depth, semi-structured, face-to-face interview (24, one household declined)

Occupant heating and ventilation behaviour

The 2016 householder questionnaire and 2017 householder interviews showed people tended to ventilate their homes by using mechanical extract ventilation (where present) and/or opening the windows. However, the reported ventilation habits were not always aligned with best practice - for example, some participants relied on constant ventilation (the window open a small amount all the time) rather than actively and effectively airing out the house.

In the 2017 study, many householders reported they heat the living area, which appears to align with the results seen in the temperature data. However, little direct heating of bedrooms was reported or picked up in the measurements. This spot heating behaviour may ensure the living area is at a healthy temperature, but bedrooms were often much colder than recommended levels.

Further work

Further work planned by BRANZ includes:

- analysing floor dust samples at 200 homes to detect mycotoxins (toxins from moulds and bacteria)
- using this technique to investigate whether the presence of mycotoxins produced by certain moulds aligns with the occupants' lung function
- finding out whether householder-reported behaviours align with observed temperature, relative humidity and levels of mould
- exploring reported window-opening habits by looking at data from motion sensors affixed to windows as part of a parallel study.

Table 2. Amount of time that some bedrooms were below healthy temperatures (18ºC).

READINGS	1 JUNE – 31 AUGUST 2016 (ALL MEASURED LOCATIONS)		1 JUNE – 31 AUGUST 2017 (WELLINGTON ONLY)	
	AMOUNT OF TIME (%)	BEDROOMS AFFECTED (%)	AMOUNT OF TIME (%)	BEDROOMS AFFECTED (%)
Less than 10ºC	3	54	2	29
Less than 12ºC	10	86	6	60
Less than 14ºC	25	96	19	89
Less than 16ºC	50	99	44	93
Less than 18ºC	76	100	70	95
Less than 21ºC	96	100	99	100

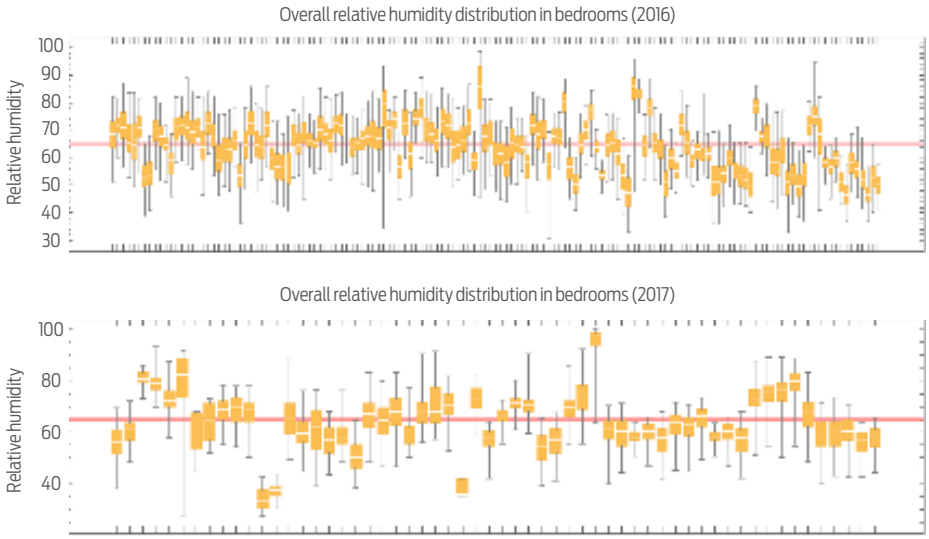

Figure 1. Overall relative humidity over the whole day in the bedrooms of homes during the 2016 and 2017 studies. Line indicates 65% relative humidity that should not be exceeded for a sustained period of time.

Conclusions

Many homes in New Zealand lack adequate heating and ventilation to provide a healthy indoor environment during the winter months. This is most likely due to the relatively poor insulation in older homes, which means they are expensive to heat to 18°C or over. The excess moisture in many homes means there is mould growth in bathrooms and bedrooms where occupants spend a large amount of their time.

Heating homes to a higher temperature and ventilating them adequately can reduce moisture-related problems. However, in practice, this may not be affordable or realistic for some households who struggle to heat their homes adequately. This highlights the impact of cost on heating habits and home comfort and the importance of thermal performance in dwellings.

Table 3. Mould observed in the main bedroom during the 2017 study.

	COUNT OF HOUSES WITH VISIBLE MOULD IN THE MAIN BEDROOM				
MOULD SCALE	WALLS	CEILING	FLOOR	WINDOWS	CURTAINS
None	20	18	22	9	11
Small	1	4	0	5	6
Moderate	1	0	1	6	3
Large or extensive	1	1	0	3	3

More information

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Table 4. Types of mould and bacteria detected in air samples.

HOUSE LOCATION	STACHYBOTRYS	CHAETOMIUM	PENICILLIUM/ASPERGILLUS		CLADOSPORIUM		BACTERIAL CLUSTERS (HIGH LEVELS)	OTHER SPORE TYPES
			EXCESSIVE	ELEVATED	EXCESSIVE	ELEVATED		
Auckland	Bedroom 1							
Dunedin			Bedroom 1 Living room	Bathroom		Living room	Living room* Bedroom 1	Living room
Auckland		Bathroom	Bedroom 1	Bathroom Living room	Bedroom 1		Bedroom 1 Bathroom** Living room	Bedroom 1 Living room
Wellington			Bedroom 3		Bedroom 3		Bedroom 3	Bedroom 3
Auckland			Bedroom				Bedroom	Bedroom
Auckland			Bedroom 2				Bedroom 2	
Wellington			Bedroom 3		Bedroom 3		Bedroom 3	
Christchurch				Bedroom 1		Bedroom 1	Bedroom 1	
Auckland				Bedroom		Bedroom	Bedroom	Bedroom
Auckland				Bedroom				Bedroom
Christchurch		Living room		Bathroom				Living room Bathroom
Dunedin		Bathroom						

* Likely to be due to increased moisture resulting in bacterial growth.
** Likely to be indicative of condensation and a lack of good ventilation.