



Keeping our children warm and dry: Evidence from *Growing Up in New Zealand*

In world-first research, measures of indoor environments were assessed against children's physical and mental health and wellbeing to determine optimal ranges for indoor temperature and humidity. The optimal bedtime temperature in children's homes was found to be 19-25°C with a relative humidity of 50%. Children living in environments outside these optimal conditions had increased odds of experiencing poorer general health.

The World Health Organization (WHO) has recommended that an indoor housing temperature of 18-24°C in temperate countries is the optimal range for staying healthy. There has been relatively little detailed research behind these figures, however, and sparse evidence connecting actual recorded indoor climate measures directly to children's health and wellbeing.

Measuring indoor temperature and relative humidity in the homes and classrooms of 8-year-old children was therefore included in the most recent 8-year data collection wave as part of the ongoing *Growing Up in New Zealand* longitudinal cohort study.

The *Growing Up in New Zealand* study recruited 6,853 unborn children via their pregnant mothers in 2009/10. The cohort includes significant numbers of Māori, Pacific and Asian children as well as Pākehā New Zealander or European children. Data collection began during pregnancy, with data collected on multiple occasions during the children's early years. The study was designed to follow children from before birth to young adulthood. Its primary objective is to understand what shapes wellbeing of the current generation of young New Zealanders in the context of their families.

The research described in this Research Now is the result of collecting multiple indoor climate measures from the homes and schools of the main cohort children when they were approximately 8 years old. This research was conducted with the children between July 2017 and January 2019.

The three main areas of focus were to:

- determine the optimal temperature and humidity ranges associated with measures of children's health and wellbeing
- better understand the nature of the

association between home indoor environments and children's health and wellbeing

- understand the relationships between socio-demographic and home environmental factors and optimal indoor climates.

Direct indoor environment measures from the children's homes and schools were linked to existing longitudinal information about their overall health and wellbeing collected as part of the core *Growing Up in New Zealand* study. The researchers believe that this study is the first in the world to describe an optimal indoor climate range by combining temperature as the lower cut-off point and humidex (a calculation that considers heat and humidity - Masterton and Richardson, 1979) as the higher cut-off point.

HOW DATA WAS COLLECTED AND ANALYSED

The children collected indoor temperature and relative humidity data using a small hand-held digital temperature and relative humidity gauge. Measurements were made and entered

into diaries at eight different times across one weekday and one weekend day.

The scheduled times on the weekday included when the child:

- woke up in the morning
- arrived in the school classroom in the morning
- had a school lunchbreak
- arrived home from school
- went to bed at night.

The scheduled times on the weekend day included when the child:

- woke up in the morning
- had dinner
- went to bed at night.

The project assessed the indoor environment measures against 20 child health and wellbeing outcomes. Sixteen of these were reports from the mother on the child's physical health over different time periods - the past 12 months, the past month or recorded on the interview day.

The researchers also assessed indoor environment data against family and home socio-demographic factors based on 25 variables. These included measures of material hardship such as crowding (number of people per bedroom), putting up with cold to reduce cost and whether/how often food runs out due to lack of money.

The *Growing Up in New Zealand* study participants were recruited initially from three adjacent district health board areas (Auckland, Counties Manukau and Waikato). By the time of the 8-year data collection, most families had moved at least once and the children are now spread from the far north to the far south of the country, but the majority still lived in the original recruitment areas. It may therefore not be possible to extrapolate or generalise the results of this study to parts of the country that regularly experience colder or more extreme temperatures. It is possible that the links found between indoor temperatures and child wellbeing may be an underestimate of the association seen for all regions.

In the 8-year data collection, 81% of eligible children took part in some component of the data collection. A similar proportion of male and female children completed the measurements and diary compared to those that did not. This part of the survey was less likely to be completed by Māori and Pacific children, children from families without two parents present or families with income below \$70,000 per year and by those whose mothers, at the time the child was born, were under 30, whose education was less than a bachelor's degree and/or who lived in a high deprivation area.

The findings reflect results from children who are generally experiencing less

deprivation and less vulnerability. This may also mean that the findings underestimate the full impact that indoor housing conditions are having on child health and wellbeing in New Zealand. Overall, 2,232 children who recorded the indoor measurements in the scheduled times in their diary were included in this study.

Key findings around temperature:

- The mean of the average indoor temperature of the six measurements at home was 20.2°C (range of the averages of the six measurements: 10.3–29.5°C).
- The mean of the average indoor temperature of the two measurements at school was 20.2°C (range of the averages of the two measurements: 4.0–34.6°C).
- The corresponding means of the average values of NIWA outdoor temperatures were 13.4°C for home (-1.7–24.5°C) and 14.9°C for school (-0.8–30.9°C).

- The wake-up (mean 18.5°C) and bedtime (mean 21.1°C) temperatures were similar for weekday and weekend measurements.

- The mean school indoor temperature in the morning and at lunch was 18.9°C and 21.4°C.

The average temperature for both home and school was approximately 20°C. This is within the optimal range for WHO guidelines. However, considerable variability in average temperatures for both home (10.3–29.5°C) and school (4.0–34.6°C) throughout the two measurement days indicated that many children were experiencing a wide range of indoor temperatures in a 24-hour period.

There were the expected patterns of indoor temperatures rising as the day progressed and lower indoor temperatures in the winter months than the summer months (Figure 1). On winter weekdays, the wake-up (mean 17.1°C) and bedtime (mean 20.0°C) indoor temperatures

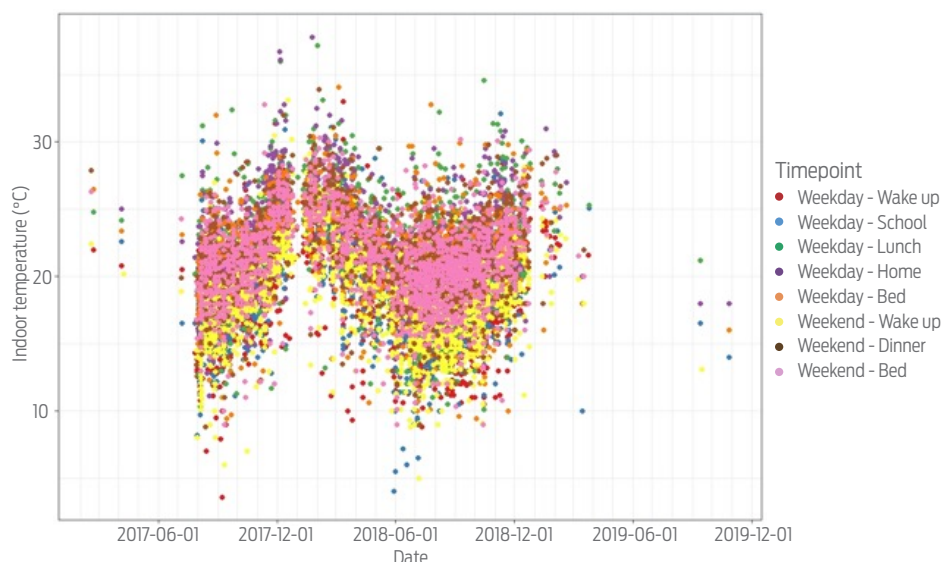


Figure 1. Indoor temperature variation across the data collection period.

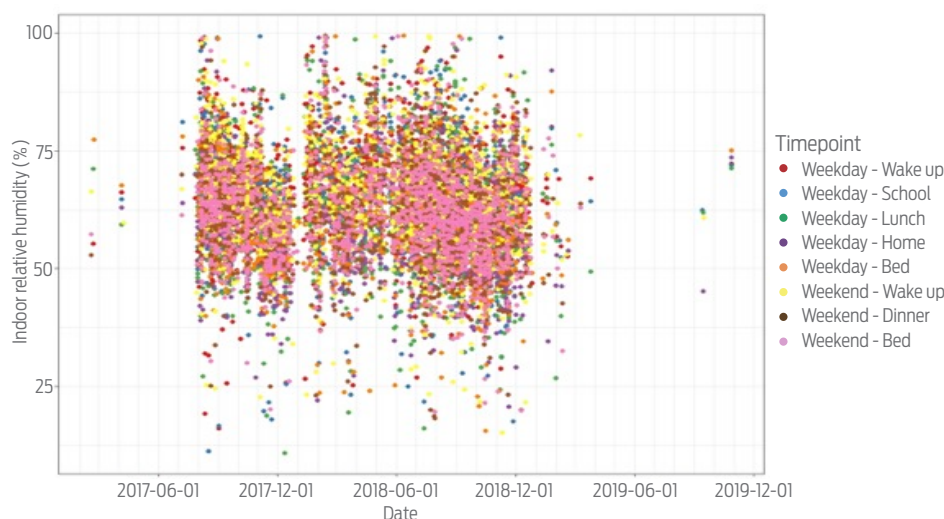


Figure 2. Indoor relative humidity across the data collection period.

were about 5°C lower than those in summer (wake-up 22.6°C, bedtime 24.7°C). There was no obvious seasonal pattern in indoor relative humidity measurements (Figure 2).

The indoor measurements taken were compared with hourly outdoor temperature and relative humidity data from the NIWA weather stations that represented the local weather close to the children's homes. Overall, indoor temperatures were positively correlated with outdoor temperatures (Figure 3).

INDOOR TEMPERATURE/HUMIDITY AND CHILD HEALTH

In terms of predicting differences in wellbeing across all the children, the most sensitive measures were the readings taken at bedtime on a weekday.

The optimal bedtime temperature was found to be 19–25°C (Table 1). Children who experienced bedtime temperatures less than 19°C or greater than 25°C had increased odds of experiencing poorer general health.

The optimal bedtime humidex range is 21–28 (Table 2). Children who experienced a bedtime humidex measure of less than 21 or greater than 28 had increased odds of experiencing poorer general health.

In addition to general health, the study found associations between indoor temperature and children's mental wellbeing. Suboptimal indoor temperatures tended to be associated with increased anxiety and depression symptoms in children.

SOCIO-DEMOGRAPHIC FACTORS

Indoor climate measures were found to be associated with child and family socio-demographic characteristics. There was a likelihood of participants experiencing temperatures less than 19°C and a humidex score greater than 28 in households where:

- there was crowding, with non-bedroom areas used regularly for sleeping
- there was a major problem with dampness or mould or families put up with feeling cold or had a problem with home heating or keeping warm in winter
- families often ran out of food, were regularly not able to afford to eat properly or experienced the lowest material wellbeing scores or the highest deprivation index score
- families paid rent rather than having a mortgage
- families had lower incomes
- the mother did not have a current partner or reported not having enough parenting support

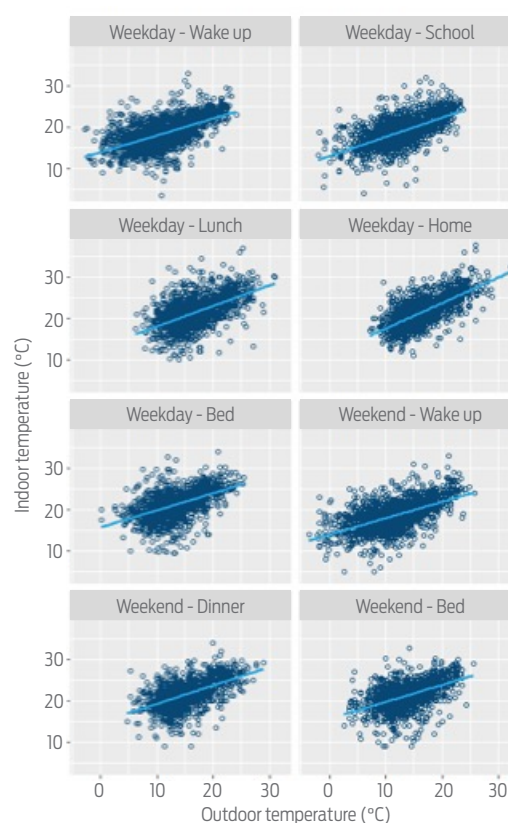


Figure 3. Correlation between indoor temperature and outdoor temperature as recorded at the local NIWA weather station.

Table 1. Determining the cut-off points of indoor bedtime temperature.

MODEL STATISTICS		HIGHER CUT-OFF LIMIT					
		>23°C	>24°C	>25°C	>26°C	>27°C	>28°C
LOWER CUT-OFF LIMIT	<16°C	189.9	222.6	232.1	181.3	188.6	181.1
	<17°C	191.9	224.9	234.0	182.6	189.8	182.2
	<18°C	260.1	294.2	297.9	239.2	246.4	237.8
	<19°C	269.8	303.7	303.9	241.3	248.4	239.2
	<20°C	194.2	228.1	234.9	181.2	188.4	180.7
	<21°C	187.4	221.0	229.2	179.4	186.6	179.5

Table 2. Determining the cut-off points of the indoor bedtime humidex score.

MODEL STATISTICS		HIGHER CUT-OFF LIMIT					
		>26	>27	>28	>29	>30	>31
LOWER CUT-OFF LIMIT	<18	203.7	218.5	227.3	200.6	205.7	179.6
	<19	210.1	224.8	233.1	205.0	209.9	183.1
	<20	213.1	227.5	235.3	205.9	210.5	183.2
	<21	237.2	249.9	255.1	220.8	224.3	194.8
	<22	227.5	239.5	244.3	210.2	213.8	184.8
	<23	220.6	232.0	236.3	202.1	205.9	177.5

- the mother reported her general health as either good, fair or poor rather than very good or excellent
- children identified themselves as Māori, Pacific or Asian.

IMPLICATIONS FOR REGULATION

On average, New Zealanders spend around 70% of each day in their homes. However, there is plentiful evidence that many homes have poor indoor environments.

The Pilot Housing Survey, a BRANZ and Stats NZ partnership, surveyed 832 houses across New Zealand in 2018/19. It found that mould is a significant problem, especially in rental houses - almost half of rental homes had bedrooms with levels of mould rated moderate or worse. Almost half our houses need more ceiling insulation to meet the recommended 120 mm thickness, and a similar number do not have mechanical extract ventilation ducted to the outside in the bathroom(s).

New Zealand Building Code clause G5 *Interior environment* requires that habitable spaces, bathrooms and recreation rooms in early childhood centres and old people's homes have the provision for maintaining the internal temperature at no less than 16°C. This does not apply to houses.

This study indicates that an indoor bedtime temperature of 16°C is below the optimal indoor climate range for children and was associated with a 75% increased risk of sub optimal/poorer child health. The findings of this study strongly suggest that a higher minimum indoor temperature limit should be considered for clause G5.

The Residential Tenancies (Healthy Homes Standards) Regulations 2019 require rental homes to have a fixed heating device that is capable of achieving a minimum temperature of at least 18°C in the main (or largest) living room in winter.

This minimum temperature of at least 18°C is close to this study's modelled cut-off point of 19°C for the child's bedroom at night, so it may be adequate. The healthy homes standards only apply to rental homes, however. They do not protect potentially vulnerable children in other home tenure types.

More information

Research Now: Indoor air quality #1 *An overview of indoor air contaminants in New Zealand houses*

Research Now: Indoor air quality #2 *An overview of indoor air contaminants in New Zealand schools*

Research Now: Indoor air quality #3 *The impact of ventilation in New Zealand houses*

Research Now: Indoor air quality #4 *Project: Indoor air quality in New Zealand homes and garages*

Research Now: Indoor air quality #5 *Project: Using a low-cost sensor platform to explore the indoor environment in New Zealand schools*

Research Now: Indoor air quality #6 *Project: Indoor air pollution at a New Zealand urban primary school*

Masterton J M & Richardson F A. (1979) *HUMIDEX - a method of quantifying human discomfort due to excessive heat and humidity*. Environment Canada. Downsview, Ontario, Canada.

This report was produced by the *Growing Up in New Zealand* team at the University of Auckland with funding and support from BRANZ. The Crown funding for the core *Growing Up in New Zealand* longitudinal study is managed by the Ministry of Social Development.

Read the full report:

Morton, S., Lai, H., Walker, C., Cha, J., Smith, A., Marks, E. & Avinesh, P. (2020). *Keeping our children warm and dry: Evidence from Growing Up in New Zealand*. BRANZ External Research Report ER58. Judgeford, New Zealand: BRANZ Ltd.

Find more details on the *Growing Up in New Zealand* study at www.growingup.co.nz