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The Southampton Survey on Asthma and Ventilation: Humidity Measurements During Winter

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Synopsis

As part of a collaborative trial on the effects of ventilation on house dust mites and asthma, 20 mechanical ventilation units were installed in houses in the Southampton area in southern England. The hypothesis is that continuous ventilation over winter months can maintain humidity below a mixing ratio of 7 g/kg, with a consequent reduction in house dust mite numbers. The systems served upstairs only, extracting from bathroom and landing and supplying fresh air to bedrooms. Temperature and humidity in the experimental houses and 20 control houses were recorded in the patients' bedrooms at carpet level. Over the 4 months from December to March the mechanically ventilated houses had significantly lower absolute humidities. Of the 20 MV houses, 15 had a mean mixing ratio below 7 g/kg, compared with only 3/20 of the non-MV houses.

1 Introduction

Much asthma is caused by an allergic reaction to the house dust mite and many approaches are under investigation for the control of mites[1]. It is known that increased levels of humidity provide a favourable environment for the growth of mites and there is strong evidence to indicate that dust mites may be controlled by maintaining a reduced indoor humidity during winter months[2]. During cold weather, indoor humidity may be reduced by ventilation with outside air to remove internally generated moisture. The use of mechanical ventilation with heat recovery (MVHR) enables this to be done efficiently, with neither draughts nor excessive heat loss.

EA Technology is collaborating in a major clinical trial on the effects of mechanical ventilation on humidity and asthma. The trial is under the overall direction of the Department of Child Health at Southampton University and the Building Research Establishment is undertaking the dust mite analysis together with IAQ measurements and householder surveys. The study covers asthma patients in 40 houses in the Southampton area and mechanical ventilation was installed in 20 houses in time for the 1994/95 heating season, after which monitoring continued for a year. In addition, half the houses have been supplied with a high efficiency vacuum cleaner to test whether it is effective in reducing ambient levels of houses dust mites and associated allergen. This report analyses the measurements of bedroom temperatures and humidities in the 40 houses covering a period up until the end of the 94/95 heating season, relating them to outside weather and the presence of mechanical ventilation.

2 Selection of houses

Southampton University recruited patients from among people attending the Southampton asthma clinic and those willing to participate completed a questionnaire about their home. Houses were rejected for the study if they were unsuitable for mechanical ventilation installation or were likely to have excessive background ventilation.

Houses were assigned to 4 experimental groups.

Group	Intervention	Number
1	Ventilation & vacuum cleaner	10
2	Ventilation	10
3	Vacuum cleaner	10
4	Monitoring alone	10

Groups 1 & 2 have mechanical ventilation, 3 & 4 do not. Allocation of houses to groups was done after preliminary observations of bedroom humidity became available. Houses were divided into 4 humidity bands and assigned randomly to groups within bands. Pressurisation tests were later carried out by the Building Research Establishment and analysis showed no significant difference in house leakage between experimental groups. The leakage results will be reported separately.

3 Ventilation equipment

To provide the benefits of mechanical ventilation without the disruption associated with retrofitting a whole house ventilation system, an 'upstairs' system was installed, complemented by an extract fan in the kitchen. The main MVHR unit containing fans and heat exchanger is mounted in the loft space, supplying tempered fresh air to bedrooms and extracting moist air from the bathroom. An additional extract point is fitted in the landing; this avoids excessive extraction rates through the bathroom terminal and intercepts moist air moving up the stair well. The system therefore only requires access to the loft space for installation and no ductwork within the house has been needed. An EU4 grade filter was mounted in the main air intake duct, capable of intercepting pollen grains.

On commissioning, the system was set to provide an air supply of 8 l/s for a double and 6 l/s for a single bedroom. Air extract in the bathroom was set at twice that in the landing, to avoid spillage of moist air out of the bathroom. The system was balanced between total extract and supply rates. After commissioning, the system was switched off. All systems were switched on at the start of the measurement period in Week 45 beginning 9th November 1994. Householders in Groups 1&2 were advised on the use of the mechanical ventilation and asked to run the system continuously.

4 Data logging

A short experimental programme was undertaken to explore the effect of logger position within a room. Data from the carpet or the floor of the room was found to be a very reliable source of information and was less susceptible to rapid variations in humidity. A 10 minutes scan period provided an accurate record of events within the room.

Small independent loggers were used, mounted in a perforated aluminium case. The case rests on the bedroom floor and can be moved and replaced by the householder when cleaning. Two further loggers were mounted on the north facing side of two dwellings within the survey area. Data was collected from the loggers using a portable computer during a visit to the subject's house. All loggers were checked before despatch and found to give satisfactory accuracy. There were some problems with the outdoor humidity sensors when exposed to lengthy periods at an RH above 90%. This caused the reading to drift upwards to give some readings above 100% RH, with a long recovery time afterwards when the humidity fell again. Discussions with the manufacturer of the sensor revealed that this problem is common and that it is possible to precondition sensors which will be used in humid environments. The troublesome loggers were replaced. Weather data has also been obtained for the Southampton region from the Southampton Weather Centre.

5 Analysis

5.1 Measurement periods

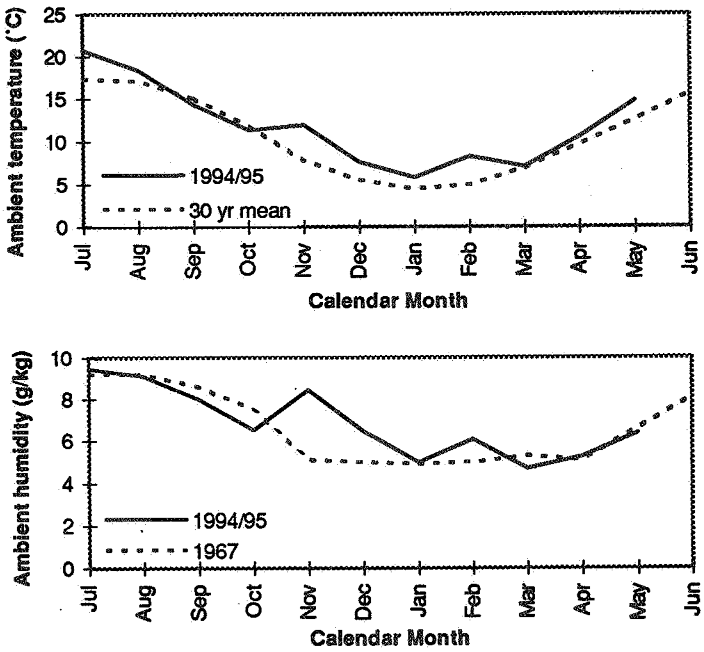
A standard week numbering nomenclature is used. A week runs from Monday to Sunday. Week 1, 1994 commences 3rd January and Week 1, 1995 starts on 2nd January 1995. Data loggers were installed in the houses between March and May 1994. All loggers were operational by Week 27. Installation of ventilation systems took place during October and November 1994; after installation the systems were commissioned and then left switched off. All ventilation systems were turned on together at the start of the heating season in Week 45, 1994.

The hypothesis to be tested in the analysis of the logger readings is that absolute humidities measured in the bedrooms of the ventilated houses (Groups 1&2) are lower than those measured in the control houses (Group 3&4). The WHO working party[5] proposed that dust mite growth is inhibited below an absolute humidity of 7 g/kg when expressed as a mixing ratio. The analysis in this paper uses 7 g/kg as a reference level. Analysis of weather records[3,4] shows that the four winter months of December to March inclusive consistently have a lower mean absolute humidity than the remainder of the year and the 18 weeks from Week 48, 1994 to Week 13, 1995 were selected for the main analysis. In addition several descriptive statistics are presented for the total available measurements from Week 27, 1994 to Week 21, 1995.

5.2 Weather

Figure 1 compares the monthly mean temperatures and humidities recorded on the roof of the Southampton Weather Centre during the total experimental period with records of other years. Thirty year mean air temperature data for Southampton was obtained

Figure 1 The weather during the measurement period was warmer and more humid than usual



from[6], but no comparable humidity data was to hand. Measured humidities were compared with those of the standard year 1967, used by environmental engineers to represent typical conditions. It can be seen that the test period was in general warmer and more humid than average. Southampton, being on the south coast of England, tends to be warmer and more humid than many other parts of the UK. In general, the UK can be assumed to be similar to or drier than Southampton, with the exception of the extreme South West region, typified by Plymouth, which is markedly moister.

5.3 Weekly mean bedroom temperatures

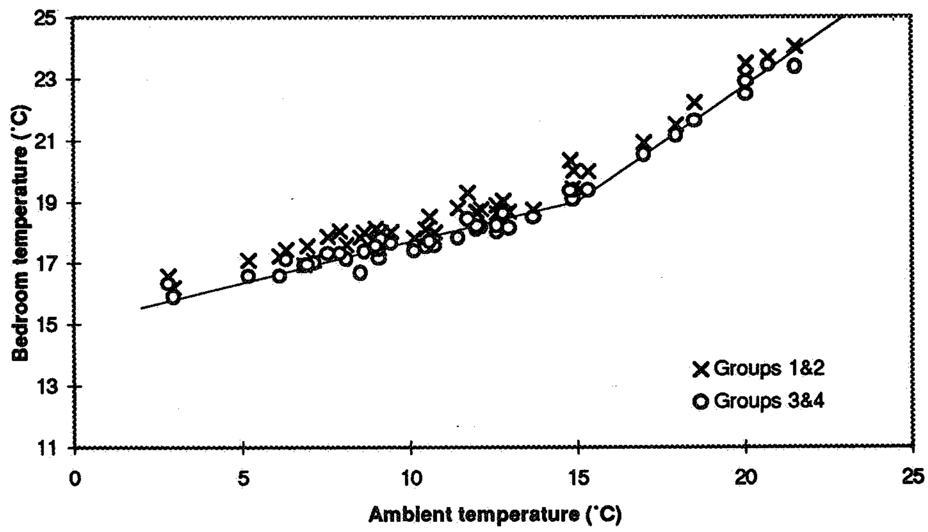
	All houses	Groups 1&2	Groups 3&4
Mean	17.29	17.51	17.08
Standard deviation	2.05	1.91	2.18
Median	17.52	17.74	17.25
Upper quartile	18.47	18.56	18.38
Lower quartile	16.19	16.55	16.03
n	713	359	354

Difference between group means: $t = 2.81$, $df = 711$. $P < 0.01$

Table 1 Analysis of weekly mean bedroom temperatures over the 18 week test period

Table 1 summarises the measurements of weekly mean bedroom temperatures during the test period for all houses. The bedrooms in Groups 1&2 are 0.4 K warmer than those in Groups 3&4 and the difference is statistically significant. However, it was not hypothesised as an effect of MVHR and is not large enough to be of practical significance. Weekly mean bedroom temperatures are shown plotted against weekly mean outdoor temperature in Figure 2. Both experimental and control groups show a

Figure 2 Bedroom temperatures in Groups 1&2 were slightly warmer than those in Group 3&4



similar behaviour. Above about 15°C ambient temperature, the bedroom temperature rises with increasing outdoor temperature, with a slope only a little below unity. Below 15°C, bedroom temperature falls only slowly with decreasing ambient temperature. A straight line has been fitted by eye to the points. The temperature behaviour is typical of dwellings, implying that no heating is used above 15°C outdoor temperature. Below this, heating is used to maintain comfort.

5.4 Bedroom humidities

Table 2 summarises the measurements of weekly mean bedroom humidities for the test period. Groups 1&2 have a significantly lower humidity than the Groups 3&4, with a difference between means of 0.75 g/kg.

	All houses	Groups 1&2	Groups 3&4
Mean (g/kg)	7.13	6.75	7.53
Standard deviation	1.02	0.82	1.06
Median	7.03	6.69	7.42
Upper quartile	7.73	7.27	8.18
Lower quartile	6.36	6.14	6.77
n	713	359	354
Values < 7.0	49%	65%	32%

Difference between group means: $t = 10.56$, $df = 711$. $P<0.001$

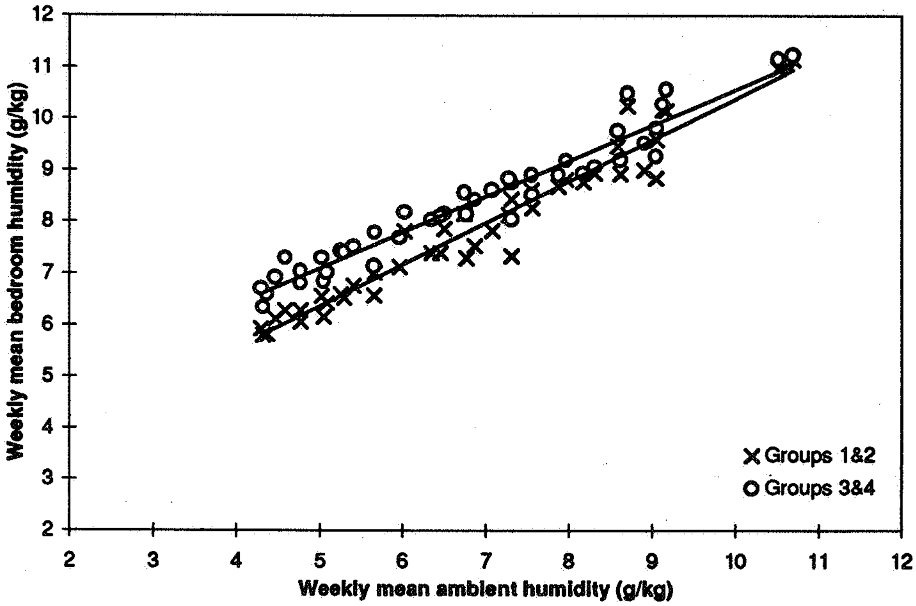
Table 2 Analysis of mean weekly bedroom humidities for all houses during the 18 week test period

Weekly mean bedroom humidities are shown plotted against outdoor humidity in Figure 3 for the entire 48 week measurement period. The points are well fitted by linear regression. The difference in slopes is significant at better than the 1% level. The implication of the graphs is that ventilation is restricted in cold weather in both groups of houses and significantly more so in the in the non MV houses compared with the test group.

Figure 3 Regression lines of bedroom vs. outdoor weekly mean humidity were significantly different for the two groups:

1&2 $g = 2.33 + 0.81\ g_o$ $r^2 = 0.95$

3&4 $g = 3.63 + 0.69\ g_o$ $r^2 = 0.94$



6 Discussion

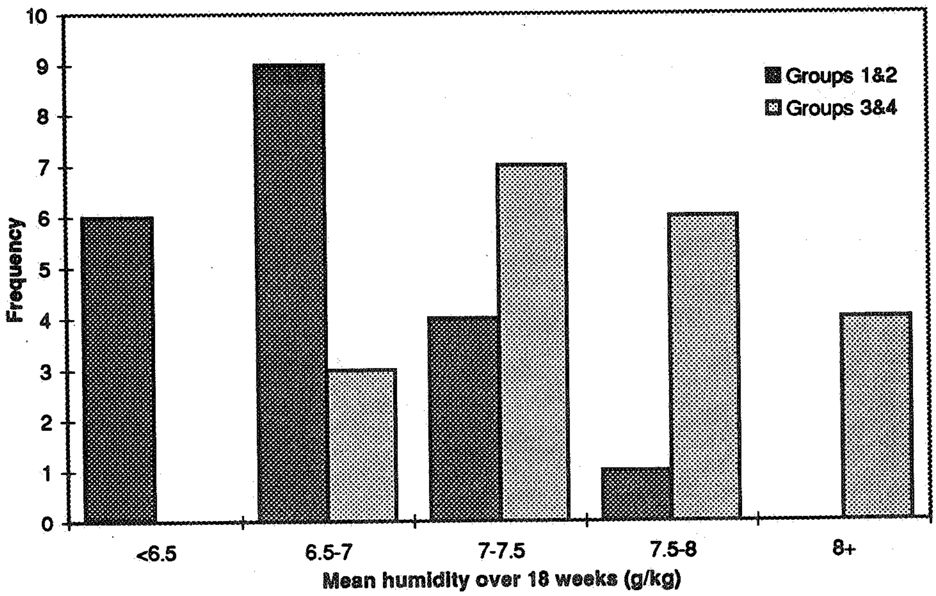
6.1 Bedroom temperatures

There was a small but significant difference between the temperatures of the MV and non-MV groups, with the MV houses being on average 0.4 K warmer. This difference was not hypothesised. The use of mechanical ventilation ensures a constant supply of tempered air into the bedroom whose temperature depends on the efficiency of the heat exchanger and the temperature of the air being extracted from bathroom and landing. The air will therefore be below the general indoor air temperature and would be expected to have some cooling effect in the ventilated bedroom. The measurements show no support for unacceptably cool bedrooms associated with mechanical ventilation.

6.2 Humidity

The difference in bedroom humidity between the MV and non-MV groups is highly significant and we may conclude that the use of mechanical ventilation has indeed resulted in a reduction of indoor humidity. The difference in mean mixing ratios is 0.75 g/kg over the 18 week test period. Figure 3 shows that the difference in humidity between the groups increases at lower outdoor temperatures. This may be interpreted

Figure 4 15/20 MV houses had a winter mean humidity below 7 g/kg, compared with 3/20 non-MV houses



that ventilation is better maintained in the MV houses, with the non-MV houses reducing ventilation in cold weather to conserve heat.

At the level of individual houses, Figure 4 shows that the groups are well separated, with three quarters of the MV houses having a mean over the test period of less than 7 g/kg, while only 3/20 of the non-MV houses do so. This paper analyses the results in terms of a critical mixing ratio of 7 g/kg, below which it may be supposed that house dust mites do not thrive; this figure is derived from[5]. In practice, of course, we cannot suppose that there is a sharp threshold. Many factors remain to be properly resolved: the interaction temperature and humidity, the influence of local micro climate in carpet or mattress and the effect of the variation of humidity may all have an important influence. If so, the mean mixing ratio over the winter period would not be a sufficient indicator to explain variation in house dust mite numbers or activity.

The experiment was conducted over the winter of 1994/95, which was milder than average, and took place on the South Coast of England. Only the extreme South West of the UK has generally higher humidities than Southampton; the consequence is that a successful result achieved in Southampton can only be strengthened in locations either north and west.

7 Conclusions

The use of mechanical ventilation with heat recovery reduced the measured bedroom humidities in a sample of 20 houses, compared with a group of 20 houses without

MVHR. The mean reduction in mixing ratio measured over the 4 winter months November 1994 to March 1995 was 0.75 g/kg. ($P<0.001$)

Fifteen of the 20 houses with MVHR had a mean bedroom humidity of under 7 g/kg over the winter four months, compared with 3/20 of the houses without.

There was little difference in mean winter bedroom temperature between the two groups. The MV group was 0.4 K warmer ($P<0.05$)

8 Acknowledgements

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This report describes only part of a larger study, and would not have been possible without the collaboration of all other parties involved. Particular acknowledgement is made to Jeanette Frederick and her colleagues, who were the prime contact with the households and who retrieved data from the loggers.

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