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Household hygiene practices in relation to dampness at home and current wheezing and rhino-conjunctivitis among school age children

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Good household hygiene practices may improve indoor air quality in the domestic environment. Conversely, a 'hygiene hypothesis' is challenging the importance of hygiene and sanitation at home. This study aims to investigate the relationship between household hygiene practices and dampness at home and current wheezing, asthma and other allergic conditions among Australian children. Nine hundred and ninety-six children from four primary schools in Perth, Western Australia, were recruited for a domestic environmental and health survey during March and April of 2002. The results showed that high cleanliness scores were negatively associated with moulds at home before and after adjustment for age of dwelling ($p < 0.001$). High ventilation scores were inversely related with damp patches, condensation and moulds at home ($p < 0.05$). However, households with high cleanliness scores appeared to have significantly higher prevalence of current wheezing ($p < 0.05$) and current rhino-conjunctivitis ($p < 0.05$) in children. The association remained even after controlling for confounders such as age and gender of children, asthma history of parents, passive smoking and dampness at home.

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Indoor air quality is important to the health of children as they spend a large proportion of their time indoors (1). There is little doubt that inadequate ventilation and dampness at home contribute to the prevalence of asthma and atopy (2). Therefore, applying good household hygiene practices to improve ventilation and indoor air quality, avoiding dampness and preventing exposure to pollutants and allergens, should decrease the prevalence of current asthma and respiratory symptoms in children. However, a 'hygiene hypothesis' (3) is challenging the importance of hygiene and sanitation at home. This prevailing hypothesis provides a plausible explanation for the allergy epidemics in developed countries. It assumes that declining family size, improvement in household amenities and higher standards of personal cleanliness over the past century has reduced the opportunity for cross-infection among children. Less infection during childhood may thus lead to a more widespread clinical expression of atopic disease (3). Immunological evidence has also suggested that lack of exposure to certain types of infectious agents and endotoxins could lead to imbalanced Th-1 and Th-2 immune responses, which would typically favour a Th-2 response known to be a key mediator in allergic reactions (4, 5). The immunological mechanisms for the 'hygiene hypothesis' have been proposed, namely missing immune deviation, reduced immune suppression, or both (6, 7).

The question arises whether certain hygiene practices in domestic environments inhibit exposure to mould and dampness, which in turn would

decrease the prevalence of asthma and respiratory symptoms in children. Alternatively, the hygiene practices minimize the exposure to infectious agents, consequently making children vulnerable to asthma and other allergic conditions.

Little is known about hygiene practices or norm of cleanliness among Australian households. This study investigated the hygiene practices in Australian households and their relationships with dampness at home as well as current wheezing, asthma and other allergic conditions in school age children. The findings will contribute towards the development of good household hygiene practices that are beneficial to the health of children.

Methods

Study design

A cross sectional study design was adopted for the present study. A total of 996 school children, aged between 4 and 12 yr, were recruited from four standard government primary schools built in the mid-1990s in the Perth (capital of the State of Western Australia) metropolitan area during March and April of 2002. The study population was thus taken to be the population of primary school children in Perth, representing Australian children in terms of asthma and respiratory symptoms. A questionnaire was completed by each consented parent/guardian in relation to household hygiene practices, dampness at home and respiratory health of their children. This validated questionnaire also included questions with regard to parent's history of asthma, passive smoking, demographics, dwelling age and other domestic characteristics (8). All questionnaires were distributed to parents by schoolteachers and later collected from the classrooms. A consent form was signed by each participating parent or guardian. The response rate was 62.5%, despite several measures had been taken to improve participation, such as repeated invitation letters, teachers' encouragement and lucky draw incentives. Although comparison could not be made between respondents and non-respondents, we expect the prevalence of respiratory symptoms would be similar between the two groups. Ethics approval was obtained from the Human Research Ethics Committee of Curtin University of Technology.

Household hygiene scores

Household cleanliness scores and ventilation scores were calculated based on each parent's report on household hygiene practices. Table 1 shows the composition of these two scores and description of each item. High cleanliness and ventilation scores would indicate good domestic hygiene.

Dampness

Three binary outcomes with respect to the occurrence of dampness in domestic environments were sought: damp patches inside the house, condensation occurring on the windows, and presence of moulds inside the house.

Current wheezing, asthma and other allergic conditions

Children who had wheezing or whistling in the chest within the past 12 months were defined as 'current wheezing', while those reported having asthma attack or taking any asthma medication within the past 12 months were regarded as 'current asthma'. Children who had a problem with sneezing, or a runny or blocked nose when they did not have a cold or 'flu' in the past 12 months were classified as 'current rhinitis'. Finally, 'current rhino-conjunctivitis' was defined as those with current rhinitis accompanied by itchy-watery eyes.

Statistical analysis

Prevalence of hygiene practices in terms of the items comprising the scores were tabulated. The cleanliness and ventilation scores were approximately normally distributed. Independent samples *t*-test was thus used to compare the scores between houses with and without damp patches, condensation or moulds. Logistic regression models were used to estimate the odds ratios for damp patches, condensation and moulds in relation to the cleanliness and ventilation scores (continuous independent variables). The analyses were repeated after adjustment for dwelling age. Likewise, unadjusted and adjusted relative risks for current wheezing, asthma and other allergic conditions were obtained, adjusting for age, gender, mother's history of asthma, father's history of asthma, passive smoking, damp patches and condensation. All statistical analyses were undertaken using the SPSS for windows package.

Results

Hygiene practices

Among the 996 households, the common hygiene practices were: 'airing' the house, regular housekeeping, vacuum/mop/sweep the floors, use

Table 1. Hygiene practice items and calculation of cleanliness and ventilation scores

Item	Description	Scales	Scores
1	How often do you vacuum/mop/sweep the floors?	Daily	2
		Weekly	1
		Less than weekly	0
Which of the following are regularly done in your house?			
2	Vacuum mattress	Yes	1
		No	0
3	Wash bed linen in hot water	Yes	1
		No	0
4	Use of protective mattress or pillow cover	Yes	1
		No	0
5	Dry clean furnishings	Yes	1
		No	0
6	Wash/dry clean curtains	Yes	1
		No	0
Cleanliness scores were calculated by adding the scores of items 1 to 6			
7	How often would you 'air' your house, that is, open lots of windows, in winter?	Daily	2
		Weekly	1
		Less than weekly	0
8	How often would you 'air' your house, that is, open lots of windows, in summer?	Daily	2
		Weekly	1
		Less than weekly	0
9	How often do you use an extractor fan when cooking?	Always	2
		Sometimes	1
		Never	0
10	Do you hang damp clothes anywhere inside the house?	Yes	0
		No	1
11	How often do you use an extractor fan when having a bath or shower?	Always	2
		Sometimes	1
		Never	0
Ventilation scores were calculated by adding the scores of items 7 to 11.			

extractor fan when cooking and bathing, and avoid placing damp clothes indoor. Table 2 shows the prevalence of each individual item. More than 96% of households 'air' their houses daily during summer, but it dropped to 63% during winter. Common housekeeping included washing bed linen at high temperature (58.7%) and using protective covers for mattress or pillow (56.7%). About 35% of houses were cleaned by vacuum/mop/sweeping the floors daily. The prevalence for using extractor fan during cooking or bathing was 53.4% and 72.8%, respectively. However, 23% of households kept damp clothes indoor.

Hygiene scores and dampness at home

Table 3 contrasts the hygiene scores in houses with and without damp patches, condensation and moulds. Significantly lower cleanliness scores ($p < 0.001$) occurred in houses with visible moulds. For houses with damp patches and condensation, their cleanliness scores were not significantly lower, but houses with either damp patches, condensation or moulds had relatively lower ventilation scores ($p < 0.001$). Logistic regression results in Table 4 further indicated that high cleanliness scores were negatively associated with moulds at home before and after adjustment for age of dwelling, a factor found to be related to dampness at home according to univariate analyses. High ventilation scores had significant inverse associations with all the outcomes (damp patches, condensation and moulds at home), before and after controlling for the age of dwelling.

Hygiene scores and current wheezing, asthma and other allergic conditions

The relative risks for current wheezing, asthma and other allergic conditions were next estimated with respect to the cleanliness and ventilation scores; see Table 5. In the logistic regression models, the outcomes were binary variables indicating the presence or absence of the condition, and the hygiene scores were continuous covariates. After adjusting for age of children, gender, mother's history of asthma, father's history of asthma, passive smoking and dampness at home, which were all significant risk factors for current wheezing and asthma, low

Table 2. Prevalence of hygiene practice items*

Hygiene practices	%
Airing house during summer (n = 981)	
Daily	95.4
Weekly	3.2
Less than weekly	1.4
Airing house during winter (n = 979)	
Daily	62.9
Weekly	27.5
Less than weekly	9.5
Regular house keeping (n = 994)	
Vacuum mattress	27.1
Wash bed linen at high temperature	58.7
Use of protective cover for mattress or pillow	56.7
Dry clean furnishings	9.1
Wash/dry clean curtains	23.8
Frequently vacuum/mop/sweep floor (n = 982)	
Daily	34.6
Weekly	60.3
Less than weekly	5.1
Use extractor fan when cooking (n = 980)	
Always	53.4
Sometimes	39.4
Never	7.2
Use extractor fan when cooking (n = 974)	
Always	72.8
Sometimes	16.8
Never	10.4
Damp clothes anywhere inside the house (n = 977)	23.1

*Sample size variations because of missing data.

Table 3. Hygiene scores in houses with and without damp patches, condensation or moulds

	Scores							
	Cleanliness				Ventilation			
			95% CI				95% CI	
	n	Mean	Lower	Upper	n	Mean	Lower	Upper
Damp patches								
Yes	86	2.8	2.5	3.1	88	6.8	6.4	7.1
No	886	3.1	3.0	3.2	870	7.4	7.3	7.5
p-value			0.066				<0.001	
Condensation								
Yes	272	3.0	2.8	3.1	272	7.1	6.9	7.3
No	698	3.1	3.0	3.2	685	7.4	7.3	7.5
p-value			0.21				<0.001	
Moulds								
Yes	166	2.6	2.4	2.8	169	6.8	6.5	7.0
No	700	3.2	3.1	3.3	686	7.4	7.3	7.5
p-value			<0.001				<0.001	

ventilation scores did not significantly increase the prevalence of current wheezing, asthma and other allegoric conditions. However, high cleanliness scores could significantly increase the risk of current wheezing and rhino-conjunctivitis after controlling for the above confounders.

Table 4. Risk of damp patches, condensation and moulds in relation to cleanliness and ventilation scores

	Unadjusted OR				Adjusted OR*			
		95% CI				95% CI		
	OR	Lower	Upper	p-value	OR	Lower	Upper	p-value
Damp patches								
Cleanliness	0.86	0.73	1.01	0.067	0.92	0.77	1.10	0.37
Ventilation	0.75	0.65	0.87	<0.001	0.82	0.70	0.97	0.017
Condensation								
Cleanliness	0.94	0.85	1.04	0.21	1.00	0.90	1.11	0.98
Ventilation	0.85	0.77	0.93	0.001	0.88	0.78	0.96	0.007
Moulds								
Cleanliness	0.74	0.65	0.84	<0.001	0.78	0.68	0.90	<0.001
Ventilation	0.74	0.66	0.83	<0.001	0.80	0.70	0.90	<0.001

*Odds ratios adjusted for age of dwelling.

Table 5. Risk of current wheezing, asthma, rhinitis and rhino-conjunctivitis in relation to cleanliness and ventilation scores

	Unadjusted OR				Adjusted OR*			
		95% CI				95% CI		
	OR	Lower	Upper	p-value	OR	Lower	Upper	p-value
Current wheezing								
Cleanliness	1.14	1.04	1.26	0.008	1.16	1.03	1.29	0.011
Ventilation	0.99	0.89	1.09	0.81	0.96	0.86	1.08	0.50
Current asthma								
Cleanliness	0.93	0.80	1.08	0.32	1.08	0.98	1.19	0.14
Ventilation	1.03	0.89	1.20	0.68	0.99	0.89	1.09	0.77
Current rhinitis								
Cleanliness	1.06	0.97	1.16	0.18	1.08	0.98	1.19	0.14
Ventilation	0.99	0.90	1.09	0.83	0.99	0.89	1.09	0.77
Current rhino-conjunctivitis								
Cleanliness	1.14	1.03	1.27	0.015	1.17	1.04	1.31	0.009
Ventilation	1.01	0.91	1.13	0.83	0.98	0.86	1.10	0.70

*Odds ratios adjusted for age of children, gender, mother's history of asthma, father's history of asthma, passive smoking and dampness at home.

Although information was also obtained on socioeconomic factors such as parent's education and employment, as well as air conditioning, gas heating and cooking, their effects were not significant and consequently these variables were excluded in the final logistic regression models.

Discussion

Good environmental hygiene practices, such as avoiding dampness, eliminating smoke from cooking and maintaining cleanliness and hygiene at home, are important to the health of children by reducing exposure to pollutants and allergens and improving indoor air quality (9). However, data on Australian household hygiene practices are scarce. The present study investigated household hygiene practices in Perth, Western

Australia. 'Airing' the house by opening doors and windows was the most common practice, especially during summer. Other popular routines included washing bed linen in hot water, use of protective mattresses or pillow covers, vacuuming floors and mattresses, and use of an extractor fan during cooking or bathing. Nevertheless, the habit of hanging damp clothes indoor was prevalent amongst one quarter of the surveyed households.

As expected, good domestic ventilation as reflected by high scores had a significant inverse association with damp patches, condensation and moulds. Similarly, high cleanliness could decrease the risk for moulds at home. As dampness at home has been consistently shown to be associated with the prevalence of asthma allergy in children and adults (2, 10–12), dampness reduction because of good household hygiene practices would lead to a lower prevalence of current wheezing, asthma and other allergic conditions in children. In this study, the variables damp patches and condensation were found to be significant risk factors for these conditions, yet households with higher hygiene scores did not have lower prevalence than those with low hygiene scores, suggesting the possibility of intervening factors that mediate the relationship between household hygiene and the respiratory diseases.

The association between cleanliness scores and prevalence of current wheezing and current rhino-conjunctivitis in children was rather unexpected. Although household hygiene practices may reduce the exposure to microbes and endotoxins, the 'hygiene hypothesis' appears to provide a plausible explanation for the inverse relationship despite its controversy (13, 14). On the contrary, alternative hypotheses concerning air pollution, less exercise and obesity have been postulated in the literature (9). The proneness to clean domestic environments for children with asthma and allergy could also be a confounding factor, but was not investigated in the present study. A study on children's hygiene practices (frequencies of face and hands wiped, hands wiped before meals, and bath or shower taken) found that high hygiene scores for children aged 15 months were independently linked with increased risks of wheezing and eczema, when the cohort reached 30 and 42 months of age respectively (15). It was claimed that a sterile environment through excessive cleanliness may potentially be harmful to the immune system (15). The finding may nonetheless reflect the association between asthma and hygiene practices (9).

Some caution should be taken when interpreting the results. A limitation of the present study is the lack of biomarkers for bacteria or fungi. Although the results indicated an association between hygiene scores and visible mould at home, quantitative measurements are needed to estimate the reduced exposure to bacteria and fungi with the improved hygiene environments. Another limitation is that parental attitudes towards hygiene habit and asthma were not ascertained. It is likely that allergic children have their houses kept clean in order to reduce their allergen exposure but equally clean houses might be associated with allergic diseases. Therefore, the findings confirm the association between cleanliness scores and prevalence of wheezing and rhino-conjunctivitis, but causality is not demonstrated. More studies are needed to ascertain the effects of home hygiene practices on asthma and allergy in children.

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