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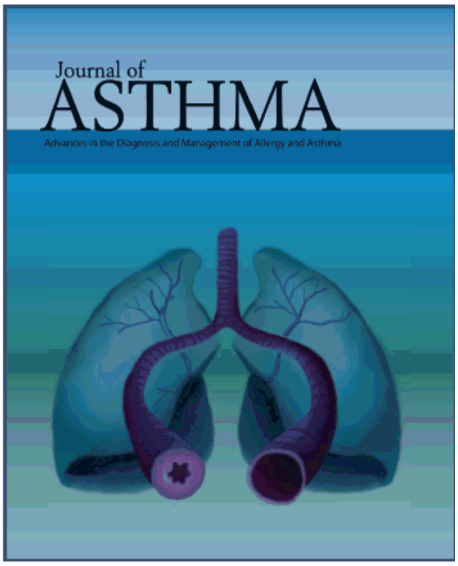

Original Article

Bedroom air quality and vacuuming frequency are associated with repeat child asthma hospital admissions

Don Vicendese, Shyamali C Dharmage, Mimi LK Tang, Andriy Olenko, Katrina J Allen, Michael J Abramson, Bircan Erbas

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Abstract

Objective: Indoor environment factors have been associated with risk of asthma exacerbations in children but little is known about their role on asthma hospital readmissions. As children in Western societies continually spend more time indoors, understanding the influence of these factors on asthma exacerbation is important. We examined the role of indoor environmental and lifestyle characteristics on child asthma readmissions.

Methods: A hospital based case control study recruited 22 children readmitted for asthma and 22 controls not readmitted for asthma. Logistic regression models were used to examine the association between aeroallergens and fungi in the bedroom and indoor lifestyle characteristics factors for asthma readmissions. To determine the best possible set of predictors amongst a large set of risk factors we used Random Forests (RF) techniques.

Results: Higher levels of airborne *Cladosporium* and yeast in the child's bedroom increased risk of readmission (OR=1.68, 95% CI 1.04, 2.72 and OR= 1.52, 95% CI 0.99 to 2.34 respectively). Carpeted floors in the bedroom and synthetic doonas were also associated with increase in asthma readmissions (OR = 4.07, 95% CI 1.03, 16.06 and OR= 14.6, 95%CI 1.26, 169.4 respectively). In the home, frequent vacuuming using bagged cleaners increased risk of asthma readmission OR= 15.7 (95%CI 2.82, 87.2).

Conclusions: Factors in the child's bedroom, play an important role in increasing the risk of asthma hospital readmissions. These findings have major clinical implications as the identified potential risk factors may be modifiable. Further epidemiological studies with larger samples are necessary to evaluate these associations further.

Original Article

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Conclusions: Factors in the child's bedroom, play an important role in increasing the risk of asthma hospital readmissions. These findings have major clinical implications as the identified potential risk factors may be modifiable. Further epidemiological studies with larger samples are necessary to evaluate these associations further.

Keywords: hospital, readmission, exacerbation, indoor, fungi, vacuum, yeast, *Cladosporium*,

INTRODUCTION

Asthma is the most common chronic medical condition among Australian children and the most common reason for admission to hospital during childhood (1). In 2010–11, Australian children between 0–14 years had higher rates of asthma hospitalization compared to the rest of the population 15 years and older, 493 compared to 91 per 100,000 population respectively. They accounted for 57% of total asthma admissions, but only 7% of all-cause admissions (2). In 2008-09 asthma expenditure was $655 million (3). It is important to understand possible triggers for asthma exacerbations requiring admission, particularly those related to the indoor environment, as it is generally accepted that in Western societies, children can spend up to 90% of their time indoors (4) (5) (6).

Childhood asthma readmissions attract a disproportionate amount of resources used for asthma in health systems (7) (8) (9). Asthma hospital readmissions are a useful indicator of severity of asthma and/or uncontrolled asthma (10) (11) (12). They can be considered a gauge of what is happening with the care of child asthma over the health system (13) (14), especially the clinical management of the disease (15). Compared to asthma exacerbations and symptoms, few studies have focused on the role of indoor environmental factors on repeat child asthma hospital admissions (16) (17) (18). Understanding factors that influence child asthma readmissions may help clinicians identify those children at risk of severe asthma and where possible, modify relevant environmental factors to reduce this risk.

Exposure to indoor allergens such as house dust mite (HDM) and indoor mould has been associated with asthma exacerbations in children (19) (20) with possibly greater exposure in the school environment (21). For exacerbations resulting in an admission, viral infection, atopy and allergen exposure can act synergistically to greatly increase the risk of child asthma hospital admission (22). Lifestyle factors such as overcrowding and residing in disadvantaged areas may also be influential (16) (17). To examine the associations between these factors and repeat asthma admissions in children we conducted a case control study, nested within the Melbourne Air Pollen Children and Adolescent Health (MAPCAH) study.

METHODS

Participants/setting

The MAPCAH study (23) was a clinical study of incident asthma admissions among children aged 2 to 17 years and admitted to the Royal Children's Hospital Melbourne (RCH), Australia, with a principal diagnosis of asthma (ICD10 J45, J46). For the sub-study, a case was defined as a child who experienced at least two admissions and a control was defined as a child who had only one admission within the MAPCAH study period from September 2009 to December 2011. Eligible participants were 96 cases and 155 controls. Of those invited, 38 (40%) cases and 32 (21%) controls consented. Of those who consented, 26 were ineligible due to reasons such as relocation from home at admission, unable to arrange appointments for indoor sampling and readmitting prior to indoor sampling). Thus 22 cases and 22 controls were eventually included in the study.

Indoor sampling

To collect indoor fungi we sampled air fungi levels in the child's bedroom using a two-stage Andersen Sampler (Andersen Samplers Inc, Atlanta, GA) for one minute at a flow rate of 28 L per minute. Two potato dextrose Agar plates (Difco Laboratories, Mt Pritchard, NSW, Australia) were prepared in deionised water according to the manufacturer's instructions and sterilized by autoclaving at 121°C for 15 minutes. Once air sampling had been performed, the plates were incubated at 25°C for five days and stored at 4°C until analysed for the presence of fungal colonies. Fungi species and yeasts were then identified and their numbers of colony-forming units counted. The results are presented as counts obtained per 28L of air.

Settled dust samples were taken by vacuuming separately a 1 square metre area for 1 minute at the side of the child's bed. The child's bedding (mattress, cushions, doona, blankets) were vacuumed for approximately 15 seconds each. We used a Modern Day Space Ace vacuum cleaner model JC861 after inserting an unwoven fabric sleeve into the nozzle. Allergens from HDM Der p 1 (Dermatophagoides pteronyssinus) and Der f 1 (Dermatophagoides farinae), cat Fel d 1 (Felis domestica) and dog Can f 1 (Canis familiaris) were quantified in the four dust samples using monoclonal antibody-based sandwich ELISA assays with a peroxidase detection system (24). Results were expressed as µg per gram of sieved dust.

Questionnaires on indoor environment and lifestyle characteristics were administered. Standardized questionnaires from the ISAAC and NZ Otago questionnaires were used (25, 26).

Data on the type of dust collection and exhaust air filtration systems that participants' vacuum cleaners used were collected and categorised as bagless or bag. Bagless included cyclonic separation (27) or ducted systems. Vacuum exhaust air systems were classified as non *High Efficiency Particulate Air (*HEPA) or HEPA (ASHRAE Standard 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size). Ducted systems were included in the non HEPA category.

This study was approved by the Royal Children's Hospital Melbourne Human Research Ethics Committee. Parents provided written informed consent.

Statistical Analysis

The outcome was whether the child had been readmitted or not. The primary exposures of interest were levels of fungi, yeast, HDM and cat and dog allergens in the air; indoor home characteristics such as carpets and heating; lifestyle (number of people in the home and presence of pets), bedding arrangements, frequency of vacuum cleaning and type of vacuum cleaner used. Logistic regression models were used to investigate the relevant associations while adjusting for potential confounders. Adjusted models included age, sex and human rhinovirus infection at admission (HRV) (detection methods described elsewhere (23). To determine the best possible predictors amongst a large set we used the **Random Forests® (RF) technique (28) as implemented by randomForest (29). In addition to the usual approach by RF for variable ranking, we also employed a recent innovation based on conditional RF that ranked variable importance by computing *p* values for the predictive ability of the variable, for checking and comparison purposes (30). This gave us a reduced number of variables to arrive at a parsimonious model that could reliably indicate best predictors for a risk of readmission. Results expressed as odds ratios (OR) with 95% confidence intervals (CI) and significance level set to 0.05 unless otherwise stated. The analyses were performed in Stata (Version 11.2, StataCorp, College Station, Texas), and R version 3.0.**

RESULTS

INSERT TABLE 1 HERE

The mean age of cases was 5.2 years (SD = 3.1) and the mean age of controls was 5.8 years (SD = 3.3) (Table 1). Half (*n* = 11) of the cases and 68% (*n* = 15) of the controls were boys. Significantly more of the cases 95% (*n* = 21) than the controls 59% (*n* = 13) were atopic (*p* = 0.004). There were no substantial differences between consenting and non-consenting individuals with respect to sex, age and atopic status at admission.

INSERT TABLE 2 HERE

For every doubling of the concentration of CFU of airborne *Cladosporium* (per 28L of air) in the bedroom, there was over a 60% increase in the odds of readmission, adjusted OR=1.68 95% CI (1.04, 2.72), *p* = 0.03 (Table 2). Similarly, for every doubling of the concentration of CFU of airborne yeast in the bedroom, there was over a 50% increase in the odds of readmission OR= 1.52, 95% CI (0.99, 2.34), *p* = 0.05.

INSERT TABLE 3 HERE

Compared to any other floor covering, carpet in the child's bedroom was associated with increased odds of readmission OR = 4.07, 95% CI (1.03, 16.06), *p* = 0.04 (Table 3). Compared to a feather doona, a synthetic doona was associated with a more than 14 times greater odds of readmission OR=14.6, 95%CI (1.26, 169.4), *p* = 0.03. Compared to homes that were vacuumed weekly or less often, vacuuming at least 2–3 times weekly was associated with a 15-fold increase in the odds of readmission OR = 15.7, 95%CI (2.82, 87.2), *p* = 0.002.

To determine the best possible predictors of readmission using RF models we found that both increased frequency of vacuuming OR=22.2, 95%CI (3.17, 156.1), p=0.002 and higher levels of yeast OR=1.82, 95%CI (1.04, 3.18), p=0.04 significantly predicted risk of readmission.

DISCUSSION

Our study found that high levels of yeast and *Cladosporium* in the bedroom and homes with high frequencies of vacuuming were associated with increased risk of repeat admissions for asthma in children. Studies of the indoor environment using home management plans of care have shown reductions in repeat admissions (31). Increased risk of emergency room visits and clinical visits in asthmatic children living in homes with high levels of *Cladosporium* have also been reported (32). However, our study is the first to show an association between indoor fungi levels in the bedroom and readmissions for asthma among children. These findings warrant further investigation given the small sample size of this study.

We found no difference in HDM levels between homes of readmitted and non readmitted children. However, the home may not necessarily represent the greatest exposure risk to HDM (33). Other studies have indicated that inadequate vacuum exhaust filtration systems may increase airborne HDM allergens (34) and/or affect their size distribution (35), thus increasing the risk of child asthma exacerbations. This may also be a mechanism by which a child is exposed to greater numbers of and smaller sized fungal spores that may penetrate deeper into the lung (36). In our study, frequent vacuuming was more likely to occur in homes with carpet in the child's bedroom. This may suggest that keeping the carpet cleaner in the children's bedrooms may have been motivating the more frequent use of the vacuum cleaner.

The association between exposure to indoor fungi and readmissions for asthma among children has not previously been examined. Although yeast levels can be high in residences (37) (38), yeast has not been associated independently with asthma risk or exacerbation in children. Among lifestyle characteristics, we found that a synthetic doona was associated with greater odds of readmission than a feather doona. Similar associations have been reported between synthetic materials and increase in asthma outcomes such as wheeze in children (39). In this study, we examined many indoor features of the built environment and lifestyle characteristics and the most important factors found to be associated with child asthma readmissions centered on the child's bedroom.

A key limitation of this study is the small sample size. Further studies with larger sample sizes are required to confirm our findings. Although the small size of our sample emphasizes that we need to interpret our results with some caution, the participants in this substudy are representative of the larger MAPCAH sample. The Anderson sampler measurements may cause non differential misclassification. Air samples were taken prior to vacuuming and this approach was consistent over all samples. We agree that the short sampling time may have under estimated fungi counts. While this may have led to a non differential misclassification of exposure, this effect would be consistent across both groups as the protocol was standardised and would only strengthen our findings if samples were taken at 4-5 minute intervals as suggested by others (40). We believe case recall bias would be limited and any recall error would push the estimates towards null so whatever we have observed could only have been stronger.

In summary, the indoor environment, particularly factors in the child's bedroom, has an important role in the risk of asthma hospital readmissions. These findings have major clinical implications as we have identified two significant risk factors which are both potentially modifiable and warrant further investigation. Vacuuming frequency could be reduced or vacuum dust collection and filtration improved. The child's bedroom can be targeted for the application of preventative measures such as removal of carpets from the child's bedroom (41). Increasing bedroom ventilation and dehumidification may also assist in mitigating air borne fungi (42) (43). The factors considered here provide an opportunity for further larger epidemiological studies and clinical trials to verify these results.

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We would like to thank the L.E.W. Carty Charitable Fund for providing us the funds to purchase the ELISA allergen kits, vacuum dust filters and pay for the allergen processing and mould identification.

Declaration of Interest:

All the authors declare that they have no conflicts of interest.

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References

1. Acam (Australian Centre For Asthma Monitoring). Asthma In Australian Children: Findings From Growing Up In Australia, The Longitudinal Study Of Australian Children. . Cat No Acm 17 Canberra:Aihw. 2009.
2. Australian Institute Of Health And Welfare. Who Gets Asthma? 2014 [Cited 2014]. Available From: Http://Www.Aihw.Gov.Au/Asthma/Prevalence/.
3. Australian Institute Of Health And Welfare. How Much Is Spent On Asthma? 2014 [Cited 2014]. Available From: Http://Www.Aihw.Gov.Au/Asthma/Expenditure/.
4. European Lung Foundation. Indoor Air Pollution And The Lungs. 2008 [Cited 2014]. Available From: Http://Www.Europeanlung.Org/Assets/Files/En/Publications/Indoor-Air-Pollution-En.Pdf.
5. Xue J, Mccurdy T, Spengler J, Ozkaynak H. Understanding Variability In Time Spent In Selected Locations For 7-12-Year Old Children. Journal Of Exposure Analysis And Environmental Epidemiology. 2004;14(3):222-33.
6. Wu X, Bennett Dh, Lee K, Cassady Dl, Ritz B, Hertz-Picciotto I. Longitudinal Variability Of Time-Location/Activity Patterns Of Population At Different Ages: A Longitudinal Study In California. Environmental Health : A Global Access Science Source. 2011;10:80.
7. Watson L, Turk F, Rabe Kf. Burden Of Asthma In The Hospital Setting: An Australian Analysis. Int J Clin Pract. 2007;61(11):1884-8.
8. Vollmer Wm, Osborne Ml, Buist As. Temporal Trends In Hospital-Based Episodes Of Asthma Care In A Health Maintenance Organization. Am Rev Respir Dis. 1993;147(2):347-53.
9. Berry Jg, Hall De, Kuo Dz, Cohen E, Agrawal R, Feudtner C, Et Al. Hospital Utilization And Characteristics Of Patients Experiencing Recurrent Readmissions Within Children's Hospitals. Jama. 2011;305(7):682-90.
10. Anderson Hr. Increase In Hospitalisation For Childhood Asthma. Arch Dis Child. 1978;53(4):295-300.
11. Mccaul Ka, Wakefield Ma, Roder Dm, Ruffin Re, Heard Ar, Alpers Jh, Et Al. Trends In Hospital Readmission For Asthma: Has The Australian National Asthma Campaign Had An Effect? Med J Aust. 2000;172(2):62-6.
12. Chen Y, Dales R, Stewart P, Johansen H, Scott G, Taylor G. Hospital Readmissions For Asthma In Children And Young Adults In Canada. Pediatric Pulmonology. 2003;36(1):22-6.

13. Australian Centre For Asthma Monitoring (Acam) 2010. Time Trends And Geographical Variation In Hospital Re-Admissions For Asthma. Canberra: Aihw; 2011 Contract No.: Cat. No. Acm 21.

14. Feudtner C, Levin Je, Srivastava R, Goodman Dm, Slonim Ad, Sharma V, Et Al. How Well Can Hospital Readmission Be Predicted In A Cohort Of Hospitalized Children? A Retrospective, Multicenter Study. Pediatrics. 2009;123(1):286-93.

15. Delmas Mc, Marguet C, Raherison C, Nicolau J, Fuhrman C. [Readmissions To Hospital For Asthma In France, 2002-2005]. Rev Mal Respir. 2009;26(7):751-8.

16. Wever-Hess J, Hermans J, Kouwenberg Jm, Duiverman Ej, Wever Am. Hospital Admissions And Readmissions For Asthma In The Age Group 0-4 Years. Pediatr Pulmonol. 2001;31(1):30-6.

17. Correll. Patricia K, Wei X, Margaret. W, Vijaya S, Ringland Clare, Marks. Guy B. Reattendance At Hospital For Asthma In Two Australian States, 2000-2003. Respirology. 2007;12(2):220-6.

18. Liu Sy, Pearlman Dn. Hospital Readmissions For Childhood Asthma: The Role Of Individual And Neighborhood Factors. Public Health Rep. 2009;124(1):65-78.

19. Etzel Ra. How Environmental Exposures Influence The Development And Exacerbation Of Asthma. Pediatrics. 2003;112(1 Pt 2):233-9.

20. Tischer C, Chen Cm, Heinrich J. Association Between Domestic Mould And Mould Components, And Asthma And Allergy In Children: A Systematic Review. The European Respiratory Journal. 2011;38(4):812-24.

21. Tovey Er, Rawlinson Wd. A Modern Miasma Hypothesis And Back-To-School Asthma Exacerbations. Medical Hypotheses. 2011;76(1):113-6.

22. Murray Cs, Poletti G, Kebadze T, Morris J, Woodcock A, Johnston Sl, Et Al. Study Of Modifiable Risk Factors For Asthma Exacerbations: Virus Infection And Allergen Exposure Increase The Risk Of Asthma Hospital Admissions In Children. Thorax. 2006;61(5):376-82.

23. Erbas B, Dharmage Sc, O'sullivan M, Akram M, Newbigin E, Taylor P, Et Al. A Case-Crossover Design To Examine The Role Of Aeroallergens And Respiratory Viruses On Childhood Asthma Exacerbations Requiring Hospitalization: The Mapcah Study. J Biomet Biostat. 2012;S7-018.

24. Wu Ff, Wu Mw, Ting Mh, Crane J, Siebers R. Cat, Dog And House Dust Mite Allergen Levels On Children's Soft Toys. The Journal Of Asthma : Official Journal Of The Association For The Care Of Asthma. 2014;51(1):75-8.

25. Isaac. International Study Of Asthma And Allergy In Children 2014 [Cited 2014]. Available From: Http://Isaac.Auckland.Ac.Nz/Index.Html.

26. Warg. Wellington Asthma Research Group, Otago 2014 [Cited 2014]. Available From: Http://Www.Otago.Ac.Nz/Wellington/Research/Waarg/.

27. Newsrx. G.B.D. Corp.; Patent Issued For Cyclonic Surface Cleaning Apparatus With A Filtration Chamber External To The Cyclone. Journal Of Engineering. 2014:4975.

28. Leo Breiman, Schapire. E. Random Forests. Machine Learning. 2001;45(1):5-32.

29. A. Liaw, M.Wierner. Classification And Regression By Randomforest. R News. 2002;2(3):18-22.

30. Hapfelmeier A, Ulm K. A New Variable Selection Approach Using Random Forests. Computational Statistics & Data Analysis. 2012;60(0):50-69.

31. Bergert L, Patel Sj, Kimata C, Zhang G, Matthews Wj, Jr. Linking Patient-Centered Medical Home And Asthma Measures Reduces Hospital Readmission Rates. Pediatrics. 2014;134(1):E249-56.

32. Barnes Cs, Amado M, Portnoy Jm. Reduced Clinic, Emergency Room, And Hospital Utilization After Home Environmental Assessment And Case Management. Allergy And

Asthma Proceedings : The Official Journal Of Regional And State Allergy Societies. 2010;31(4):317-23.
33. Tovey Er, Willenborg Cm, Crisafulli Da, Rimmer J, Marks Gb. Most Personal Exposure To House Dust Mite Aeroallergen Occurs During The Day. Plos One. 2013;8(7).
34. Custovic A, Murray Cs, Gore Rb, Woodcock A. Controlling Indoor Allergens. Annals Of Allergy, Asthma & Immunology. 2002;88(5):432-42.
35. Heinrich J. Influence Of Indoor Factors In Dwellings On The Development Of Childhood Asthma. Int J Hyg Environ Health. 2010;214(1):1-25.
36. Virginia R. Salares, Carol Ann Hinde, Miller. Jd. Analysis Of Settled Dust In Homes And Fungal Glucan In Air Particulate Collected During Hepa Vacuuming. Indoor And Built Environment. 2009;18(6):485-91.
37. Cheong Cd, Neumeister-Kemp Hg, Dingle Pw, Hardy Gsj. Intervention Study Of Airborne Fungal Spora In Homes With Portable Hepa Filtration Units. Journal Of Environmental Monitoring. 2004;6(11):866-73.
38. Su Hj, Wu Pc, Chen Hl, Lee Fc, Lin Ll. Exposure Assessment Of Indoor Allergens, Endotoxin, And Airborne Fungi For Homes In Southern Taiwan. Environ Res. 2001;85(2):135-44.
39. Ponsonby Al, Dwyer T, Trevillian L, Kemp A, Cochrane J, Couper D, Et Al. The Bedding Environment, Sleep Position, And Frequent Wheeze In Childhood. Pediatrics. 2004;113(5):1216-22.
40. Spicer Rc, Gangloff Hj. Bioaerosol Data Distribution: Probability And Implications For Sampling In Evaluating Problematic Buildings. Applied Occupational And Environmental Hygiene. 2003;18(8):584-90.
41. Sun Y, Sundell J. On Associations Between Housing Characteristics, Dampness And Asthma And Allergies Among Children In Northeast Texas. Indoor And Built Environment. 2013;22(4):678-84.
42. Burr Ml, Matthews Ip, Arthur Ra, Watson Hl, Gregory Cj, Dunstan Fd, Et Al. Effects On Patients With Asthma Of Eradicating Visible Indoor Mould: A Randomised Controlled Trial. Thorax. 2007;62(9):767-72.
43. Wright Gr, Howieson S, Mcsharry C, Mcmahon Ad, Chaudhuri R, Thompson J, Et Al. Effect Of Improved Home Ventilation On Asthma Control And House Dust Mite Allergen Levels. Allergy. 2009;64(11):1671-80.

Table 1: Characteristics of the study population at admission

	Total	Case	Control	***P***[†]
N (%)	44(100%)	22(50%)	22(50%)	
Girl	18(41%)	11(50%)	7(32%)	0.22
2-6 years of age	33(75%)	17(77%)	16(73%)	0.73
7-14 years of age	11(25%)	5(23%)	6(27%)	0.73
Atopy[‡]	34(77%)	21(95%)	13(59%)	0.004
Sensitization to:				

HDM	24(55%)	12(55%)	12(55%)	1.00
Mould (*Cladosporium* or *Alternaria*)	4(9%)*	2(8%)	4(15%)	0.92
Cat	10(23%)	4(18%)	6(27%)	0.47
Food (Egg or peanut)	13(30%)**	8(38%)	5(23%)	0.28
HRV at admission	30(68%)	16(73%)	14(64%)	0.52

† test difference in proportions for cases and controls

‡ Atopy defined as sensitization to at least one allergen

* N = 42   ** N = 43, due to SPT unable to be done for one or two children.

Table 2: Distribution of bedroom airborne fungus and bedding allergens for cases and controls. Associations between allergen and fungi exposure and readmissions for asthma in children.

	min	**25th %le**	**median**	**75th %le**	**max**	**geom mean**	***p** geom mean*	**AOR‡**	**95% CI**	***p***
Fungus: number of Colony Forming Units (CFU) / 28L of air.										
Total Fungi										
Cases	2	4	11	24	82	12.24		1.12	0.76, 1.65	0.57
Controls	0	5	6.5	26	215	10.71	0.70	1(Ref)		
Cladosporium										
Cases	0	1	3.5	10	37	5.15		1.68	1.04, 2.72	0.03†
Controls	0	0	1	3	13	2.59	0.03†	1(Ref)		
Penicillium/Aspergillus										
Cases	0	0	1	2	31	2.39		0.91	0.63, 1.32	0.63
Controls	0	0	1	4	211	3.07	0.50	1(Ref)		
Alternaria										
Cases	0	0	0	1	3	1.25		1.27	0.44, 3.67	0.66
Controls	0	0	0	0	5	1.19	0.72	1(Ref)		

Yeast										
Cases	0	2	4.5	13	53	7.31		1.52	0.99, 2.34	0.05†
Controls	0	1	3	6	214	4.04	0.11	1(Ref)		
Bedding Allergen: ug/g of vacuumed dust										
Der p 1										
Cases	0.002	0.003	0.006	0.023	70.52	0.018		1.01	0.86, 1.18	0.90
Controls	0.002	0.003	0.007	0.031	4.77	0.018	0.98	1(Ref)		
Der f 1										
Cases	0.246	0.344	0.448	0.902	41.03	0.722		0.91	0.63, 1.30	0.60
Controls	0.177	0.274	0.451	1.542	49.35	0.699	0.94	1(Ref)		
Fel d 1										
Cases	0.003	0.006	0.010	0.078	35.38	0.031		1.11	0.88, 1.39	0.37
Controls	0.004	0.006	0.110	0.029	4.04	0.018	0.42	1(Ref)		
Can f 1										
Cases	0.000	0.000	0.000	0.004	3.50	0.001		0.99	0.86, 1.13	0.88
Controls	0.000	0.000	0.001	0.004	7.84	0.001	0.97	1(Ref)		

* *P* value is for difference in geometric means between cases and controls

† *P* value less than equal to 0.05

‡ AOR represents relative change of odds for readmission of cases compared to controls for every doubling of fungus or bedding allergen, adjusted for age, sex &HRV at admission.

Table 3: Associations between indoor housing characteristics and readmissions for asthma in children.

				Adjusted‡		
	All	**Case**	**Control**	**OR**	**95% CI**	***p***

N	44(100%)	22(50%)	22(50%)			
Number People in House						
3	4(9%)	1(5%)	3(14%)			
4	26(59%)	12(55%)	14(64%)			
5	11(25%)	7(32%)	4(18%)			
6	3(7%)	2(9%)	1(5%)	2.2†	0.86, 5.45	0.10
Pets						
any pets	16(36%)	10(45%)	6(27%)	2.62	0.51, 7.25	0.33
dog	7(16%)	4(18%)	3(14%)	1.63	0.28, 9.44	0.58
cat	6(14%)	4(18%)	2(9%)	1.84	0.27, 12.69	0.53
Frequency of Vacuuming						
vacuum weekly or less	27(61%)	8(36%)	19(86%)	1(Ref)		
vacuum daily or 2/3 times week	17(39%)	14(64%)	3(14%)	15.69	2.82, 87.18	0.002
Carpet*						
in home	25(60%)	14(67%)	11(52%)	1.97	0.48, 8.02	0.34
in child's bedroom	21(50%)	14(67%)	7(33%)	4.07	1.03, 16.06	0.04
Vacuum Cleaner						
vacuum cleaner with a bag	21(48%)	13(59%)	8(36%)	4.48	0.88, 22.69	0.07
vacuum cleaner with HEPA filter	33(75%)	18(82%)	15(68%)	2.98	0.65, 13.61	0.16
Bedding**						
feather doona	8(19%)	1(5%)	7(32%)	1(Ref)		
synthetic doona	22(51%)	13(62%)	9(41%)	14.62	1.26, 169.4	0.03
Blanket	1(2%)	1(5%)	0	Unable to be calculated		
Other materials	12(29%)	6(29%)	6(27%)	10.81	0.78, 148.9	0.08
Heating*						
Central heating	6(14%)	1(5%)	5(24%)	0.20	0.02, 2.16	0.19

†Relative change in odds of readmission for an increase of 1 person in the house.

‡Adjusted for age, sex, HRV at admission.

* N = 42 and **N = 43 due to incomplete questionnaire.

If reference category is not stated, OR compares relative change in odds of readmission for those with exposure to those without exposure.