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ORIGINAL ARTICLE

β -(1,3)-Glucan Levels and Its Determinants in New Zealand Bedrooms

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β -(1,3)-glucan is a pro-inflammatory component of the fungal cell wall, indoor levels of which have only been considered in a few studies. This study assessed levels of β -(1,3)-glucan in 35 domestic bedrooms. β -(1,3)-glucan levels were estimated using a modified *Limulus* amoebocyte lysate kinetic assay. β -(1,3)-glucan geometric mean levels (95% confidence interval) were 163.9 $\mu\text{g/g}$ (129.5–209.3) from bedroom floors; 76.6 $\mu\text{g/g}$ (61.4–94.0) from mattresses; 132.1 $\mu\text{g/g}$ (68.9–207.9) from duvets; and 110.0 $\mu\text{g/g}$ (82.2–146.4) from pillows. Synthetic bedding and older mattresses contained higher β -(1,3)-glucan levels. Synthetic bedding contains higher levels of β -(1,3)-glucan than feather bedding, which may be of importance to asthmatics.

Keywords β -(1,3)-glucan, fungi, bedding, feather, synthetic

INTRODUCTION

Home dampness has consistently been shown to have a negative effect on respiratory health and to exacerbate asthma (1, 2). This may be owing to increased microbial products such as fungal extracellular polysaccharides, fungal glucans, and bacterial endotoxin. Glucans are non-allergenic fat-soluble structural cell wall components of fungi and can account for up to 60% of the dry weight of the cell wall, the main glucan being β -(1,3)-glucan (3). In humans, inhalation of β -(1,3)-glucan can cause lung function changes, including peak flow variability (4). Dose-response relationships have been demonstrated between levels of airborne β -(1,3)-glucan and throat irritation, dry cough, itching skin, nose irritation, and tiredness (5).

To date only a few studies have determined β -(1,3)-glucan levels in the domestic environment (4, 6–11). As we spend approximately one third of our lives in the bedroom and bedding is in close proximity to the airways, we measured β -(1,3)-glucan levels from individual bedding items and looked for factors determining these levels.

METHODS

Dust Collection

Dust samples from mattresses, duvets, pillows, and floors were collected during late spring (November/December 2006) from the master bedroom in each of 35 domestic residences in the greater Wellington region of New Zealand. The study was approved by the Central Districts Ethics Committee.

Dust samples were collected using an 1100W Hitachi vacuum cleaner fitted with a 25 μm pore-sized nylon sock. A 1-m² area of the duvet, mattress, and floor was sampled for 1

minute. Any duvet or occlusive covers were left on the mattress. The floor sample was obtained as close to the bed as possible. Pillows were vacuumed for 1 minute on each side. Participants completed a questionnaire about the composition and age of each bedding component, cleaning and airing habits, experience of dampness in the room, and the presence of pets in the bedroom.

β -(1,3)-glucan Determination

The mattress and floor dust samples were sieved through a 425- μm mesh steel filter, and total dust weights were recorded and stored at -20°C until extraction. For extraction, 20 mg was mixed with 20 mL of 0.3 M NaOH, rocked for 30 minutes on a linear shaker, centrifuged at 4,000g for 10 minutes, and the supernatants were stored at -20°C before analysis. β -(1,3)-glucan levels in the dust extract supernatants were estimated at a 1:1000 dilution with a modified *Limulus* amoebocyte lysate kinetic assay specific for β -(1,3)-glucan (GlucateLL; Cape Cod Inc, Falmouth, MA) in one analytical batch as previously described (10).

Data Analysis

Due to log non-normal distribution, β -(1,3)-glucan results were log transformed and expressed as geometric mean levels together with 95% confidence intervals (95% CI). Data analysis was conducted using “R” version 2.2.0. The effects of the bedding characteristics were estimated by nonparametric bootstrapping. Correlation between sampling locations were calculated as ratios by using the non-parametric Spearman rank-order correlation coefficient. Statistical significance was set at the $p = 0.05$ level.

RESULTS

β -(1,3)-glucan Levels

A total of 178 dust samples were obtained from 35 floors, 35 mattresses, 35 duvets, and 73 pillows. Table 1 shows the overall β -(1,3)-glucan levels in these bedding components

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TABLE 1.—Geometric mean (95% confidence interval) β-(1,3)-glucan levels in individual bedding components.

	n	μg/m ²	μg/g
Floor	35	32.4 (22.0–47.7)	163.9 (129.5–209.3)
Mattress	35	15.7 (10.4–23.9)	76.6 (61.4–94.0)
Duvets	35	8.8 (5.4–14.1)	132.1 (68.9–207.9)
Pillows	73	3.5* (2.5–4.8)	110.0 (82.2–146.4)

*Total β-glucan (μg/pillow).

expressed as concentrations (μg/g) and per unit area (μg/m²).

Table 2 shows the β-(1,3)-glucan levels of pillows from six bedrooms where at least one pair of synthetic and feather pillows was on their bed. Total β-(1,3)-glucan levels recovered from the synthetic pillows were two- to threefold higher than from feather pillows; however, this just failed to reach statistical significance.

Table 3 shows that there were seven- to eightfold higher levels of β-(1,3)-glucan from synthetic duvets than from feather duvets. Allowing dogs or cats in the bedroom resulted in significantly higher β-(1,3)-glucan levels for synthetic duvets only (OR = 11.3, 95% CI = 2.0–25.9; *p* = 0.012). This effect was not seen in feather or other duvet types.

Mattresses older than 5 years of age (*n* = 25) had about threefold higher β-(1,3)-glucan load (β-glucan μg/m² ratio: 3.31; 95% CI: 1.53–6.11; *p* = 0.0064) than mattresses less than 5 years of age (*n* = 10).

Floor β-(1,3)-glucan levels were not significantly affected by vacuuming or carpet age. The effect of a damp bedroom as measured by the presence of condensation, a musty smell, or visible mold also had no significant effect on β-glucan levels from floors or bedding items (results not shown).

Mattress β-(1,3)-glucan levels were positively correlated with pillow β-(1,3)-glucan levels (*r* = 0.28; *p* = 0.01). However, there were no other significant correlations between the other bedroom components.

DISCUSSION

This study has shown a wide variation in β-(1,3)-glucan levels in individual bedding items. Only a few studies have determined β-(1,3)-glucan levels in the home environment. We cannot directly compare results as previous studies used a β-(1,3)-glucan specific inhibition enzyme immunoassay (4, 6–8), whereas a kinetic *Limulus* amoebocyte lysate assay was used in our study.

Synthetic pillows were shown to have a two- to threefold higher level of β-(1,3)-glucan than feather pillows. Although not statistically significant in this study, we have previously

TABLE 2.— Geometric mean levels and geometric mean ratios (95%CI) of β-(1,3)-glucan from synthetic and feather pillows.

Pillow type	μg/pillow	Ratio*	μg/g	Ratio*
Synthetic	3.8 (1.4–11.0)	2.53 (0.79–4.27)	105.4 (76.9–144.6)	1.37 (0.48–2.25)
Feather	2.0 (0.8–5.1)		76.6 (36.7–159.9)	
<i>p</i>		0.061		0.47

*Ratio synthetic-feather.

TABLE 3.—Effect of duvet type on β-(1,3)-glucan levels.

Duvet type	N	Ratio*	95%CI	<i>p</i>
Feather	10	1		
Synthetic	16	7.57	(1.47–17.64)	0.036
Other	9	1.37	(0.66–2.67)	0.70

*Ratio of the mean β-(1,3)-glucan μg/m².

found significantly higher β-(1,3)-glucan levels from synthetic pillows (11). Synthetic duvets also had seven- to eightfold higher levels of β-(1,3)-glucan than feather duvets. This has also previously been demonstrated for house dust mite allergens (12). This could be of relevance as various studies have shown that synthetic bedding is associated with more asthma symptoms compared to feather bedding (reviewed in reference 13).

Mattress age and the presence of pets affected β-(1,3)-glucan levels in the bedroom. Allowing pets into the bedroom increased levels of β-(1,3)-glucan only in synthetic duvets. An increase in β-(1,3)-glucan due to pets has previously been shown in mattresses and floors in Europe (6, 8), while higher levels of endotoxin in living rooms have also been associated with the presence of pets (3). Older mattresses resulted in higher levels of β-(1,3)-glucan, as also has been found for house dust mite allergens (14).

We found no association between house dampness and β-(1,3)-glucan levels. However, previous studies have shown an increase in β-(1,3)-glucan levels associated with mold spots on living room floors (8). Airing the bedding, vacuuming the mattress and the floor, and age of the carpet were all shown to have no significant effect on β-(1,3)-glucan levels. Studies from Europe have shown that frequency of vacuuming had a dose response relationship with β-(1,3)-glucan levels, while older carpets were associated with higher β-(1,3)-glucan levels (6–8).

There were some limitations in our study. One limitation may be location as samples were taken from one greater urban area in the country. We have found some differences in bedroom floor β-(1,3)-glucan levels between Wellington and Christchurch (unpublished results), whereas another study has shown differences in β-(1,3)-glucan levels between European countries (6). The small sample size of the matched pillow component of our study could have led to the non-significant findings of lower β-(1,3)-glucan levels from pillows; however, our results are in agreement with the significant findings of our previous study (11). Finally, a limitation may be because the dust samples were taken in early summer, as a previous study showed that lower temperatures leads to lower β-(1,3)-glucan levels while increased humidity was associated with higher β-(1,3)-glucan levels (8). We have also found significantly higher levels of β-(1,3)-glucan in spring compared with summer (unpublished results).

Our findings could be of potential importance to asthma patients because although β-(1,3)-glucan does not induce immunoglobulin- E (IgE) synthesis it is pro-inflammatory and is associated with increased peak flow variability in children (4). The levels in bedding could have a significant role in these respiratory symptoms as bedding items are in close proximity to the airways. Further research is also needed to determine what range of β-(1,3)-glucan levels, as measured

with the kinetic *Limulus* amoebocyte lysate assay, are associated with asthma and respiratory symptoms.

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