INTERNATIONAL PERSPECTIVES

Presence of Household Mold, Children's Respiratory Health, and School Absenteeism: Cause for Concern

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Abstract **A study examining the relationship between housing conditions, respiratory health, and school absenteeism was conducted in the city of Winnipeg in Manitoba, Canada. As part of this study, a survey was completed by 3,424 parents of children in grades 3 and 4 to determine the a) relationship between self-reported visible mold in homes and tested airborne mold; b) relationships of self-reported visible mold, tested airborne mold, and asthma and/or persistent colds; c) school absenteeism rates due to asthma and/or persistent colds; and d) children's socioeconomic status (SES) and incidence of asthma and/or persistent colds. In addition, a complete inspection of a subset of 715 homes was conducted, including the collection of over 1,400 indoor and 500 outdoor air samples for mold analysis. Results indicate a significant association between self-reported visible mold and airborne mold. Additionally, a significant association was found between *Cladosporium* levels from air samples (the most common genus type found) and children's asthma in combination with persistent colds. Children with persistent colds in combination with asthma miss significantly more school than children who have only asthma or only persistent colds. Children from poorer families reported more persistent colds than children from high-income families. No association was found between income and asthma. Furthermore, SES was not a significant factor for number of school days missed.**

Introduction

One of the most comprehensive Canadian surveys completed to date on the state of asthma reported that 2 million Canadians, including 10%–15% of children, are currently affected by this condition (Glaxo Wellcome, Inc., 2000). In the U.S., approximately 10.2 million children (9.2%) were diagnosed with asthma (National Center for Health Statistics [NCHS], 2015). Each year, approximately 10 children and 450 adults die in Canada from asthma, while 23% of children with asthma miss school every year due to their condition. A study by the Winnipeg Regional Health Authority reported that inner-city Winnipeg has the highest number of physician visits for asthma by children in the province of Manitoba (Winnipeg Regional Health Authority, 2004). Between 2001 and 2003, in one of the inner-city Winnipeg neighborhoods (Inkster West), there were 174.9 physician visits by children 5–9 years of age for asthma per 1,000 population. For comparison, the average number of physician visits by children of the same age for asthma for the entire Winnipeg Health Authority region was 138.6 per 1,000 population. Similar studies in the U.S. have indicated that asthma-related hospitalizations have risen disproportionately for inner-city children (Crain et al., 2002; Malveaux & Fletcher-Vincent, 1995).

A number of studies have found a significant increase in school absenteeism for children who have asthma (Bener, Kamal, & Shanks, 2007; Bonilla et al., 2005; Freeman, Schneider, & McGarvey, 2003; Gasana et al., 2016; Hsu, Qin, Beavers, & Mirabelli, 2016; Meng, Babey, & Wolstein, 2012). Webber and coauthors (2003) surveyed 6,433 parents of children in six elementary schools in the Bronx in New York. They found that the prevalence of asthma was 19.9% and children with asthma missed an average of 21.3 school days per year. A study conducted by Parcel and coauthors (1979) found that children with asthma have a significantly higher absenteeism rate (8.4% of school days) than do nonasthmatic children (5.9% of school days). In fact, asthma has been found to be the major cause of absenteeism due to chronic illness (Shendell, Alexander, Sanders, Jewett, & Yang, 2010; Wang, Zhong, & Wheeler, 2005).

Asthma severity is also a significant indicator of days absent from school. Parcel and coauthors (1979) concluded that the mean number of absent days increased according to the mother's perception of the severity of her child's asthma. Those with mild asthma

TABLE **1**

Response Rates for Initial Contact Survey and House Inspection by Group

Study Part	Health Condition	No Asthma	Asthma[a]	Total
Initial contact survey	No/few colds	1,956 (57%)	171 (5%)	2,127 (62%)
	Persistent colds[b]	841 (25%)	456 (13%)	1,297 (38%)
	Total	2,797 (82%)	627 (18%)	3,424 (100%)
House inspection	No/few colds	201 (28%)	72 (10%)	273 (38%)
	Persistent colds	225 (31%)	217 (30%)	442 (62%)
	Total	426 (60%)	289 (40%)	715 (100%)

[a]Asthma = having received a formal diagnosis of asthma from a physician or having had at least one asthma attack, gone one or more times to a hospital emergency department due to asthma, been hospitalized at least once due to an asthma attack, or been prescribed steroids, over the last 12 months.

[b]Persistent colds = having ≥4 respiratory infections/colds in the past year (more conservative than Williamson and coauthors' (1997) definition of ≥3/year).

missed 6.9% of school days, those with moderate asthma missed 7.9% of school days, and those with severe asthma missed 13.9% of school days. Similarly, Moonie and coauthors (2006) found a significant difference in absent days per school year based on severity of symptoms: mild intermittent asthma (8.5 days), mild persistent asthma (11.3 days), and severe persistent (11.6 days).

Waking up during the night due to asthma symptoms was also associated with school absenteeism. Diette and coauthors (2000) showed that among children with severe symptoms, 58% missed school because of asthma when awakened 1–3 nights, but only 20% missed school if there were no nights when their sleep was disturbed due to asthma.

There is also evidence to suggest that absenteeism rates due to asthma are greater for girls than for boys (Bener, Abdulrazzaq, Debuse, & Abdin, 1994) and that, as students get older, absenteeism due to asthma decreases (König & Shaffer, 1996; Parcel, Gilman, Nader, & Bunce, 1979). Moonie and coauthors (2006) concluded that the differences between the rates of absenteeism between asthmatic and nonasthmatic children were so high as to warrant further studies.

The results presented here are part of a larger study examining the relationship between housing conditions and respiratory health among 9-year old children in Winnipeg (Polyzois, Polyzoi, Wells, & Koulis, 2016; Wells, 2014). In the current paper, we examine the a) relationship between self-reported visible mold in homes and association with tested airborne mold; b) relationships of self-reported visible mold, tested airborne mold, and incidence of asthma and/or persistent colds; c) school absenteeism rates due to asthma and/or persistent colds; and d) children's socioeconomic status (SES) and incidence of asthma and/or persistent colds.

Methods

Participants

A total of 3,424 students, drawn from six main school divisions in the city of Winnipeg in Manitoba, Canada, participated in this study. The mean age of the students at the time of the survey was 8.4 years (minimum 6.5 years; maximum 10.3 years; standard deviation 7.3 months). There were 1,714 (51%) males and 1,675 (49%) females (35 missing information); of these, 1,777 (52%) were in grade 3 and 1,623 (48%) in grade 4 (24 missing information).

The University of Manitoba Education/Nursing Research Ethics Board approved this study (protocol # E2005:058: Respiratory Health, Housing Conditions, and School Absenteeism among Nine-Year-Old Children in Winnipeg).

Procedure

In September 2005, following formal permission from all six school-division chief superintendents, an initial contact survey was distributed through the individual school teachers to the entire third- and fourth-grade school student population of 13,729 children in Winnipeg. This survey was designed to obtain parental information on a) their child's respiratory health, including incidents of respiratory infections/asthma over the past academic year (2004–2005), as well as trips to the doctor and/or hospital; b) the child's home environment, including the age of home, presence of mold, carpeting, number of smokers in the home, presence of cats or dogs, and relatives who have asthma; and, c) number of school days missed by the child in 2004–2005 due to respiratory tract infections and/or asthma.

Based on the returned parent surveys (n = 3,424 or 25% response rate), children were categorized into four health groups (Table 1). Of the 3,424 responders, 2,064 parents (61%) agreed to participate in a follow-up housing inspection, which included the collection and analysis of over 1,400 indoor and 500 outdoor air samples. A total of 715 homes were completely inspected. A detailed description of the design methodology and procedure used can be found in Polyzois and coauthors (2016).

Results

Self-Reported Visible Mold and Tested Airborne Mold

Tests of independence (Pearson's chi-squared test) for contingency tables were used to assess the associations between self-reported visible mold and airborne mold. A statistically significant association was found for the month of April between self-reported mold in the house and airborne mold (all species combined) for both the children's bedrooms and basements (Table 2).

Cladosporium was the most common mold found in Winnipeg homes (98.2% of children's bedrooms and 97.8% of basements), followed by *Alternaria* (82.4% of children's bedrooms and 77.0% of basements), and *Penicillium* (35.4% of children's bedrooms and 48.8% of basements).

Self-Reported Visible Mold, Tested Airborne Mold, and Incidence of Asthma and/or Persistent Colds

Tests of independence (Pearson's chi-squared test) for contingency tables showed that the

child's respiratory health is significantly associated with self-reported visible mold in the basement of the child's home (Table 3). Generally, there are more healthy children (few or no colds/no asthma) when mold was not reported in the home and more children with compromised respiratory health when mold was reported in the home.

In order to link reported mold to tested airborne mold, a Kruskal-Wallace Nonparametric test of the distribution of *Cladosporium* spores (the most common genus type found) by area of the home (children's bedroom or basement) was performed (Table 4). Results showed a significant association between *Cladosporium* levels from air samples taken in April and children's asthma in combination with persistent colds. No statistically significant association between *Penicillium* or *Alternaria* and respiratory health was found.

TABLE **2**

Self-Reported Indoor Visible Mold (Yes/No) by Total Airborne Mold (Combined Genus Types) in CFU/m³ (Data Collected in April)

Location	Self-Reported Mold (Presence/Absence)	Air Sample Results in CFU/m³			
		≥100 # (%)	≥200 # (%)	≥300 # (%)	≥400 # (%)
Children's bedroom	Yes (n = 143)	85 (59.4)[a]	46 (32.2)[a]	16 (11.2)	10 (7.0)[a]
	No (n = 145)	66 (45.5)	27 (18.6)	9 (6.2)	1 (0.7)
Basement	Yes (n = 139)	85 (61.2)[a]	46 (33.1)[a]	28 (20.1)[a]	18 (12.9)
	No (n = 142)	66 (46.5)	29 (20.4)	15 (10.6)	9 (6.3)

[a]$p < .05$.

TABLE **3**

Association of Selected Aspects of the Home Environment and Children's Persistent Colds and/or Asthma

Mold in Basement	Few or No Colds/No Asthma (%)	Persistent Colds Only (%)	Asthma Only (%)	Asthma and Persistent Colds (%)	χ^2 (df) p-Value
Yes (n = 612)	47.4	29.9	5.9	16.8	29.11 (3) <.0001
No (n = 2,812)	59.3	23.4	4.8	12.5	

School Absenteeism Rates due to Asthma and/or Persistent Colds

School absenteeism data were obtained during the initial contact survey involving 3,424 students in grades 3 and 4 in Winnipeg. In Manitoba, students attend between 194 and 196 days of school during any academic year. Parents were asked to respond to the following survey item: Over the past 12 months, how many days of school has your child missed due to a) upper respiratory tract infections (colds)? and b) asthma?

The total number of days absent from school was calculated as the sum of days absent due to colds *and* asthma (from survey items a and b, above). As parents reported absenteeism in a range of days, two analyses were run: one considered the minimum number of days absent due to colds and asthma (using the lowest value in the range) and the other considered the maximum number of days (using the highest value in the range). For the total minimum number for each child, the possible range of values is 0, 1, 2, 3, 4, 6, etc. For the total maximum number for each child, the possible range of values is 0, 2, 4, 5, 7, etc. Table 5 shows the mean number of days absent by group when using these two different approaches.

Children who had asthma in combination with persistent colds had the highest incidence of absenteeism. As shown in Figure 1, 30% of these children missed a maximum of 2–4 school days, 39% missed a maximum of 5–10 days, and an additional 12% missed a maximum of 12–42 days.

The absenteeism data are count versus continuous and because statistical methods such as least squares and ANOVA are designed for continuous dependent variables, therefore Poisson regressions were used to investigate the associations among asthma, persistent colds, and the total number of days missed. The two independent variables for the Poisson regressions were asthma (yes/no) and persistent colds (yes/few or no colds). Each independent variable has two levels indicating the presence or absence of the condition. The dependent variables were minimum and maximum total number of days missed. The likelihood ratio statistic was used to test the significance of the independent variables on the dependent variables (Cameron & Trivedi, 1998).

Results showed that the two independent variables (asthma and persistent colds) were significantly associated with both the minimum (asthma: $p < .001$; persistent colds: $p < .001$) and maximum total number of days missed (asthma: $p < .001$; persistent colds: $p < .001$). As shown in Figure 2, children with persistent colds in combination with asthma miss significantly more school than children with only asthma or only persistent colds. For "healthy" children (i.e., with no asthma and no persistent colds) the mean total number of days missed was between 0.37 (using the minimum) and 0.68 (using the maximum) (Table 5). Children who have only asthma, however, miss from 2.4–2.6 times more days of school than healthy children. Similarly, children with only persistent colds miss from 3.7–4.2 times more days of school than healthy children. Children with both asthma and persistent colds miss 8.8–10.9 times more days than this same comparison group.

Children's Socioeconomic Status (SES) and Incidence of Asthma/ Persistent Colds

In order to examine this relationship, we looked at the association of children's respira-

TABLE **4**

Median *Cladosporium* Levels (in CFU/m³) by Area in the Home (Children's Bedroom or Basement) by Respiratory Condition of Child (Data Collected in April)

Median *Cladosporium* Levels (in CFU/m³) by Area in the Home	Respiratory Condition of Child				
	Few or No Colds/ No Asthma	Persistent Colds Only	Asthma Only	Asthma and Persistent Colds	χ^2 (*df*) *p*-Value
Bedroom median mold counts (25th percentile, 75th percentile)	97.0 (63, 125)	91.0 (59, 137)	97 (44, 190)	125 (91, 181)	9.82 (3) .020
Basement median mold counts (25th percentile, 75th percentile)	88 (63, 119)	75 (44, 125)	112 (69, 197)	131 (66, 187)	9.65 (3) .022

TABLE **5**

Mean Number of Days Absent (Minimum and Maximum) by Group

	n Valid	Mean (95% *CI*)
Minimum number of days		
Few or no colds/no asthma	1,943	0.37 (0.33, 0.41)
Asthma only	170	0.95 (0.66, 1.25)
Persistent colds only	838	1.57 (1.40, 1.74)
Asthma and persistent colds	454	4.08 (3.56, 4.60)
Maximum number of days		
Few or no colds/no asthma	1,943	0.68 (0.61, 0.75)
Asthma only	170	1.67 (1.21, 2.13)
Persistent colds only	838	2.51 (2.28, 2.73)
Asthma and persistent colds	450	5.99 (5.40, 6.58)

CI = confidence interval.

Note. For the minimum number of days, 23 students had missing information. For the maximum number of days, 27 students had missing information.

tory health by the mean income of Winnipeg neighborhoods in which they lived. In the lowest income neighborhood clusters, one generally can find higher incidences of reported persistent colds. For example, the poorest district had a mean neighborhood income of $33,523 and 56% of children in our study who lived in this area had persistent colds. In contrast, the most affluent district had a mean neighborhood income of $106,617 and 30.5% of children in our study who lived in this area had persistent colds. Of the 23 neighborhood clusters examined, three out of the five clusters with the lowest average income were also in the top five clusters with the highest number of respondents with persistent colds.

In order to examine these associations on a finer scale, we used income data linked to children's individual postal codes (Manitoba Centre for Health Policy, 2016). The data are in the form of income quintile codes by postal code. An income quintile is a measure of SES that divides the population into five income groups (from lowest to highest) based on average household income, a population value (year specific), and an urban/rural indicator. Approximately 20% of the population falls in each income group.

The relationship between SES and respiratory health was examined only for the subgroup of urban children, as the vast majority of the children in our study (92%) fall within that category. Tests of independence (Pearson's chi-squared test) for contingency tables were used to assess the associations between SES group and respiratory health. Table 6 shows that children from poorer families tend to have more persistent colds than children from high-income families (p = .003). There was no statistically significant association, however, between SES and asthma (i.e., children with asthma were found at all SES levels).

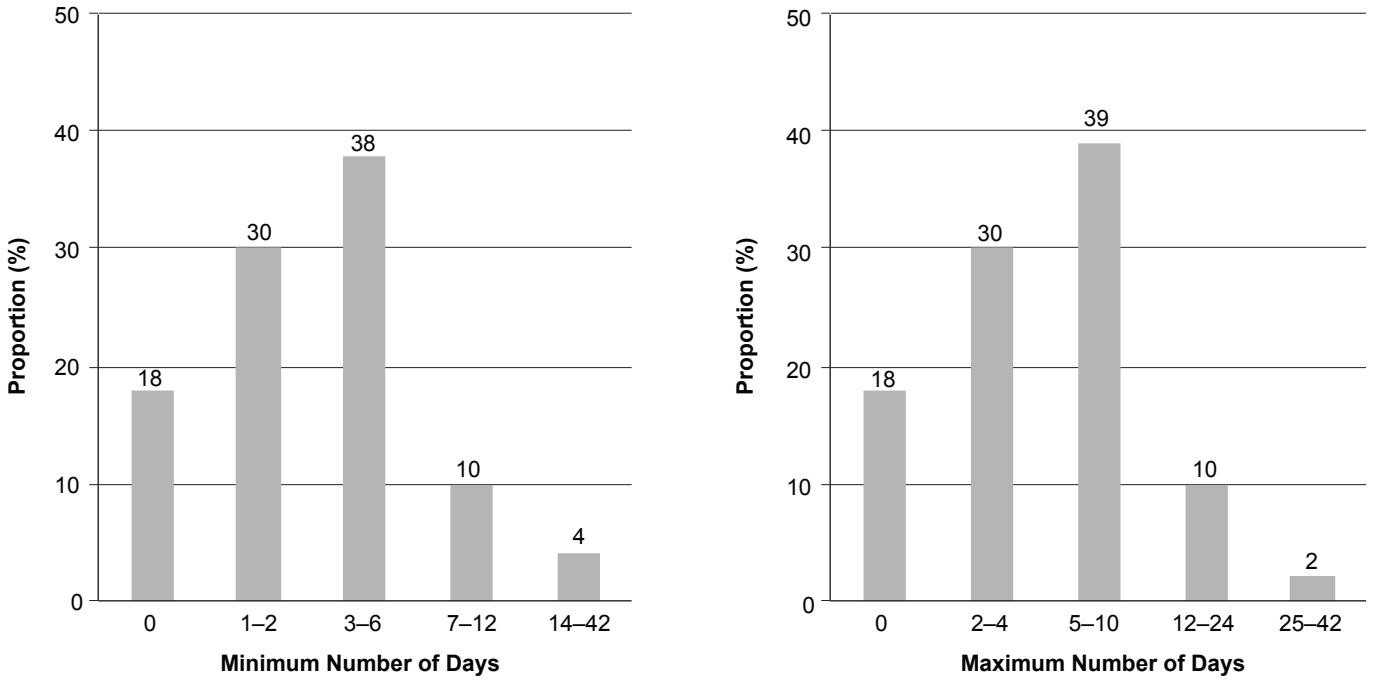
In order to determine the relationship between children's SES and school absenteeism, the Poisson regression analyses for the number of days missed conducted earlier were repeated by including SES group as an independent variable (in addition to the two independent variables, asthma and persistent colds). Two separate analyses were performed where the dependent variable was the number of days missed using the minimum and maximum values. In both cases, SES was not a significant factor for the number of days missed (minimum days: p = .147; maximum days: p = .457). In addition, when controlling for SES, persistent colds and asthma remained as significant factors for the number of days missed.

Discussion

Results from this study indicate a significant association between self-reported visible mold and tested airborne mold. Additionally, a significant association was found between *Cladosporium* levels from air sample analyses (the most common genus type found) and children's asthma in combination with persistent colds. This same group also miss significantly more school

FIGURE **1**

Distribution of the Total Number of Days Absent for Students With Asthma in Combination With Persistent Colds



days than children who have only asthma or only persistent colds. Childen facing economic adversity are subject to more persistent colds than those from high-income level families—a finding that is supported by the literature. For example, Brownell and coauthors (2012) found that 32% of occurrences of hospital utilization (hospital episodes) for children in urban Manitoba were from the lowest income quintile, although this group only makes up 20% of the urban population—a clear overrepresentation by impoverished groups. In contrast, children with asthma in the current study were found in all income-level families. Finally, no link was found between SES and absenteeism; that is, students missed school because of asthma and colds, not because of SES.

Examining children's respiratory illness as related to household mold is important for a number of reasons. Children's persistent colds and/or diagnosed asthma condition not only affect their school attendance, they also result in parental lost work days. For example, among U.S. children and adolescents aged 5–17 years, asthma accounts for a yearly loss of 10 million school days and costs caretakers $726.1 million/year because of lost wages (NCHS, 2015). According to Wang and coauthors (2005), this loss of productivity from asthma-related school absences amounts to approximately $791/child with asthma per year. Additionally, children who are frequently absent from school not only disrupt their education, but are at a much greater risk of premature school dropout (Moonie, Sterling, Figgs, & Castro, 2006). Reducing absences could avoid compromising children's school performance (Haas & Fosse, 2008).

Healthcare professionals, educators, and housing authorities must share the responsibility to support and manage children's respiratory health and, by extension, encourage school attendance. Only in this way can we help buffer the negative effects of children's asthma and optimize their capacity for learning.

Limitations

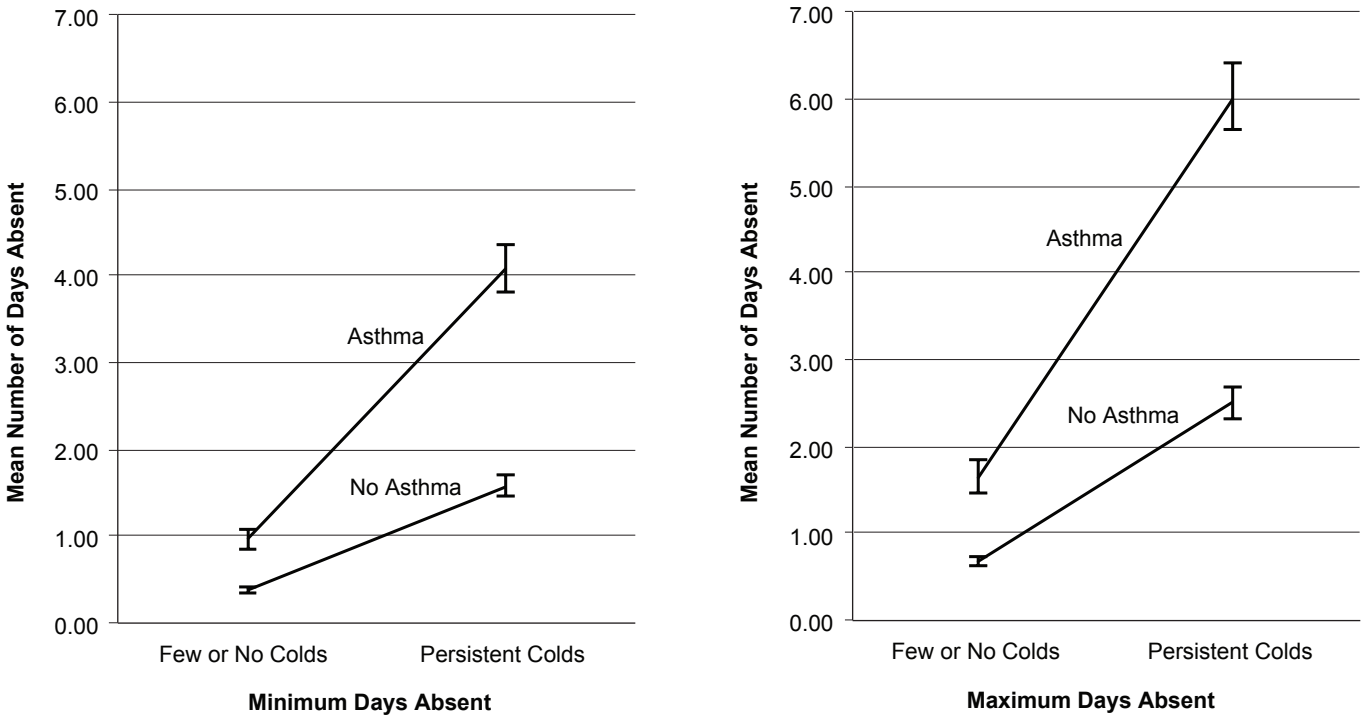
With a return rate of 25% in our survey, resulting in 3,424 children in grades 3 and 4 being represented in the survey, there is a possibility that results may be biased in favor of those parents with children who have known or suspected respiratory health conditions. It is noteworthy, however, that 57% of our study's respondents had no reported respiratory health problems. Furthermore, the reported proportion of asthma cases in our study sample (5%) was much lower than the reported percentage of asthmatic children of similar age within the broader Canadian population (9%).

Second, simply asking parents about the presence of visible mold, as we did in our survey, might not be the same as actually identifying the mold in the homes. Results from our study suggest that the presence of self-reported mold was confirmed by the air sample counts for April for mold in both bedrooms and basements. We found a statistically significant association between self-reported visible mold and airborne mold through an analysis of over 1,500 indoor air samples.

Third, school absenteeism in the present study was based on retrospective data re-

FIGURE **2**

Mean Total Number of Days Absent for Students With Persistent Cold (Yes/Few or No Colds) and Asthma (Yes/No) for Minimum and Maximum Days



Note. Error bars represent 95% confidence intervals.

called by parents regarding their children's missed days over the past academic year. A more accurate, yet labor-intensive approach would have been to directly examine each child's school record/report card for absent days. This alternate process would also have limitations, however, because schools typically do not record the reasons for absenteeism, including any asthma-related illnesses or persistent colds.

Future Research

Future research could involve linking school absenteeism precipitated by upper respiratory tract infections or asthma to school performance. Research suggests that absenteeism is linked to lower academic performance, particularly among inner-city minority youth (Hsu et al., 2016). A further line of study could involve linking absenteeism to severity of asthma and/or upper respiratory tract infections based on frequency of hospital/doctor visits and medications prescribed by a physician. Although in our study we found no association between asthma and SES, if severe instances of asthma were isolated, perhaps higher incidence levels among those who are impoverished might be more evident.

In Manitoba, such information can be obtained through the Manitoba Centre for Health Policy's unique data repository, which holds the Manitoba physician claim, hospital discharge abstracts, and prescription record health databases for all residents in the province, including children. Accessing these will permit an examination of such links to children's respiratory health, based on severity. We have secured formal consent from the parents to link the respiratory health condition of their children to these provincial health databases, enabling such an exploration to be undertaken in the near future.

Acknowledgements: This work was supported by grant 74307 from the Institute of Population and Public Health of the Canadian Institutes of Health Research (CIHR) and by grant 135495 from the CIHR Regional Partnership Program. In addition, funding support was received from the Province of Manitoba through the Manitoba Research and Innovation Fund.

We would like to thank all the families who participated in this study and who allowed us into their homes to conduct an extensive housing audit, including the collection of air samples.

We are indebted to Research Associate Dr. Dan Chateau, Biostatistics Consulting Unit of the Department of Community Health Sciences, Faculty of Medicine, for his initial assistance with the statistical analysis of the data. We would also like to thank Research Associate Scott McCullough and Research Assistant Adrian Werner from the Institute

of Urban Studies, University of Winnipeg, for the mapping analysis using ARC-GIS. Other members of the larger research team include Anita Kozyrskyj, Associate Professor, Department of Community Health Sciences, Faculty of Medicine and Faculty of Pharmacy, University of Manitoba, and Kimberly Thompson, Associate Professor of Risk Analysis and Decision Science, Harvard Medical School.

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TABLE **6**

Association Between Persistent Colds and Socioeconomic Status (SES) Group (Urban Only)

	SES Group*					χ^2 (*df*) *p*-Value
	1 (Poor) # (%)	2 # (%)	3 # (%)	4 # (%)	5 (Affluent) # (%)	
Persistent colds						
Yes	134 (44.7)	178 (38.9)	247 (39.7)	314 (41.5)	351 (34.2)	15.81 (4) .003
No	166 (55.3)	280 (61.1)	375 (60.3)	443 (58.5)	674 (65.8)	
Asthma						
Yes	53 (17.7)	84 (18.3)	117 (18.8)	164 (21.7)	171 (16.7)	7.38 (4) .117
No	247 (82.3)	374 (81.7)	505 (81.2)	593 (78.3)	854 (83.3)	

*SES groups correspond to the following income quintiles (as defined by Manitoba Centre for Health Policy, 2015): Group 1 (10%), $14,640–$42,340; Group 2 (14%), $42,348–$54,441; Group 3 (20%), $54,455–$67,696; Group 4 (24%), $67,726–$86,350; and Group 5 (32%), $86,390–$406,531.

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