



*Original Article*

# The association between respirable dust exposure and allergic symptoms in the libraries and general offices at Chulalongkorn University, Bangkok, Thailand

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## Abstract

**Background:** Nowadays, people face health problems from poor indoor air quality caused by indoor air pollutants such as dust. Dust accumulates in various places and libraries are among those. Therefore, library officers are vulnerable to symptoms related to dust exposure. **Method:** This study was cross-sectional survey to find the association between respirable dust, PM<sub>10</sub>, and allergic symptoms in librarians compared with general officers. Chi-square and logistic regression were used to identify the prevalence of variables and to analyze the association between PM<sub>10</sub> exposure and allergic symptoms respectively. **Result:** Librarians were exposed to PM<sub>10</sub> levels higher than the general officers ( $p < 0.001$ ) and skin rash symptoms was significantly associated with PM<sub>10</sub> exposure ( $p = 0.041$ ). **Conclusion:** Librarians had higher risk of PM<sub>10</sub> exposure and associated allergic symptom of skin rash. Other risk factors related to the symptoms were workplace renovation, daily dust exposure and history disease.

**Keywords:** PM<sub>10</sub>, allergic symptoms, librarians, general officers

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## 1. Introduction

Nowadays, many people are facing health problems from poor indoor air quality which causes illness and death (WHO, 2014). According to the report by WHO in 2012, 4.3 million people who live in low and middle income countries are found to have died from household air pollution and diseases which related to poor indoor air pollution. Those commonly found are stroke (34%) ischemic heart disease (26%) COPD (22%) acute lower respiratory disease (12%) and lung cancer (6%) (WHO, 2012). The South East Asian and Western Pacific regions had the highest occurrences of death from indoor air pollutants with 1.69 and 1.62 million deaths respectively. The other regions that had the same incidents

attributable from household or indoor air pollution were Africa, Eastern Mediterranean and America respectively (WHO, 2010). Indoor air pollution caused “sick building syndrome” among workers who have prolonged routine work in the building. This result aligns with WHO report of approximately about 30% of building in the United States having problems from poor indoor air quality (Research and Development U.S.EPA, 1991) and symptoms related to poor indoor air quality such as skin, eyes, nose and throat irritation, cough, shortness of breath, headache and dizziness (WCB, 2005). Generally, the contaminated pollutants in the building come from airborne dust, painting, and daily activities such as smoking, cosmetics powder and cooking (WCB, 2005) or other building components such as chemicals from furniture, ventilation system and pesticides (Indoor Air Division U.S.EPA, 1991). The United States of America indoor air report in 2007 showed that indoor air pollutants related to household indoor air quality problem mostly came from

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particulate matter (91%), chemical pollutants (70%), humidity (49%), carbon dioxide (45%), temperature (30%) and carbon monoxide (2%) respectively (IAQE, 2011.) Particulate matter or dust was the major pollutant for indoor air quality problem which caused people health problems especially particulate matter with diameter less than 10 microns ( $PM_{10}$ ) that pass through the lower respiratory tract and alveoli and affect respiratory function and lung disease (U.S.EPA., 2013). Those pollutants also affect people who stayed for long periods in the area. Not only buildings like houses and general offices, but also libraries where there were many books are also likely have high concentrations of dust, especially respirable dust ( $PM_{10}$ ), and fungi. High humidity and appropriate temperature are main contributors to dust growth and accumulation on bookshelves or the gap between books, and cover them including other objects in the library with a dust film (Lloyd, 2014). Workplaces like libraries are sources of high risk of pollutants from accumulated dust and fungi that can affect librarians and library users that lead to health symptoms. Those symptoms are short-term effects such as eyes, nose and throat irritation, sneezing, running nose (CDC, 2013). This study aimed to identify the association between  $PM_{10}$  exposure and allergic symptoms in the staff in the library and in general offices and to compare the health risk related to dust exposure.

## 2. Materials and Methods

### 2.1 Questionnaire

This study was cross-sectional study to identify the association between respirable dust ( $PM_{10}$ ) and allergic symptoms using a questionnaire survey. The participants in this study were 119 librarians who were defined as an exposed group and 74 general office workers who were defined as an un-exposed group. The data were collected by using structural questionnaire enquiring socio-demographic and personal information (gender, age, education, respiratory and allergic disease history and smoking habit), risky behavior (type of transportation to work, daily dust exposure and pesticide used in household), characterization of work (work hours, history of dust and chemical exposure at work), workplace characteristics (type of ventilation, workplace cleaning schedule and renovation of workplace) and allergic symptoms

### 2.2 Respirable dust measurement

National Institute for Occupational Safety and Health guideline were employed in this study (NIOSH, 1998). A personal air pump with personal environmental monitor (PEM) and PVC filter continuously collected  $PM_{10}$  in all participants of both group during work (eight hours per day). The  $PM_{10}$  concentration was calculated by pre-post weight of the filters as following equation.

$$C = \frac{(W_1 - W_2)}{V(L)} \times 10^{-3}, \mu g / m^3$$

Details: C = concentration of particulate matter ( $mg/m^3$ )

$W_1$  = Pre-weight of filter before sampling (mg)

$W_2$  = Post-weight of filter before sampling (mg)

V = Air volume as sampled at flow ( $m^3$ )

Personal  $PM_{10}$  measurements were not obtained from all study participants (the measurement was done in 103 staff from 66 librarians and 37 office workers). To enable inclusion of all subjects for  $PM_{10}$  level analysis with symptoms prevalence, the mean of  $PM_{10}$  measurements in each workplace was calculated. The workplace specific mean  $PM_{10}$  level was assigned to each participant in that workplace.

### 2.3 Data analysis

The analysis focused on the relationship between  $PM_{10}$  exposure and the allergic symptom prevalence from work, adjusted appropriately for other independent variables. Firstly, normality distribution test was used in choosing the appropriate statistical analysis then T-test was used for comparing the average of  $PM_{10}$  exposure between exposed and un-exposed group. Also descriptive statistics were used to describe variable levels with bivariate analysis one independent variable at a time. Moreover, Chi-square and Fisher's Exact test were used for categorical independent variables to compare allergic symptoms prevalence between exposed group and un-exposed group.

## 3. Results and Discussion

The results of socio-demographic has shown that most librarians were aged between 51-60 years old (37%) whereas general office workers were rarely 31-40 years old (40.5%) ( $p < 0.001$ ). A majority (79.8%) of librarians were female while general office workers were almost equally male and female ( $p = 0.002$ ). Most of the librarians and general office workers had no history of respiratory or allergic disease (89.9% and 89.2% respectively) ( $p = 0.872$ ).

Exposure to daily dust and chemical at work were the factors that could possibly be related to the allergic symptoms. This study has shown that most librarians were exposed to dust from traveling to work by private car (48.7%), bus with air condition (26.9%), BTS (21.0%), bus without air conditioning (17.6%), motorcycle (14.3%) and walking (3.4%) respectively. While most general office workers were exposed to dust from traveling to work by BTS (29.7%), private car (27.0%), bus with air conditioner (23.0%), walking (16.2%), motorcycle (14.9%) and bus without air conditioner (5.4%) respectively. According to these results, there were differences between librarians and general office workers about types of transportation including used private car, bus without air conditioner and walk to work ( $p = 0.003$ ,  $p = 0.014$  and  $p = 0.002$  respectively).

There was no difference between the daily dust exposure among librarians and general office workers. By the way, librarians exposed to daily dust from traffic (81.5%), cleaning house (70.6%), cooking (32.8%), incense smoking (15.1%) and open burning in their home (11.8%) respectively. These were similarities in the group of general office workers who exposed to daily dust from traffic (90.5%), cleaning house (73.0%), cooking (28.4%), incense smoking (13.5%) and open burning in their home (12.2%), respectively. According to the results, the prevalence of daily dust exposure in librarians came from cooking ( $p = 0.521$ ) and incense smoking ( $p = 0.757$ ) which were not significantly higher than the average found in general officers, while general office workers had prevalence of daily dust exposure from traffic ( $p = 0.088$ ), cleaning house ( $p = 0.721$ ) and open burning at home ( $p = 0.093$ ) were not significantly higher than in librarians. Moreover, numbers of librarians used pesticide in household (42.9%) were not

significantly higher than general office workers (37.8%) ( $p = 0.490$ ) (Table 1).

From Table 2, we found that most of libraries had air conditioner (97.5%) that slightly higher than general offices (87.8%) ( $p = 0.012$ ) and mostly of air conditioners in libraries were cleaned up about 1 time per month (69.7%) when those in general offices were cleaned up only 1-4 times per year (40.5%) ( $p < 0.001$ ). Besides, libraries floors were cleaned every day (96.6%) which was significantly higher than general offices (71.6%) ( $p < 0.001$ ).

The workplace of librarians were renovated, last one year, with polished floor (64.7%), re-painted (45.4%), renew floor (42.9%) and renovated any areas (40.3%), respectively. This prevalence were higher than general offices that renovated workplaces with polished floor (47.3%), re-painted (16.2%), renew floor (13.5%) and renovated any areas (8.1%), respectively.

Table 1. Socio-demographic and daily behaviors between the librarians and general office workers

Characteristics	Librarians (n= 119)	General office workers (n= 74)	p-Value
<b>Socio-demographic</b>			<0.001
1. Age interval (%)			
- 20–30 years	14 (11.8)	20 (27.0)	
- 31–40 years	30 (25.2)	30 (40.5)	
- 41–50 years	31 (26.1)	16 (21.6)	
- 51–60 years	44 (37.0)	8 (10.8)	
2. Gender (%)			0.002
- Male	24 (20.2)	30 (40.5)	
- Female	95 (79.8)	44 (59.5)	
3. History of respiratory and allergic disease (%)			0.872
- Yes	12 (10.1)	8 (10.8)	
- No	107 (89.9)	66 (89.2)	
<b>Daily dust and chemical exposure</b>			
1. Type of transportation to work (%)			
- Motorcycle	17 (14.3)	11 (14.9)	0.912
- Private car	58 (48.7)	20 (27.0)	0.003
- Bus without air conditioner	21 (17.6)	4 (5.4)	0.014
- Bus with air conditioner	32 (26.9)	17 (23.0)	0.543
- BTS	25 (21.0)	22 (29.7)	0.170
- Walk	4 (3.4)	12 (16.2)	0.002
2. Source of daily dust exposed (%)			
- Incense smoke	18 (15.1)	10 (13.5)	0.757
- Cooking	39 (32.8)	21 (28.4)	0.521
- Traffic	97 (81.5)	67 (90.5)	0.088
- Open burning	14 (11.8)	9 (12.2)	0.093
- Cleaning house	84 (70.6)	54 (73.0)	0.721
3. Pesticide used in household (%)			0.490
- Yes	51 (42.9)	28 (37.8)	
- No	68 (57.1)	46 (62.2)	

Table 2. Workplace characteristics compared between the libraries and general offices

Characteristics	Librarians (n= 119)	General office workers (n= 74)	p-Value
<b>Workplace characteristic</b>			
1. Ventilation mechanism (%)			0.012
- Air conditioner	116 (97.5)	65 (87.8)	
- Other : Fan Natural ventilation	3 (2.5)	9 (12.2)	
2. Cleaned air conditioner (%)			<0.001
- Never	12 (10.1)	9 (12.2)	
- Everyday	3 (2.5)	6 (8.1)	
- 12 times per years	83 (69.7)	29 (39.2)	
- Less than 12 times per years	21 (17.6)	30 (40.5)	
3. Cleaned floor (%)			<0.001
- Everyday	115 (96.6)	53 (71.6)	
- Not more than 3 times/week	4 (3.4)	21 (28.4)	
4. Type of renovation workplace at last one year (%)			
- Renovated floor	51 (42.9)	10 (13.5)	<0.001
- Renovated some areas	48 (40.3)	6 (8.1)	<0.001
- Polished floor	77 (64.7)	35 (47.3)	0.017
- Re-paint	54 (45.4)	12 (16.2)	<0.001

### 3.1 Exposure to particulate matter diameter less than 10 micron (PM<sub>10</sub>)

The mean of PM<sub>10</sub> exposure in librarians were 202.81 µg/m<sup>3</sup>, range of exposure between 9.89-1298.7 µg/m<sup>3</sup>, this was prominently higher than the mean of PM<sub>10</sub> exposure in general office workers with 102.95 µg/m<sup>3</sup>, range of exposure between 9.88-515.53 µg/m<sup>3</sup>, (p<0.001). However, the concentration of PM<sub>10</sub> were in acceptable criteria of Occupational Safety and Health Administration (OSHA) that respirable dust concentration should not be exceeding over 5,000 µg/m<sup>3</sup> in period of work (Table 3).

### 3.2 The prevalence of allergic symptoms

In this study, the prevalence of allergic symptoms that are most found are itchy eyes (50.3%), headache (44.6%), running nose (35.2%), stinging eyes (33.7%), skin rash (31.6%), running eyes (24.9%), redness (19.2%), watery eyes (19.2%) and dark circle under eyes (17.1%) respectively. From

the result, we found that the librarians had prevalence of allergic symptoms insignificantly higher than general office workers including dark cycle under eyes (OR = 2.19, 95%CI = 0.93-5.17, p = 0.076), skin rash (OR = 1.76, 95%CI = 0.92-3.37, p = 0.086), itchy eyes (OR = 1.73, 95%CI = 0.96-3.11, p = 0.067), redness of skin (OR = 1.60, 95%CI = 0.74-3.50, p = 0.231), headache (OR = 1.56, 95%CI = 0.87-2.82, p = 0.138), stinging eyes (OR = 1.34, 95%CI = 0.72-2.50, p = 0.360), watery eyes (OR = 1.19, 95%CI = 0.56-2.50, p = 0.655) and running eyes (OR = 1.18, 95%CI = 0.60-2.33, p = 0.631) respectively. However, general office workers had insignificantly more risk to develop running nose symptom compared to librarians (OR = 0.83, 95%CI = 0.45-1.52, p = 0.550) (Table 4).

### 3.3 The association between PM<sub>10</sub> exposure and allergic symptoms

PM<sub>10</sub> exposure was found positively associated to skin rash (OR=1.004, 95%CI = 1.00001-1.008, p = 0.041) but it was scarcely associated to running eyes (OR=1.002, 95%

Table 3. PM<sub>10</sub> exposure in librarians compared with general office workers

Characteristics	Librarians (n = 119)	General office workers (n = 74)	p-Value
PM <sub>10</sub> exposure in the workplace: (µg/m <sup>3</sup> )			<0.001
- Mean	202.81	102.95	
- Minimum	9.89	9.88	
- Maximum	1298.7	515.53	

Analyzed with independent sample t-test.

Table 4. Unadjusted prevalence of allergic symptoms in librarians compared with general office workers

Allergic symptoms	Total prevalence (%)	Librarians (%)	General office workers (%)	OR	95%CI	<i>p</i> -value
- Skin rash	61 (31.6)	43 (36.1)	18 (24.3)	1.76	0.92-3.37	0.086
- Running eyes	48 (24.9)	31 (26.1)	17 (23.0)	1.18	0.60-2.33	0.631
- Watery eyes	37 (19.2)	24 (20.2)	13 (17.6)	1.19	0.56-2.50	0.655
- Itchy eyes	97 (50.3)	66 (55.5)	31 (41.9)	1.73	0.96-3.11	0.067
- Stinging eyes	65 (33.7)	43 (36.1)	22 (29.7)	1.34	0.72-2.50	0.360
- Running nose	68 (35.2)	40 (33.6)	28 (37.8)	0.83	0.45-1.52	0.550
- Redness of skin	37 (19.2)	26 (21.8)	11 (14.9)	1.60	0.74-3.50	0.231
- Dark circle under eyes	33 (17.1)	25 (21.0)	8 (10.8)	2.19	.93-5.17	0.067
- Headache	86 (44.6)	58 (48.7)	28 (37.8)	1.56	0.87-2.82	0.138

Analyzed with Chi-square test.

CI = 0.998-1.006,  $p = 0.443$ ), watery eyes (OR=1.00003, 95% CI = 0.996-1.004,  $p = 0.991$ ), itchy eyes (OR=1.002, 95% CI = 0.999-1.006,  $p = 0.198$ ), stinging eyes (OR=1.0005, 95% CI = 0.99-1.004,  $p = 0.808$ ), running nose (OR=1.001, 95% CI = 0.997-1.005,  $p = 0.687$ ), redness of skin (OR=1.001, 95% CI = 0.997-1.006,  $p = 0.590$ ), dark circle under eyes (OR=0.999, 95% CI = 0.993-1.006,  $p = 0.860$ ) and headache (OR=1.001, 95% CI = 0.997-1.004,  $p = 0.759$ ). In conclusion, PM<sub>10</sub> can predict the symptom of skin rash in the workers (Table 5).

#### 4. Conclusions

The objective of this study was to investigate the association between respiratory dusts, PM<sub>10</sub>, and any allergic symptoms in libraries and to compare to general offices. This research had never been conducted before in Thailand. The results showed that the socio-demographic of the librarians were mostly different from general office workers ( $p < 0.05$ ). Firstly, the librarians who worked in the libraries mostly were woman (79.8%) with age between 51-60 years old (37%). This result was different with general office workers who were both male and female and age between 31-40 years old (40.5%). There were similar socio-demographic of respiratory and allergic disease in both of the officers ( $p = 0.872$ ) and pesticide used in their household ( $p = 0.490$ ). Moreover, the finding showed that PM<sub>10</sub> exposure was twice higher in librarians than the general office workers (202.81 and 102.95  $\mu\text{g}/\text{m}^3$  respectively), it means the librarians had higher risk than other office workers ( $p < 0.001$ ). PM<sub>10</sub> concentrations was within the range of acceptable values (OSHA standard decided PM<sub>10</sub> concentration should not over than 5,000  $\mu\text{g}/\text{m}^3$ ) that was related to previous study about dust in the libraries which was range between 40-350  $\mu\text{g}/\text{m}^3$  and not over the acceptable value. There really was no connections to allergic symptoms such as sore eyes, dry throat and breathing difficulties (Righi, 2002).

Nevertheless, the librarians had prevalence of allergic symptoms with insignificantly higher than those of general

Table 5. The association between PM<sub>10</sub> exposure and allergic symptoms

Allergic symptoms	OR	95% CI	<i>p</i> -value
- Skin rash <sup>1</sup>	1.004	1.00001-1.008	0.041
- Running eyes <sup>2</sup>	1.002	0.998-1.006	0.443
- Watery eyes <sup>3</sup>	1.00003	0.996-1.004	0.991
- Itchy eyes <sup>4</sup>	1.002	0.999-1.006	0.198
- Stinging eyes <sup>5</sup>	1.0005	0.997-1.004	0.808
- Running nose <sup>6</sup>	1.001	0.997-1.005	0.687
- Redness <sup>7</sup>	1.001	0.997-1.006	0.590
- Dark circles under eyes <sup>8</sup>	0.999	0.993-1.006	0.860
- Headache <sup>9</sup>	1.001	0.997-1.004	0.759

Analyzed with Logistic regression and adjust with:

<sup>1</sup>Sex, open burning exposure and pesticide used in household and clean floor period

<sup>2</sup>Sex, respiratory and allergic disease, work history with exposure to chemical, smoke from printing, transport to work by motorcycle and bus with air conditioner and cleaned air conditioner

<sup>3</sup>Underlying disease, floor polished and painted workplace

<sup>4</sup>Respiratory and allergic disease, transport to work by motorcycle and pesticide used in household

<sup>5</sup>Work history with exposure to dust, pesticide used in household, cleaning ventilation and set wallpaper in workplace

<sup>6</sup>Respiratory and allergic disease, work hour per day, insect smoke exposure, transport to work by bus without air, pesticide used in household, cleaned air conditioner and set wallpaper in workplace

<sup>7</sup>Respiratory and allergic disease, cooking smoke exposure and pesticide used in household

<sup>8</sup>Librarians group, respiratory and allergic disease, smoke from printing, transport to work by bus without air conditioner, pesticide used in household and floor polished in workplace

<sup>9</sup>sex, respiratory and allergic disease, insect smoke exposure, smoke from printing, walk to work, cleaned air conditioner and set up wallpaper in workplace

office workers accepted skin rash symptoms which associated to PM<sub>10</sub> ( $p = 0.041$ ). This was related to the finding that other allergic symptoms were highly associated to other factors such as history of respiratory and allergic disease, pesticide used in household, type of transportation to work and air conditioner cleaning schedule ( $p < 0.05$ ). This consisted of other finding from Italy which showed that any pollutants and poor condition in the library such as indoor microclimate, VOCs and total dust related to users health (Righi, 2002; Fantuzzi, 1996). The future research should find out the association between respiratory and allergic symptoms with other pollutants in the library that possibly affect to people health such as microclimate parameters (related humidity, temperature, wind speed), volatile organic compounds (VOCs) from books and microorganisms (bacteria or fungal). The accumulation in indoor air of libraries revealed to previous studied that books in the storeroom are contaminated with many species of fungal and bacteria (Karbowska Berent, 2011). The libraries in Thailand should be aware of health issue from indoor air pollutants such as particulate matter, fungi, humidity and temperature in the workplace. Nonetheless the indoor air quality surveillance program is important for all libraries to estimate indoor air quality situation that align to develop program to protect library staff and users.

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