

Risk of asthma in relation to occupation: A hospital-based case-control study

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Summary

Background: Asthma is a common occupational lung disease and is preventable by removing identifiable allergens.

Objectives: (1) To assess the relationship between occupation and asthma (2) To determine the agents associated with asthma.

Methods: In this hospital-based, case-control study 153 cases from the Asthma Clinic and 306 non-asthmatic controls from Srinagarind Hospital, Thailand were interviewed. Crude odds ratios (COR), 95% confidence intervals (95% CI) and adjusted ORs (AOR) for multiple logistic regression were calculated.

Results: Of the 153 cases, 70.6% were females with median age of 53 (IQR-14). Of the 306 controls, 62.4% were females with median age of 56 (IQR-16). The highest risk of asthma was family history of asthma and history of atopy [AOR 11.68 (95% CI 4.52, 30.24) and AOR 8.03 (95% CI 5.07, 13.60)], respectively. If only occupations were considered, healthcare workers had the highest risk [AOR 4.08 (95% CI 1.35, 12.30)], followed by textile workers [AOR 3.34 (95% CI 1.07, 10.47)] and school workers AOR 2.40 (95% CI 1.31, 4.41). When subgroups of non-atopy were considered, school workers had a significant association with asthma [COR 3.18 (95% CI 1.48, 6.83)]. When no family history of

asthma was considered, school and textile workers had the most significant association with asthma [COR 3.10 (95% CI 1.87, 5.13) and COR 3.06 (95% CI 1.15, 8.13), respectively]. Inorganic dust was the agent most significantly associated with asthma COR 1.89 (95% CI 1.25, 2.82).

Conclusion: School, textile and healthcare workers have the greatest risk of asthma. Family history of asthma and being atopic would also promote asthma in relation to occupation. (*Asian Pac J Allergy Immunol* 2015;33:152-60)

Keywords: occupational asthma, case-control studies, hospital-based, occupations, agents

Introduction

Asthma is the most frequently reported work-related respiratory disease in many countries, especially in industrialized countries where it accounts for an estimated 25% of all adult asthma.^{1,2} When asthma occurs during or after long years of work exposure, it is called workplace-related asthma and is characterized by airway hyper-responsiveness due to exposure to specific agents.³ Workers who suffer from an asthmatic reaction at work, such as coughing, wheezing, and dyspnea usually get well when they are removed from the exposure environment.

Previous studies have demonstrated certain occupations elevate the risk of asthma, including farming, painting, cleaning, agriculture,⁴ baking, lacquering⁵ and health care.⁶ The number of workplace stimulating agents known to cause asthma has been increasing with over 450 known agents⁷, albeit that the primary causative agents are grain dust, flour dust, latex, textile dust, welding fumes and chemical agents, like isocyanate², welding fumes, man-made mineral fibers, and solvents.⁸ Asthma can be prevented by removal from the identifiable factors;⁹ before airway remodeling,¹⁰ which makes treatment more difficult and costly.¹¹ Most studies of occupational asthma are based on community based controls and have a large sample size and a response rate of about 80-

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90%.^{12,13} The literature focuses on occupations^{4,5,12} and whether the study was multicenter or not.⁴

In this case-control study, a sample of asthmatics and controls were investigated using a questionnaire completed by interviewing participants. This approach permitted the researchers (a) to discern the relationship between occupation and asthma and (b) to identify specific agents amongst attendees at the asthma clinic. We implemented this study because asthma is a chronic disease that directly affects the quality of life and for which occupation may be the major contributing to factors. In Thailand, there is a dearth of information about the relationship between occupations and asthma and any definitive association with work-related causative agents. Ours is a novel approach and timely for Thailand as the nation joins the ASEAN Economic Community in the fall of 2014.

Methods

Study population and samples

A 1:2 case-control study was conducted with 153 cases of asthmatic and 306 controls at Srinagarind (University) Hospital, Khon Kaen Thailand. The study was reviewed and approved by the Ethics Committee for Research, Khon Kaen University Thailand. The asthmatics (between 18-70 years of age) were diagnosed between January 2010 and December 2012 at the Asthma Clinic of Srinagarind (university) Hospital, Khon Kaen Thailand using the 2006 GINA Guidelines (the degree of reversibility in FEV1 which indicates a diagnosis of asthma is generally accepted as >12% or > 200 ml from the pre-bronchodilator value).¹⁴ The 306 controls were systematic sampling selected from the Internal Medicine Out-patient Department at Srinagarind (university) Hospital, Khon Kaen, Thailand. The controls were 18-70 years of age and asthma was excluded by using questionnaires.

Data collection

This hospital-based, case-control study included face-to-face interviews performed by trained interviewers. A screening questionnaire was used to exclude anyone with asthmatic symptoms from the control group. The same questionnaires were used for both the case and control subjects. Information was collected regarding demographic variables, tobacco smoking, history of atopy, family history of asthma among first-degree relatives, history of disease and occupational history. Occupations were classified using the 2008 international standard classification for occupations (ISCO 2008).

Data analysis

The statistical significance of differences between cases and controls were assessed using the Chi-squared test. The median difference between the two groups was also assessed. The respective association between risk factors and asthma was assessed using a bivariate logistic regression to derive the crude odds ratio (COR). Multiple logistic regression (Forward LR) was used to determine the adjusted OR (AOR) for sex, age, smoking, history of atopy and family history of asthma. The 95% confidence intervals (95 % CI) were also calculated. In the current study, subgroup analyses were applied to determine the risk of asthma vis-à-vis occupation by adjusting for other potential risk factors (i.e. atopy and family history of asthma).

Results

Females outnumbered males among both the cases and controls. The median age of the cases and controls was comparable. Among the 153 cases, 70.6% were females and the median age was 53 (IQR 14); among the 306 controls, 62.4% were female and the median age was 56 (IQR 16). Almost all of the participants were from Northeast Thailand (100% of cases vs. 96.4% of controls). The cost of medical care among the cases was mostly reimbursed from the Comptroller General Department (n=114; 74.5%). A history of smoking was more common in the control group than the study group. A history of second-hand smoke between groups was comparable. Among the asthma cases, ever-smokers accounted for 16.3% (n=25); of whom 1.3% (n=2) were current smoker. Exposure to second-hand smoke affected 26.1% (n=40) of cases. Asthma cases were significantly more likely to have a history of atopy and a family history of asthma (74.5% vs. 24.2%) (Table 1). Most cases developed their symptoms of asthma after working in an environment with risk factors (87.6%) and the onset occurred at an average of 21.5 (9.3-33.8) years of working in that environment. The majority of the cases (87.6%) had developed their symptoms of asthma after working in their environments. The duration of work of school workers was 30.0 years (IQR 12), of healthcare workers 27.0 years (IQR 8) and of textile workers 17.0 years (IQR 12).

Occupations were classified using the 2008 International Standard Classification of Occupation (ISCO 2008) (Table 2). Individuals having several jobs differed between the asthma cases and controls. The two most common occupations among members

Table 1. General characteristics of the cases and controls

Characteristics		Cases		Controls		P-value
		n=153	%	n=306	%	
Age (yr)	Median(IQR)	53	IQR=14	56	IQR=16	0.123
Gender	Male	45	29.4	115	37.6	0.083
	Female	108	70.6	191	62.4	
Cost of medical care	Comptroller General's Department	114	74.5	141	46.1	<0.001
	Other	39	25.5	165	53.9	
Address	North East	153	100	295	96.4	0.101
Smoking	Ever-smokers	25	16.3	89	29.1	0.002
	- Current smokers	2	1.3	17	5.6	0.075
	Second-hand smokers	40	26.1	103	33.7	0.098
Atopy		114	74.5	78	25.5	<0.001
	Allergic rhinitis	110	71.9	59	19.3	
	Eczema	25	16.3	29	9.5	
	Allergic conjunctivitis	23	15.0	19	6.2	
	Hay fever	8	5.2	2	0.7	
Family history of asthma		37	24.2	7	2.3	<0.001

of the asthma case group were (ISCO Group 6) skilled agricultural, forestry and fishery workers (35.3%) and (Group 2) professionals 34.6%. In the control group, the two most common occupations were (Group 6) skilled agricultural, forestry and fishery workers 74.1% and (Group 5) service and sales workers 25.2%.

The bivariate logistic regression analyses of the risk factors for asthma revealed that a family history of asthma and a history of atopy were significantly associated an increased risk of developing asthma (OR= 13.62; 95% CI 5.91, 31.43 and OR= 8.54; 95% CI 5.47, 13.33 respectively) (Table 3). The total number of jobs was 212 jobs. Those staying at one job accounted for 68%, followed by those having two (25.5%) and three (6.5%) over their working lives. The average was 1.4 jobs / person in the asthma case group. We examined occupations according to potential exposure to asthma-causing agents among both asthma cases and controls. We subdivided occupations into 9 groups for analysis of risk for asthma including: (1) healthcare workers; (2) textile workers; (3) school workers (teachers, students and janitors); (4) housewives; (5) office workers; (6) food processors; (7) employees; (8) agricultural workers; and (9) construction workers.

The odds ratios varied across the occupational groups (Table 4). The occupations with the highest risk of asthma were healthcare workers (OR= 3.59;

95% CI: 1.53, 8.40), followed by textile workers (OR= 2.89; 95% CI: 1.14, 7.33) and school workers (OR= 2.82; 95% CI: 1.77, 4.47). Being an agricultural worker was a significant protective factor for avoiding asthma (OR = 0.26; 95% CI: 0.16, 0.43). This may be because agricultural workers accounted for 40.5% of the control group; hence skewing the analysis.

Asthmatic agents were classified by type of dust and molecular weight. The types of dust included inorganic dust (e.g., synthetic fabric textile dust, trawl dust, chemical marker dust, chalk dust, nuisance dust and chemical fertilizer dust) and organic dust (e.g., grain dust, straw dust, bran dust, latex dust, house dust mite and wood dust). The molecular weight was defined as low molecular weight (e.g., cleaning agent, chemical marker, dyeing color, solvent, herbicide, hair spray, chemotherapy drug and ethylene oxide) and high molecular weight (e.g., dandruff, latex, grain, manure, pollen, pathogen, chaff and straw). The agent most significantly associated with an increased risk of asthma was inorganic dust (OR=1.89; 95% CI 1.25, 2.82). Since multiple factors were associated with the risk of asthma, multiple logistic regressions were performed. Adjusted ORs were used to adjust for sex, age, smoking, a history of atopy and a family history of asthma. The 95 % confidence intervals (95 % CI)

Table 2. Occupations defined by the International Standard Classification of Occupation 2008

International Standard Classification of occupation 2008 (ISCO 2008)		Cases		Controls	
		n	%	n	%
1	Managers	8	5.2	6	2.0
2	Professionals	53	34.6	44	14.4
3	Technicians and associate professionals	11	7.2	25	8.2
4	Clerical support workers	5	3.3	7	2.3
5	Service and sales workers	33	21.6	77	25.2
6	Skilled agricultural, forestry and fishery workers	54	35.3	227	74.1
7	Craft and related trades workers	11	7.2	14	4.6
8	Plant and machine operators, and assemblers	1	0.7	4	1.3
9	Elementary occupations	7	4.6	20	6.5
0	Armed forces occupations	27	17.6	34	11.1

were used to determine statistical significance. Occupations with the highest risk of asthma were healthcare workers (COR= 3.59; 95% CI 1.53, 8.40; AOR = 4.08; 95% CI 1.35, 12.30), textile workers (COR= 2.89; 95% CI 1.14, 7.33; AOR = 3.43; 95% CI 1.07, 10.47) and school workers (COR= 2.82; 95% CI 1.77, 4.47; AOR = 2.40; 95% CI 1.31, 4.41). Overall, the agent significantly associated with an increased risk of asthma was exposure to inorganic dust (AOR = 1.89; 95% CI 1.25, 2.82) (Table 5). For exposure among (a) healthcare workers, (b) school workers and (c) textile workers, the most important agents were (a) latex gloves (n=9, 60.0%), pathogens (n=7, 46.7%) and house dust mites (n=6, 40.0%), (b) chalk dust (n=32, 64%), chemical markers (n =17, 34.0%) and house dust mites (n=16, 32.0%), and (c) synthetic fabric textile dust (n=7, 63.6%), ink (n=4, 36.4%) and house dust mites (n=4, 36.4%), respectively. We identified 143 cases: 45 school workers (90%), 11 health care workers (73.3%) and 8 textile workers (72.7%) who developed asthma after prolonged exposure in the work setting (87.6%) with a mean onset after 21.5 years of exposure. Both a history of atopy and a family history of asthma had a significant association with the development of asthma (COR= 8.54; 95% CI: 5.47, 13.33; AOR = 8.30; 95% CI: 5.07, 13.60 and COR= 13.62; 95% CI: 5.91, 31.43; AOR = 11.68; 95% CI: 4.52, 30.24, respectively)

Subgroup analyses of attendees without any history of atopy or family history of asthma are presented in Table 6 and Table 7. We found that school workers had the most significant association with the development of asthma (OR = 3.18; 95% CI: 1.48, 6.83) when they had no atopy. When the analysis

was confined to no family history of asthma, both school and textile workers had a significant association with development of asthma (OR = 3.10, 95% CI: 1.87, 5.13 and OR = 3.06; 95% CI: 1.15, 8.13 respectively). For health care workers with a history of atopy, we found a significant association with asthma (OR = 8.22; 95% CI: 1.04, 65.06).

Discussion

This is the first of analytical study focusing on occupational exposure as a determinant of asthma in Thailand. Only a few reports on occupational asthma in Thailand and South East of Asia have been published.^{15,16,17} We, therefore, conducted a hospital-based case-controlled study of asthma to investigate this association in Thailand. The current study revealed that > 80% of the cases became asthmatic after years of exposure to agents at work; healthcare services, textile manufacturing and school environments had the greatest association with development of asthma in the current study.

Our hospital-based case-controlled study provided clear evidence of the specific occupations associated with asthma, confirming the findings of several case controlled studies using community reference groups.^{1,4,8,12,13} Thus, using hospital cases as a reference suggested an appropriate design for our study.

Most of our cases were civil servants (with special government employee insurance) who attended an asthma clinic, while our controls were mostly patients covered under the more general national health insurance attending the Out-Patient Department of Internal Medicine. As a consequence, farm workers (normally on the general insurance) were not well represented in the asthma case group.

Table 3. Risk factors for asthma (Crude OR)

Risk factors	Cases		Controls		Crude OR	95%CI
	n=153	%	n=306	%		
Family history of asthma	37	24.2	7	2.3	13.62	5.91, 31.43
Atopy	114	74.5	78	25.5	8.54	5.47, 13.33
Gender						
Male	45	29.4	115	37.6	1.45	0.95, 2.19
Female	108	70.6	191	62.4		
Secondhand smokers	40	26.1	103	33.7	0.70	0.45, 1.01
Ever-smokers	25	16.3	89	29.1	0.48	0.29, 0.78

Notice - Crude OR = Crude odds ratio, 95 % CI = 95 % Confidence interval

According to the 2008 International Standard Classification Of Occupation (ISCO 2008) the most common occupations in Northeast Thailand among the cases and controls are skilled agricultural, forestry & fishing (35.3% and 74.1%), respectively. This unintentional selection bias might have led to some occupations being incorrectly labeled as protective factors for being asthmatic (COR= 0.26; 95% CI 0.16, 0.43). In addition, there were significant differences in the numbers with a history of atopy and a family history of asthma amongst asthma cases, which trended to a risk for asthma. Hence a subgroup analysis was done to test whether

occupation was a risk contributor to their asthma. After applying such analyses, the results of the current study indicated an association between occupational exposure and asthma.

In the present study, although the OR was adjusted for sex, age, history of smoking, history of atopy and history of asthma in the family by using multiple logistic regression (Forward LR), the risk factors strongly associated with asthma were family history of asthma and history of atopy [AOR 11.68 (95% CI 4.52, 30.24) and AOR 8.03 (95% CI 5.07, 13.60)], respectively. Atopic workers are at risk of asthma associated with work place

Table 4. Risk factors for asthma associated with occupation and exposure to relevant agents (Crude OR)

Occupations	Cases		Controls		Crude OR	95%CI
	n=153	%	n=306	%		
Health care workers	15	9.8	9	2.9	3.59	1.53, 8.40
Textile workers	11	7.2	8	2.6	2.89	1.14, 7.33
School workers (teacher, student and janitor)	50	32.7	45	14.7	2.82	1.77, 4.47
Housewives	10	6.5	16	5.2	1.27	0.56, 2.86
Office workers	28	18.3	53	17.3	1.07	0.65, 1.77
Food processors	5	3.3	12	3.9	0.83	0.29, 2.39
Employees and cleaners	10	6.5	28	9.2	0.69	0.33, 1.47
Agricultural workers	23	15.0	124	40.5	0.26	0.16, 0.43
Builders	1	0.7	11	3.6	0.18	0.02, 1.38
Agents classified by type of dust						
Inorganic dust	98	64.1	159	52	1.88	1.25, 2.82
Organic dust	55	35.9	147	48	0.61	0.41, 0.91
Agents classified by type of molecular weight						
High molecular weight agents (HMW)	50	32.7	98	32	1.03	0.68, 1.56
Low molecular weight agents (LMW)	103	67.3	208	68	0.97	0.64, 1.47

Table 5. Risk factors for asthma (Adjusted OR)

Risk factors	Crude OR	95%CI	AOR	95%CI	P-value
Family history of asthma	13.62	5.91,31.42	11.68	4.52,30.24	<0.001
History of Atopy	8.54	5.47,13.34	8.30	5.07,13.60	<0.001
Health care workers	3.70	1.53,8.99	4.08	1.35,12.30	0.012
Textile workers	3.06	1.16,8.03	3.34	1.07,10.47	0.039
School workers (teacher, student and janitor)	2.47	1.48,4.13	2.40	1.31,4.41	0.005
Agricultural workers	0.41	0.24,0.71	0.56	0.30,1.04	0.065

Odds ratios (OR) are adjusted for sex, age, smoking, family history of asthma and history of atopy. CI: confidence intervals.

agents which induce a specific IgE response.¹⁸ We therefore, applied subgroup analysis by selecting cases and controls who had no history of atopy and/or no family history of asthma in order to calculate the OR. The explanation of this analysis is discussed later.

According to the literature, > 25% of all adult cases of asthma are associated with work^{2,3,19} and 37.1% of working adults with current asthma developed the condition from the work environment.²⁰ Asthma can be prevented by removing a person from the known 450 causative agents⁷ and factors;⁹ that is, before airway remodeling occurs¹⁰ which results in chronic suffering and makes treatment more difficult and costly.¹¹ Our results agree with previous studies that revealed that health care workers have an increased risk for asthma (AOR= 4.08; 95% CI: 1.35, 12.30). Pechter et al., (2005) surveyed four states (viz., California, Massachusetts, Michigan and New Jersey) and found that health care workers were at risk for work-related asthma.⁶ Karjalainen et al., (2001) also found an increased risk for occupational asthma among medical and nursing workers in Finland over workers in administrative position.⁵ Amr, (2004) found that 5-18% of health care workers suffered from natural rubber latex allergy, which is currently the leading cause of occupational asthma.²¹ We can confirm that latex was the most frequent exposure (60%) identified among health care workers in the present study, significantly greater than the respective 20% and 24% reported by Pechter et al., (2005)⁶ and Esterhuizen et al., (2001).²² Natural rubber latex is a measurable aeroallergen²³ and should be avoided. Non-natural rubber latex gloves are, however, expensive (130 Bath/50 pairs/pack) while latex gloves are 90 bath/50 pairs/pack and not widely available in Thailand. To relocate patients to an

environment where natural rubber latex gloves are not used is therefore not practicable, due to budget and infrastructure limitations.²⁴

Other causes of occupational asthma amongst health care worker are exposure to cleaning agents: for example Dumas, (2012), found that female hospital workers exposed to decalcifiers had a significant association with current asthma (OR 2.38 95% CI 1.06, 5.33).²⁵ Glutaraldehyde also causes occupational asthma, eye irritation, allergy and other respiratory symptoms in exposed workers although exposure levels measured below the current occupational exposure standard.^{26,27}

Following subgroup analyses, by selecting cases and controls who had no history of atopy and/or no family history of asthma, we found no significant risk for asthma among healthcare workers (OR = 3.14; 95% CI: 0.90, 10.99 and OR = 2.39; 95% CI: 0.90, 6.35). There was, however, a significant association of asthma amongst healthcare workers with a history of atopy (OR = 8.22; 95% CI: 1.04, 65.06). This finding may imply that health care workers who had asthma usually had a history of atopy and/or family history of the disease. The period of latency before most (73.3%) healthcare workers developed asthma varied from a month to years.²⁸

As with previous studies, we found that textile workers were at risk of developing asthma (AOR =3.34; 95% CI: 1.07, 10.47). Tze Pin Ng et al., (1994) studied community-based government outpatient polyclinics in Singapore and found textile workers had an OR of 5.83; 95% CI 1.93, 17.57 for asthma.⁸ Meanwhile Jaakkala et al., (2003) studied adult textile workers in Southern Finland and found that they had an OR of 4.70; 95% CI 0.29, 77.1.¹² The asthma risk associated with textile dust exposure was greater among female Swedish

Table 6. Subgroup analyses in non-atopic patients

Non atopy (n= 267)	Cases n=39	Controls n=228	Crude OR	95%CI
School workers (teacher, student and janitor)	13	31	3.18	1.48, 6.84
Health care workers	4	8	3.14	0.90, 10.99
Food processors	3	10	1.82	0.48, 6.92
Office workers	8	33	1.52	0.65, 3.61
Housewives	2	8	1.49	0.30, 7.28
Builders	0	9	0.85	0.81, 0.89
Textile workers	1	7	0.83	0.10, 6.95
Agricultural workers	7	98	0.29	0.12, 0.69
Employees and cleaners	1	24	0.22	0.03, 1.70

workers (OR= 1.7; 95% CI 1.0, 2.9),⁸ which agrees with our study in which 63.7% of cases exposed to synthetic fabric textile dust developed asthma. However, among textile workers, perhaps their current symptoms of asthma may be partly due to Byssinosis, as this might not have been recognized in the asthma clinic.

After subgroup analysis of those with no family history of asthma, we confirmed that textile workers had a significant association with asthma (OR 3.06; 95% CI: 1.15, 8.13); there was not, however, any significant association with a non-history of atopy. Most textile workers (72.7%) in our study developed asthma after working for many years as textile workers.

A new finding was that persons in school environments were at greater risk of developing asthma. Case group members who were school workers in the current study included 39 teachers, 11 students and 4 janitors. Most of these persons became asthmatic after prolonged exposure in this working environment (90%): exposure to chalk dust (64%) and chemical whiteboard markers (34%). Despite having no history of atopy or a family history of asthma, they nevertheless developed asthma (non atopy OR= 3.18; 95% CI 1.48, 6.83; no family history of asthma OR= 3.10; 95% CI 1.87, 5.13). Katz, (2003) wrote an open letter to the California Energy Commission because many schools failed to maintain their ventilation systems.²⁹ Classrooms also have numerous sources of dust and chemicals including pets, arts & crafts supplies, possible heavy use of whiteboard markers

Table 7. Subgroup analyses in patients without family history of asthma

Non family history of asthma (n=415)	Cases n=116	Controls n=299	Crude OR	95%CI
School workers (teacher, student and janitor)	39	42	3.10	1.87, 5.13
Textile workers	9	8	3.06	1.15, 8.13
Health care workers	8	9	2.39	0.90, 6.35
Food processors	5	11	1.18	0.40, 3.47
Office workers	22	52	1.11	0.64, 1.93
Housewives	5	16	0.80	0.29, 2.23
Employees and cleaners	7	28	0.62	0.26, 1.47
Agricultural workers	20	122	0.30	0.18, 0.52
Builders	1	11	0.23	0.03, 1.78

and cleaners, and active children.²⁹ Quirce and Barranco (2010), reviewed cleaning agents containing main sensitizers products (i.e. disinfectants, quaternary ammonium, amine compounds, and fragrances).³⁰ Strongly irritating, asthma-causing agents were also found in these environment including: bleach (sodium hypochlorite), hydrochloric acid, and alkaline agents (ammonia and sodium hydroxide).³⁰

Civil servants involved in education in Thailand (fiscal year 2010) number 499,389, or more than one-third (38.4%) of all government workers. Teachers and educational personnel (91.8%) were classified by sex, position, and level of education.³¹ Many of the teachers had used whiteboard markers instead of chalk for more than 10 years. In 2008 in Thailand, the Director Bureau Of Occupational and Environmental Diseases, Ministry of Health, warned that school occupants, especially those who worked in areas with poor ventilation, were a risk.³² Our study confirmed that persons exposed to inorganic dust (OR 1.89, 95% CI 1.25, 2.82) had a significantly higher risk. Goe et al., (2004) confirmed that common work exposure to mineral and inorganic dusts aggravates asthma cases.³³

In the current study, it is, however, difficult to identify the exact causes of asthma in school workers because of limitations in the study design. Further studies are needed to explore the agents present in school environments and their association with asthma.

Taken together, the current study narrowed the risk factors and potentially-at-risk occupations for

asthma in the Thai population. Specifically, a history of atopy and a family history of asthma pose significant risks for the development of asthma. Three occupations were strongly associated with development of asthma: school workers, textile workers, and healthcare workers. Participants exposed to inorganic dust also had a significant association with increased risk for developing asthma.

Recommendations

Based on the results of this study, we recommend: (1) workers with a history of atopy and family history of asthma should recognize and avoid stimulating agents; (2) a further prospective study should be done to identify causes of asthma among the newly identified group of persons working in the schools; (3) further studies of community-based, case-control studies throughout Thailand and perhaps Southeast Asia are useful to identify risk factors and agents causing asthma.

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Declarations

The authors designed and conducted the research, collected and analyzed the data, and wrote the manuscript. We have no competing interests.

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