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Symptoms related to air pollution, mask-wearing and associated factors: a cross-sectional study among OPD pollution clinic patients in Bangkok, Thailand

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Abstract

Purpose – The purpose of this article was to investigate the relationship between symptoms related to air pollution, mask-wearing, mask choices and related factors.

Design/methodology/approach – A cross-sectional study among outpatient department (OPD) pollution clinic patients at Nopparat Rajathanee Hospital (PCNRH) during 2019 in Bangkok, Thailand.

Findings – The most common symptom after exposure to air pollution that affects treatment in the OPD is respiratory symptoms. A total of 45.7% (107/234) of the population wears a mask, 55.1% (59/107) of the population that wears a mask wears a surgical mask, and only 10.3% (11/107) of them wear an N95 mask. Mask-wearing and air quality index (AQI) onset were associated with the respiratory symptoms group, whereas wearing an N95 mask or surgical mask was found to be a protective factor for the occurrence of respiratory symptoms (adjusted OR = 0.065, 95% CI: 0.014–0.306, p = 0.001 and adjusted OR = 0.154, 95% CI: 0.058–0.404, $p < 0.001$, respectively). Therefore, the best practice in the face of air pollution, while the resolution needs a long period, is to wear a mask. In this study, the results showed that the best type of mask to prevent respiratory symptoms from air pollution is the N95, followed by the surgical mask; cloth masks are not recommended to use to protect against respiratory symptoms from air pollution.

Research limitations/implications – Wearing an N95 and a surgical mask can help reduce respiratory symptoms. Hence, in addition to establishing hospital measures, cooperation from local and government agencies is necessary to effectively and jointly build a national health public policy framework.

Originality/value – 1. This study provides evidence of a correlation between symptoms associated with air pollution and related factors, in-hospital visits in Bangkok, Thailand. 2. In this study, wearing an N95 mask and a surgical mask were found to be a protective factor for the occurrence of respiratory symptoms.

Keywords Health risks, Air pollution, Mask-wearing, Thailand

Paper type Research paper

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Introduction

Over the past decade, the global burden of environment-related diseases has increased at an alarming pace. In 2012, 12.6 million deaths worldwide were attributable to unhealthy environments [1]. Air pollution affects everyone regardless of race, age or social status as the greatest environmental risk. In 2016, The World Health Organisation (WHO) estimated that 90% of the urban population lived in an environment where dust contamination was higher than the established AQI values. 91% of the burden of air pollution occurred in low- to middle-income countries, mostly in Southeast Asia and the Asia-Pacific Region. Key factors for air pollution include particulate matter 2.5 (PM2.5), particulate matter 10 (PM10), sulphur dioxide, ozone, carbon monoxide, nitrogen oxides, lead, mercury, organic carbon, and hazardous air pollutants such as benzene and formaldehyde. In 2016, ambient (outdoor) air pollution in low-, middle- and high-income countries, in both cities and rural areas, was estimated to be the cause of 4.2 million premature deaths worldwide due to exposure to air pollution, causing cardiovascular and respiratory diseases and cancers [2]. Thailand is a developing country that is transitioning from agriculture to industrialisation. The Bangkok metropolitan area (BMA) has a population of 10 million people, and the recent rapid development of economics and society has resulted in a severe air pollution problem.

In Bangkok, Thailand, PM2.5 exceeded the standard for 61 84 days, and the average 24-h maximum was 96 115 μg/m^3 in 2017 and 2018, respectively [3]. The guidelines set by the WHO for PM2.5 are 10 μg/m^3 for the annual mean and 25 μg/m^3 for the 24 h mean. Air pollution such as small-sized particles can easily penetrate the nasal hair and reach the lungs, increasing the risk of lung cancer. The main sources of air pollution are diesel engine combustion, burning biomass, dust combined with pollutant gases and industrial activities. Bangkok has steadily been deteriorating air quality since 2000, and in 2019, it was recorded as having the third-worst air quality in the world on AirVisual. Exceedingly small dust particles can easily enter and harm the lungs, causing problems for human health. The pollution level of PM2.5 remains hazardous in most areas of Bangkok and the surrounding provinces. Combustion from diesel engines, burning biomass and industrial activities are the main causes of pollution in the country and its neighbouring areas. In Bangkok, the PM2.5 haze is highest during the drought and cold seasons due to stagnant air [4]. PM2.5 can easily enter the lungs and migrate into the bloodstream, causing adverse health effects like asthma, respiratory infections, chronic airway inflammatory diseases [5] and cardiovascular disease [6]. These afflictions are most prevalent in children, the elderly and pregnancy groups [7]. In Thailand, the standard PM2.5 level has been set as not to exceed 50 μg/m^3 of air, while the WHO standard is set at 25 μg/m^3 for the 24 h mean [3].

There are several ways to prevent the effects of air pollution. The most practical and easiest way is to wear a protective mask. However, although there have been several studies on the effects of wearing masks, there have been no studies on the use of different masks associated with symptoms of exposure to air pollution. This study was conducted to determine whether wearing a mask, including the type of mask, was associated with the onset of symptoms of exposure to air pollution.

Methodology

Study design

The cross-sectional and quantitative study was conducted from 1 January 2019 to 31 December 2019. A total of 234 patients from the OPD pollution clinic in Nopparat Rajathanee Hospital (PCNRH) in Bangkok, Thailand, participated in the interviews.

Inclusion/exclusion criteria

The inclusion criterion was patients who attended the PCNRH during 2019. Exclusion criteria were as follows: (1) unable to speak, read and write in Thai; (2) repeated filling

(IP and basic information must be consistent) and (3) missing information on mask-wearing.

Recruitment procedures

The programme was initiated by the PCNRH. An official medical record was issued to all patients in the PCNRH. The survey questionnaire was completed by the nurse, with all patients at the PCNRH in 2019.

Instrument

The structured medical record and questionnaire consisted of socio-demographic characteristics, including gender, age, outgoing history, smoking profile, AQI onset (air quality data were obtained from the pollution control department [PCD] of Thailand's surface air pollution monitoring network sources), and 71 questionnaire questions consist of wearing a mask, the symptoms related, the type of appropriate mask, knowledge and the type of mask used.

Variable definitions

Independent variables included all socio-demographic characteristics and consisted of gender, age (group), outgoing history, smoking status, second-hand smoke, mask-wearing, mask choice and AQI onset (The exposure to air pollution levels is counting from the days a patient comes to the OPD and conducts interviews going back to the date of onset of the symptoms, the place or province). The AQI was later taken from the same place and period specified by the patient from the pollution control department, Thailand). AQI stands for air quality index and is a representative index of the concentration of six air pollutants (PM2.5, PM10, O_3, CO, NO_2 and SO_2), where the highest index is taken as the AQI value. The calculation of the index value is based on that of Thailand because each country has a different formula. Methods are categorised according to the PCD of Thailand, which divides AQI into five groups: 1) AQI 0–25; 2) AQI 26–50; 3) AQI 51–100; 4) AQI 101–200; 5) AQI 201 or more, which was classified into three groups: 1 + 2 (0–50), 3 (51–100) and 4 + 5 (>100). The AQI value applied depends on the area of residence. The dependent variable was symptoms related to particulate matter, classified according to the doctor's diagnosis. Symptoms related to particulate matter included the following: (1) respiratory symptoms group (RS) consisting of (1.1) dyspnoea, (1.2) cough for at least 3 days, (1.3) sputum, (1.4) wheezing, (1.5) heavy breathing, (1.6) sore throat, (1.7) nose irritation and (1.8) runny nose, (2) cardiovascular symptoms group (CVS) consisting of (2.1) chest discomfort, (2.2) dyspnoea on exertion, (2.3) chest pain and (3) skin symptoms group (SKIN) consisting of face rash. Each symptom group was classified in the binary system (0 = do not have a symptom and 1 = have a symptom). The symptomatic and asymptomatic ratio refers to the number of people having symptoms per number of people without symptoms.

Statistical analysis

All analyses were conducted using SPSS version 22.0 (IBM Corp., Armonk, NY and USA). If a normality test was not statistically significant ($p > 0.05$), data were presented by frequencies and percentages. Chi-squared tests were used to find the association among the different groups. Independent variables with $p < 0.25$ were included in binary logistic regression analysis. The variables that had a significant association with each symptom group related to air pollution were identified on the basis of odds ratio (OR) with a 95% confidence interval (CI), and $p < 0.05$ (two-sided) was considered statistically significant. Finally, the logistic regression analysis was conducted between symptom related to air pollution and all independent variable with $p < 0.25$ (adjusted OR).

Ethical approval

The study was approved by Nopparat Rajathanee Hospital's institutional review board (IRB No. 55/2563) and adhered to the tenets of the Declaration of Helsinki.

Results

Socio-demographic characteristics

A total of 234 participants were included in this study. Most (61.1%) were female. Ages ranged from one to 89 years, with a median (interquartile range, IQR) of 44.5 (49.5). Additionally, 93.2% had an outgoing history (leaving home or work), 99.1% were non-smokers, and the majority had no history of exposure to tobacco smoke from other people in the home or office (81.2%). More than half of the participants (54.3%) did not wear face masks while they were out of the house or at the office. The onset of symptoms for 42.7% of the recorded illness occurred when AQI levels were greater than 100.

When classified by symptoms, both males and females had similar symptomatic and asymptomatic ratios between all symptom groups (RS, CVS and SKIN). All age groups had similar symptomatic and asymptomatic ratios between the RS, CVS and SKIN. History of outgoing activities showed a similar ratio between symptomatic and asymptomatic groups in the RS and CVS. The SKIN related to the history of outgoing activities with a lower symptom ratio (7.3/85.9%) than no history of outgoing activities (1.7/5.1%). Smoking had a similar symptomatic and asymptomatic ratio between all symptom groups.

Among the RS and SKIN, participants with a history of cigarette smoke exposure from other people at home or in the office also had a similar symptomatic and asymptomatic ratio. The CVS with a history of exposure to cigarette smoke from other people at home or in the office recorded a higher ratio between the occurrence of various symptoms than those without a history of cigarette smoke from other people in the home or office (Table 1).

A similar ratio was shown for using different types of masks when leaving the home or office between symptomatic and asymptomatic groups in the CVS and SKIN. Groups that did not wear masks had the highest symptomatic to asymptomatic ratio, while groups wearing (N95) respiratory face masks had the lowest ratio. AQI level on the day of the onset had a similar symptomatic and asymptomatic ratio between all groups.

Factors were associated with symptom groups

In the binary logistic analysis, age (years) and mask-wearing were significantly associated with the RS (Table 2). Study participants who reported wearing N95 and surgical masks were more likely to report lower chances of developing respiratory symptoms than those who did not wear masks, with an estimated OR of 0.118 (95% CI: 0.028–0.488, $p = 0.003$) and 0.197 (95% CI: 0.078–0.497, $p = 0.001$). In the CVS, the OR of those with a history of exposure to cigarettes from other people in the home or office was 2.457 times higher (95% CI: 1.020–5.917, $p = 0.045$) compared to the non-exposed group. Results of binary logistic analysis also showed that outgoing history and N95 mask were significantly associated with skin symptoms. Participants who had a history of outdoor activities (outgoing history) (OR = 0.254, 95% CI: 0.074–0.873, $p = 0.030$) were less likely to report skin symptoms than those without a history of outdoor activities. Study participants who wore an N95 mask were more likely to develop skin symptoms than those who did not wear a mask, with an estimated OR of 4.917 (95% CI: 1.108–21.815, $p = 0.036$).

After the univariate analysis, factors associated with each symptom group with statistical significance at $p < 0.25$ were analysed by the logistic regression method at $p < 0.05$ (Table 3).

Table 1. Comparison of have/do not have a rate of symptom-related air pollution among participants in different symptom groups (n = 234)

Characteristic	Group	RS symptom group Have rate/do not have rate (n/%)	p-value	CVS symptom group Have rate/do not have rate (n/%)	p-value	Skin symptom group Have rate/o not have rate (n/%)	p-value
Gender	Male	80(34.2)/11(4.7)	0.676	13(5.6)/78(33.3)	0.294	7(3.0)/84(35.9)	0.584
	Female	123(52.6)/20(8.5)		14(6.0)/129(55.1)		14(6.0)/129(55.1)	
Age (years)	≤15	68(29.1)/5(2.1)	0.415	8(3.4)/65(27.8)	0.696	8(3.4)/65(27.8)	0.362
	16–30	9(3.8)/2(0.8)		1(0.4)/10(4.3)		2(0.9)/9(3.8)	
	31–45	29(12.4)/6(2.6)		6(2.6)/29(12.4)		1(0.4)/34(14.5)	
	46–60	51(21.8)/10(4.3)		8(3.4)/53(22.6)		7(3.0)/54(23.1)	
	≥ 61	46(19.7)/8(3.4)		4(1.7)/50(21.4)		3(1.3)/51(21.8)	
Median (IQR) 44.5 (49.5), range (min-max) (1 – 89)							
Outgoing history	Yes	190(81.2)/28(12.0)	0.452[a]	24(10.3)/194(82.9)	0.407[a]	17(7.3)/201(85.9)	0.043[a]*
	No	13(5.5)/3(1.3)		3(1.3)/13(5.5)		4(1.7)/12(5.1)	
Smoking	Present and ex-smoker	2(0.9)/0(0.0)	1.000[a]	0(0.0)/2(0.9)	1.000[a]	0(0.0)/2(0.8)	1.000[a]
	Never	201(85.9)/31(13.2)		27(11.5)/205(87.6)		21(9.0)/211(90.2)	
Experience cigarette smoke from others	Yes	37(15.8)/7(3.0)	0.563	9(3.8)/35(15.0)	0.040*	7(3.0)/37(15.8)	0.084[a]*
	No	166(70.9)/24(10.3)		18(7.7)172(73.5)		14(6.0)/176(75.2)	
Mask-wearing	Not wearing	119(50.9)/8(3.4)	0.001*	15(6.4)/112(47.9)	0.066*	9(3.9)/118(50.4)	0.155*
	N95	7(3.0)/4(1.7)		0(0.0)/11(4.7)		3(1.3)/8(3.4)	
	Surgical	44(18.8)/15(6.4)		11(4.7)/48(20.5)		5(2.1)/54(23.1)	
	Cloth	33(14.1)/4(1.7)		1(0.4)/36(15.4)		4(1.7)/33(14.1)	
AQI onset	0–50	56(23.9)/13(5.6)	0.241*	12(5.1)/57(24.4)	0.167*	9(3.9)/60(25.6)	0.342
	51–100	57(24.4)/8(3.4)		7(3.0)/58(24.8)		4(1.7)/61(26.1)	
	>100	90(38.4)/10(4.3)		8(3.4)/92(39.3)		8(3.4)/92(39.3)	

Note(s): *$p < 0.25$, [a]Fisher exact test

Table 2. Crude OR of potential factors of symptom related to air pollution (n = 234)

Factors	Variables	Crude OR	95% CI of OR	p-value
RS	*Mask-wearing*			
	Not wearing	1		
	N95	0.118	0.028, 0.488	0.003*
	Surgical	0.197	0.078, 0.497	0.001*
	Cloth	0.555	0.157, 1.957	0.359
	AQI onset			
	0–50	1		
	51–100	1.654	0.637, 4.297	0.302
	>100	2.089	0.859, 5.084	0.104
CVS	*Mask-wearing*			
	Not wearing	1		
	N95	0.000	0.000, 7.694	0.999
	Surgical	1.711	0.733, 3.997	0.215
	Cloth	0.207	0.026, 1.625	0.134
	AQI onset			
	0–50	1		
	51–100	0.573	0.211, 1.560	0.276
	>100	0.413	0.159, 1.072	0.069
	Experience cigarette smoke from others			
	No	1		
	Yes	2.457	1.020, 5.917	0.045*
SKIN	*Mask-wearing*			
	Not wearing	1		
	N95	4.917	1.108, 21.815	0.036*
	Surgical	1.214	0.388, 3.795	0.739
	Cloth	1.589	0.460, 5.489	0.464
	Experience cigarette smoke from others			
	No	1		
	Yes	2.378	0.898, 6.300	0.081
	Out-going history			
	No	1		
	Yes	0.254	0.074, 0.873	0.030*

Note(s): OR–odds ratio, 95% CI–95% confidence interval, *p < 0.05

Divided by symptom groups, results from multivariate logistic regression analysis revealed the OR of mask-wearing with N95 masks (adjusted OR = 0.065, 95% CI: 0.014–0.306, p = 0.001) and surgical masks (adjusted OR = 0.154, 95% CI: 0.058–0.404, p < 0.001) as less likely to report respiratory symptoms than those who did not wear masks after controlling all other variables. An AQI level at symptom onset of more than 100 was 3.851 times higher (95% CI: 1.386–10.697, p = 0.010) compared to an AQI level of 0–50, while an AQI level of 51–100 found no significance after controlling all other variables.

Discussion

Self-protection measures, such as wearing a mask as an effective filter, are used to prohibit small particles from entering the respiratory tract. Different generations of populations, contexts and limitations greatly affected mask-wearing compliance. Most of the samples in our study (54.3%) did not wear a mask, showing a slight awareness of the risks of air pollution, in line with previous studies of the risk reduction of mask-wearing regarding air pollution exposure among outdoor exercisers in China who had moderate awareness [8]. Westerners are generally opposed to mask-wearing, while experience in Asia (i.e. China, Japan and South Korea) showed that mask-wearing was an effective measure [9].

Factors	Variables	Crude OR	Adjusted OR	95% CI of OR	p-value
RS	*Mask-wearing*				
	Not wearing	1	1		
	N95	0.118	0.065	0.014, 0.306	0.001*
	Surgical	0.197	0.154	0.058, 0.404	<0.001*
	Cloth	0.555	0.338	0.088, 1.299	0.114
	AQI onset				
	0–50	1			
	51–100	1.654	2.076	0.743, 5.805	0.164
	>100	2.089	3.851	1.386, 10.697	0.010*
CVS	*Mask-wearing*				
	Not wearing	1	1		
	N95	0.000	0.000	0.000, 7.694	0.999
	Surgical	1.711	1.615	0.655, 3.982	0.298
	Cloth	0.207	0.250	0.030, 2.068	0.198
	AQI onset				
	0–50	1	1		
	51–100	0.573	0.608	0.217, 1.699	0.343
	>100	0.413	0.545	0.197, 1.507	0.242
	Experience cigarette smoke from others				
	No	1	1		
	Yes	2.457	2.155	0.845, 5.493	0.108
SKIN	*Mask-wearing*				
	Not wearing	1	1		
	N95	4.917	4.718	1.003, 22.194	0.050
	Surgical	1.214	1.137	0.353, 3.666	0.830
	Cloth	1.589	1.764	0.500, 6.227	0.378
	Experience cigarette smoke from others				
	No	1	1		
	Yes	2.378	1.344	0.367, 4.923	0.655
	Out-going history				
	No	1	1		
	Yes	0.254	0.301	0.060, 1.514	0.145

Note(s): OR–odds ratio, 95% CI–95% confidence interval, $*p < 0.05$

Table 3. Adjusted OR of potential factors of symptom related to air pollution ($n = 234$)

For example, N95 masks and surgical masks reduced concentrations of ambient air particles, aerosols, and pathogens by 91% and 68% [10].

People living in air-polluted areas should wear a mask. N95 mask-wearing is recommended as a widely available personal protective measure. The suspension of very small (0.01–100 µm in diameter) particles or droplets in the air can cause the severe acute respiratory syndrome. Our results found that 45.7% of the population wore a mask, only 10.3% wore an N95 mask, 55.1% wore a surgical mask and 34.6% wore a cloth mask, far below our expectation. Among those who work or go outside of buildings or homes (exposed to air pollution), more than half chose to wear a mask. The study's findings indicate that even wearing a face mask can still cause symptoms, which may be explained by improper mask selection. According to Huang and Morawska [11], wearing face masks could raise pollution risks due to a false sense of security. However, symptom groups not wearing a mask had the highest proportion of respiratory symptoms, while those wearing N95 masks had the lowest proportion of respiratory symptoms. After controlling all other parameters, this result was consistent with studies showing that the N95 mask can filter out PM2.5 air pollution (adjusted OR = 0.065, 95% CI: 0.014–0.306, $p = 0.001$) [12].

A face mask must be worn properly, with a snug fit and no gaps on the sides, covering the nose, mouth and chin. The mask wearer should be able to easily remove or adjust the mask.

The mask must be worn safely, not blocking breathing, and it can then protect against small particles entering the respiratory system. Young children who are not able to remove the mask themselves may not be suitable for wearing some types of masks subject to such restrictions. In our study, 49.6% of the non-masked groups were under 15 years of age. Preutthipan *et al.* [13] found that elevated levels of particulate matter concentrations in Bangkok affected the respiratory symptoms of schoolchildren with and without asthma. Accordingly, young children should take appropriate mask precautions.

Wearing a mask can prevent health problems; however, it is not easy to maintain compliance, especially for the N95 in Thailand since most people typically work outdoors in high temperatures and high relative humidity [14]. Additionally, although previous studies have indicated that N95 mask respirators block more than 95% of PM2.5 inhalation [15], wearing an N95 mask can make people feel uncomfortable [16]. Also, the previous study reported that outdoor air pollution can cause skin problems. It was found that in the univariate analysis, the participants who had a history of outdoor activities outgoing history) reported statistical significance, but in the multivariate analysis, no statistical significance was found. Because, only 4.3% (10/234) of participants with outgoing history wear N95, while those with no outgoing history wear N95 (0.4% (1/234).

Epidemiological studies have shown a significant correlation between fine particle pollutants and respiratory morbidity and mortality [17], while previous studies revealed that high AQI levels can cause asthma and inflammation of the respiratory system, harm lung function and even promote cancers [18, 19]. Concurring with our findings, AQI levels at onset greater than 100 showed some signs of contributing to respiratory symptoms compared with lower AQI levels (Adjusted OR = 3.851, 95% CI:1.386–10.697) [18, 20]. Hayes *et al.* [6] reported that exposure to air pollution, both acute and chronic, had a wide range of adverse effects on human health, especially on the cardiovascular system. In our study, 44.4% (12/27) of participants who came to the PCNRH with symptoms of cardiovascular disease were wearing a mask. People with certain medical conditions, such as severe chronic obstructive pulmonary disease (COPD), may not be able to wear a mask for extended periods, as this can lead to dangerously low oxygen levels [21].

Analysis of symptoms related to air pollution, mask-wearing, and its impact factors identified the need for further study in the following areas. First, information regarding important variables such as economic status, education, duration of mask-wearing in one day, and number of mask replacement times was lacking. Secondly, this study had a cross-sectional design, and since a temporal sequence cannot be established, it cannot be used to infer causality.

Conclusions

Our findings indicated a significant association between mask-wearing and reduction in the occurrence of respiratory symptoms due to air pollution exposure in Bangkok, Thailand. Wearing face masks properly and choosing an appropriate type of mask were shown to ameliorate the health effects of exposure to air pollution to a certain extent. The limitation of this study is that it is only a short-term solution. Hence, in addition to establishing hospital measures, cooperation from local and government agencies is necessary to effectively and jointly build a national public health policy framework to reduce the number of people receiving treatment due to long-term exposure to air pollution.

Conflict of Interest: None

References

1. World Health Organization [WHO]. Quantifying environmental health impacts: preventing disease through healthy environments: a global assessment of the burden of disease from environmental

risks. [cited 2020 Nov]. Available from: https://www.who.int/quantifying_ehimpacts/publications/preventing-disease/en/.

2. World Health Organization [WHO]. Ambient (outdoor) air pollution. [updated 2018 May; cited 2020 Nov. Available from: https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health.
3. Vichit-Vadakan N, Vajanapoom N. Health impact from air pollution in Thailand: current and future challenges. Environ Health Perspect. 2011; 119(5): A197-8. doi: 10.1289/ehp.1103728.
4. Mao M, Zhang X, Yin Y. Particulate matter and gaseous pollutions in three metropolises along the Chinese Yangtze River: situation and implications. Int J Environ Res Public Health. 2018; 15(6): 1102. doi: 10.3390/ijerph15061102.
5. Liu Q, Xu C, Ji G, Liu H, Shao W, Zhang C, *et al.* Effect of exposure to ambient $PM_{2.5}$ pollution on the risk of respiratory tract diseases: a meta-analysis of cohort studies. J Biomed Res. 2017; 31(2): 130-42. doi: 10.7555/jbr.31.20160071.
6. Hayes RB, Lim C, Zhang Y, Cromar K, Shao Y, Reynolds HR, *et al.* PM2.5 air pollution and cause-specific cardiovascular disease mortality. Int J Epidemiol. 2020; 49(1): 25-35. doi: 10.1093/ije/dyz114.
7. Amsalu E, Wang T, Li H, Liu Y, Wang A, Liu X, *et al.* Acute effects of fine particulate matter ($PM_{2.5}$) on hospital admissions for cardiovascular disease in Beijing, China: a time-series study. Environ Health. 2019; 18(1): 70. doi: 10.1186/s12940-019-0506-2.
8. Xiong L, Li J, Xia T, Hu X, Wang Y, Sun M, *et al.* Risk reduction behaviors regarding $PM_{2.5}$ exposure among outdoor exercisers in the Nanjing Metropolitan Area, China. Int J Environ Res Public Health. 2018; 15(8):1728. doi: 10.3390/ijerph15081728.
9. Zhou SS, Lukula S, Chiossone C, Nims RW, Suchmann DB, Ijaz MK. Assessment of a respiratory face mask for capturing air pollutants and pathogens including human influenza and rhinoviruses. J Thorac Dis. 2018; 10(3): 2059-69. doi: 10.21037/jtd.2018.03.103.
10. Sim SW, Moey KS, Tan NC. The use of facemasks to prevent respiratory infection: a literature review in the context of the Health Belief Model. Singapore Med J. 2014; 55(3): 160-7. doi: 10.11622/smedj.2014037.
11. Huang W, Morawska L. Face masks could raise pollution risks. Nature. 2019; 574(7776): 29-30. doi: 10.1038/d41586-019-02938-1.
12. Rengasamy S, Eimer BC, Shaffer RE. Nanoparticle filtration performance of commercially available dust masks. J Int Soc Respir Prot. 2008; 25(3): 27-41.
13. Preutthipan A, Udomsubpayakul U, Chaisupamongkollarp T, Pentamwa P. Effect of PM10 pollution in Bangkok on children with and without asthma. Pediatr Pulmonol. 2004; 37(3): 187-92. doi: 10.1002/ppul.10398.
14. Langkulsen U, Vichit-Vadakan N, Taptagaporn S. Health impact of climate change on occupational health and productivity in Thailand. Glob Health Action. 2010; 3. doi: 10.3402/gha.v3i0.5607.
15. Münzel T, Sørensen M, Gori T, Schmidt FP, Rao X, Brook J, *et al.* Environmental stressors and cardio-metabolic disease: part I-epidemiologic evidence supporting a role for noise and air pollution and effects of mitigation strategies. Eur Heart J. 2017; 38(8): 550-6. doi: 10.1093/eurheartj/ehw269.
16. Jiang W, Cao W, Liu Q. Wearing the N95 mask with a plastic handle reduces pressure injury. J Am Acad Dermatol. 2020; 82(6): e191-2. doi: 10.1016/j.jaad.2020.04.001.
17. Comunian S, Dongo D, Milani C, Palestini P. Air pollution and Covid-19: the role of particulate matter in the spread and increase of Covid-19's morbidity and mortality. Int J Environ Res Public Health. 2020; 17(12): 4487. doi: 10.3390/ijerph17124487.
18. Xing YF, Xu YH, Shi MH, Lian YX. The impact of PM2.5 on the human respiratory system. J Thorac Dis. 2016; 8(1): E69-74. doi: 10.3978/j.issn.2072-1439.2016.01.19.

19. Brunekreef B, Beelen R, Hoek G, Schouten L, Bausch-Goldbohm S, Fischer P, *et al.* Effects of long-term exposure to traffic-related air pollution on respiratory and cardiovascular mortality in The Netherlands: the NLCS-AIR study. Res Rep Health Eff Inst. 2009; (139): 5-71; discussion 3-89.
20. Rice MB, Ljungman PL, Wilker EH, Gold DR, Schwartz JD, Koutrakis P, *et al.* Short-term exposure to air pollution and lung function in the Framingham Heart Study. Am J Respir Crit Care Med. 2013; 188(11): 1351-7. doi: 10.1164/rccm.201308-1414OC.
21. Kyung SY, Kim Y, Hwang H, Park JW, Jeong SH. Risks of N95 face mask use in subjects with COPD. Respir Care. 2020; 65(5): 658-64. doi: 10.4187/respcare.06713.

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