Regional air pollution severity affects the incidence of acute myocardial infarction triggered by short-term pollutant exposure: A time-stratified case-crossover analysis

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Abstract

Background

Long-term exposure to air pollution results in a high incidence of cardiovascular disease. Whether acute myocardial infarction is triggered by short-term exposure to air pollution is related to the average severity of air pollution in the area.

Design

Case-crossover analysis.

Methods

This was a retrospective study based on hospital medical records. The study period was 2017-2018. Research data were collected from Taoyuan Hospital, which is located in a low-severity pollution area, and Taichung Hospital, which is in a high-severity pollution area, and the correlation between short-term air pollution exposure and acute myocardial infarction was analyzed.

Results

The correlation between short-term exposure to ambient air pollutants and acute myocardial infarction was not significant for the cases collected from Taoyuan Hospital ($PM_{2.5}$ OR: 1.006 & 95% CI: 0.995-1.017; PM_{10} OR: 0.996 & 95% CI: 0.988-1.003). However, for the cases collected from Taichung Hospital, short-term exposure to ambient $PM_{2.5}$ (odds ratio: 1.021; 95% confidence interval: 1.002-1.040) and PM_{10} (odds ratio: 1.010; 95% confidence interval: 1.001-1.020) resulted in high incidence of acute myocardial infarction.

Conclusions

Short-term pollutant exposure will increase the incidence of acute myocardial infarction based on the severity of regional air pollution. In addition to addressing traditional cardiovascular disease risk factors, the government must formulate relevant policies for reducing air pollution and thus the hazards to national health.

Introduction

Acute myocardial infarction is the main disease leading to poor human health (WHO 2016). It poses a heavy financial burden on families and requires considerable society-based treatment. Through national health policy, governments have been investing considerable effort into reducing the incidence of myocardial infarction. Instead of investigating the traditional risk factors for myocardial infarction, scholars are increasingly focusing on the correlation between air pollution and cardiovascular disease (Miller et al. 2007 ; Brook et al. 2004 ; Pope et al. 2006 ; Xie et al. 2015).

The main pathophysiological framework used to explain the epidemiological association between exposure to ambient air pollutants and acute myocardial infarction is an increase in the mean resting arterial blood pressure due to an increase in the sympathetic tone and regulation of potential systemic vascular tone. By transiently increasing plasma viscosity and the amount of endothelial function damage, the risk of intravascular thrombosis is increased, promoting the development of atherosclerosis (Brook et al. 2002 ; Pekkanen et al. 2002 ; Sun et al. 2010).

Most studies have discovered that long-term exposure to ambient air pollutants increases the incidence of cardiovascular disease. However, whether short-term exposure to ambient air pollutants can trigger acute myocardial infarction remains controversial (Kathrin et al. 2015 ; Janine et al. 2014 ; Ai et al. 2014).

This study investigated whether an observed difference in the occurrence of short-term exposure to ambient air pollutants and the incidence of acute myocardial infarction was due to differing severities of ambient air pollution in the study area.

Materials And Methods

This study was conducted at Taoyuan Hospital and Taichung Hospital, which are 450-bed academic regional Emergency Responsibility Teaching Hospital; these hospitals are located in Taoyuan and Taichung, Taiwan (R.O.C.), respectively. Taoyuan Hospital and Taichung Hospital are located in areas with low-severity and high-severity air pollution, respectively. Data were obtained from a retrospective review of patient medical records. The data were the date of illness onset, sex, age, body mass index, hypertension, hyperlipidemia, diabetes, smoking, drinking, and heart disease history of the patient and patient's family. This retrospective study involved 352 patients in Taoyuan and 278 patients in Taichung who received a diagnosis of acute myocardial infarction through cardiac catheterization from January 2017 to December 2018. Nonlocal workers or residents were excluded.

The Air Quality Monitoring Station of the Environmental Protection Agency of the Executive Yuan provided information on environmental air pollutants. Each monitoring station obtains hourly air pollutant data and provides the 24-hour-average daily concentration of pollutants, including $PM_{2.5}$, PM_{10}, O_3, SO_2, and NO_2 as well as the temperature and humidity.

We examined the associations between short-term air pollutant exposure and acute myocardial infraction by using a time-stratified case-crossover design. The levels of ambient air pollutants on the date of illness onset were compared with those 2 weeks before the onset. Odds ratios (ORs) and 95% confidence intervals (CIs) were estimated using Poisson regression in the generalized linear model. Models were adjusted for average temperature and relative humidity on the day of an event.

Categorical variables were compared between groups using the χ^2 test and Student's *t* test; continuous variables are presented as mean ± standard deviation and were compared using the *t* test. $P < 0.05$ was considered statistically significant. Data analyses were performed using SPSS version 22 (SPSS, Chicago, IL, USA).

Discussion

The results of our research revealed that the effects of short-term air pollution exposure and the incidence of acute myocardial infarction were closely related to the severity of air pollution in the study area. During the study period (2017–2018), poor air quality was indicated on only 7% of the days in the Taoyuan area, whereas in the Taichung area, this percentage was 30%. This result is similar to the finding in our analysis using a health insurance database, and the occurrence of acute myocardial infarction was positively correlated with average air pollution severity in the study area.

Similar findings have been reported in systematic reviews. In low- severity air pollution area, short-term pollutant exposure did not affect the incidence of acute myocardial infarction (Kathrin et al. 2015 ; Janine et al. 2014 ; Ai Milojevic et al. 2014). Studies conducted in moderate- to high-severity air pollution area, which have reported a positive correlation between short-term exposure to pollution and the incidence of acute myocardial infarction (Yongquan et al. 2018 ; Qin et al. 2017 ; Anyang et al. 2017 ; Xiaofang et al. 2016 ; Yisi et al. 2015).

A patient's chronic health conditions can affect their susceptibility to acute myocardial infarction, but these factors are usually not measured accurately. In 1991, Maclure proposed the case-crossover study design, which is a method for studying transient effects on the risk of acute events (Maclure et al. 1991). Our study employed a 2-week time interval; the air pollution level during the acute myocardial infarction event was compared with the air pollution level 2 weeks before the event. This research method effectively controlled the individual differences between cases.

The mechanism through which long-term exposure to air pollution can lead to cardiovascular disease development has been proven which can increase oxidative stress, the inflammatory response, and vascular endothelial damage, leading to atherosclerosis (A. Seaton et al. 1995 ; Robert et al. 2004 ; Urmila et al. 2002). In cardiovascular disease, atherosclerosis leads to coronary artery stenosis which takes time to accumulate. Long-term exposure to air pollution increase latent cardiovascular diseases and short-term exposure to air pollution can produce oxidative stress and inflammation, increase the burden on the heart then trigger latent cardiovascular diseases. This explains why short-term exposure to air pollutants in areas with severe air pollution increases the risk of acute myocardial infarction.

Our study has three strengths. First, we used medical records from two hospitals, and all patients were identified as having acute myocardial infarction based on records of cardiac catheterization. Second, we could confirm that all patients had been active near the hospital for a long time; thus, the air pollution data from the corresponding monitoring station could represent the patient's exposure to air pollutants. Third, we use the comparison between the day of onset and the day 2 weeks previously to eliminate the effect of changes in patient lifestyle and physical illness.

Nevertheless, our research has two limitations. First, we still could not determine the true air pollution exposure of the patients, which would have been affected by the use of protective equipment or working indoors. Second, we employed medical records from only two hospitals for analysis and research. The

results of the study revealed a positive correlation in an area with high-severity air pollution but no correlation in an area with low-severity air pollution. We cannot precisely define a high-severity of air pollution; doing so would require more research data.

Conclusion

The severity of regional air pollution has a serious short-term impact on the risk of acute myocardial infarction. Therefore, to fully prevent acute myocardial infarctions caused by exposure to ambient air pollutants, relevant laws and regulations should be complied with to control the level of ambient air pollutants to the greatest extent possible and thus reduce people's exposure to air pollutants.

Declarations

Ethical Approval: The present study was approved by the Institutional Review Board of Taipei Medical University and all procedures were accordance with prevailing ethical principles.

Consent to Participate: This study is a retrospective case study. All cases have been treated before data collection and do not involve patient identification. Therefore, patients' informed consent is not required.

Consent to Publish: Not applicable.

Authors Contributions: Chih-Chien Yen was responsible for study design, acquisition, analysis and interpretation of data, and drafting the manuscript. Ping-Ling Chen contributed to design and interpretation of the analysis and drafting and critical revision of the manuscript. All authors provided approval of the final version of the manuscript and agree to be accountable for all aspects of the work.

Availability of data and materials: The air pollution data is open providing by the Protection Agency of the Executive Yuan. https://airtw.epa.gov.tw/. The full datasets used in this analysis are available from the corresponding author on reasonable request.

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Conflicts of Interest: The authors declare they have no actual or potential competing financial interests.

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Tables

Table 1 Demographic and medical-related variables of the patients from Taoyuan Hospital.

Acute myocardial infraction	Number	Percentage
Total	352	100.00
Sex		
Male	269	76.40
Female	83	23.60
Age	62.90 ± 14.89	
Age group (years)		
<45	42	11.90
45-65	157	44.60
>65	153	43.50
BMI (kg/m^2)	27.51 ± 4.07	
<18.5	8	2.30
18.5 to <25	128	36.40
25 to <30	178	50.60
≧30	38	10.80
Hypertension		
Yes	244	69.30
No	108	30.70
Hyperlipidemia		
Yes	65	18.50
No	287	81.50
Diabetes mellitus		
Yes	131	37.20
No	221	62.80
Smoking		
Yes	229	65.06
No	123	34.94
Drinking		
Yes	79	22.40
No	273	77.60
Heart disease		
Yes	113	32.10
No	239	67.90
Family heart disease		
Yes	76	21.60
No	276	78.40

Table 2 Demographic and medical-related variables of the patients from Taichung Hospital.

Acute myocardial infraction	Number	Percentage
Total	278	100.00
Sex		
Male	199	71.58
Female	79	28.42
Age	66.16 ± 16.71	
Age group (years)		
<45	46	16.55
45-65	99	35.61
>65	133	47.84
BMI (kg/m^2)	26.18 ± 4.31	
<18.5	3	1.08
18.5 to <25	109	39.21
25 to <30	122	43.88
≧30	44	15.83
Hypertension		
Yes	199	71.58
No	79	28.42
Hyperlipidemia		
Yes	93	33.45
No	185	66.55
Diabetes mellitus		
Yes	127	45.68
No	151	54.32
Smoking		
Yes	187	67.27
No	91	32.73
Drinking		
Yes	96	34.53
No	182	65.47
Heart disease		
Yes	83	29.86
No	195	70.14
Family heart disease		
Yes	67	24.10
No	211	75.90

Table 3 Demographic and medical-related variables of the cases collected from Taoyuan Hospital and Taichung Hospital.

	Taoyuan Hospital (N = 352)	Taichung Hospital (N = 278)	*P*
Age, y	62.90 ± 14.89	66.16 ± 16.71	0.51
Male sex, n (%)	269 (76.40)	199 (71.58)	0.44
BMI (kg/m^2)	27.51 ± 4.07	26.18 ± 4.31	0.85
Hypertension, n (%)	244 (69.30)	199 (71.58)	0.53
Hyperlipidemia, n (%)	65 (18.50)	93 (33.45)	0.16
Diabetes mellitus, n (%)	131 (37.20)	127 (45.68)	0.43
Smoking, n (%)	229 (65.06)	187 (67.27)	0.62
Drinking, n (%)	79 (22.40)	96 (34.53)	0.27
Heart disease, n (%)	113 (32.10)	83 (29.86)	0.34
Family heart disease, n (%)	76 (21.60)	67 (24.10)	0.55

Table 4 Incidence of short-term exposure to ambient air pollutants and acute myocardial infarction in the patients from Taoyuan Hospital

Table 4. Poisson regression in the generalized linear model

	OR	95% CI	95% CI	*P*
$PM_{2.5}$	1.006	0.995	1.017	0.315
PM_{10}	0.996	0.988	1.003	0.253
NO_2	0.998	0.975	1.021	0.848
SO_2	1.051	0.897	1.233	0.536
O_3	1.005	0.995	1.014	0.345

OR = odds ratio: adjusted variables listed in the table; CI = confidence interval

Table 5 Incidence of short-term exposure to ambient air pollutants and acute myocardial infarction in the patients from Taichung Hospital.

Table 5. Poisson regression in the generalized linear model

	OR	95% CI	95% CI	*P*
$PM_{2.5}$	1.021	1.002	1.040	0.026
PM_{10}	1.010	1.001	1.020	0.035
NO_2	0.997	0.988	1.007	0.551
SO_2	1.002	0.985	1.021	0.788
O_3	1.007	1.000	1.014	0.057

OR = odds ratio: adjusted variables listed in the table; CI = confidence interval