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# Relationship between Air Pollutants and Acute Myocardial Infarction in a Large Industrial Region

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## Abstract

Associations between the increase in the number of hospitalizations for primary myocardial infarction and increased levels of oxide and nitrogen dioxide in the winter period compared to the summer period were revealed. It was found that during the entire observation period the increase in the concentration of nitrogen oxide in 10 % of the MPC increases the number of hospital admissions for MI by 1.4 cases and excess concentration of nitrogen dioxide by 0.9 cases. In winter period the excess of the average concentration of nitrogen oxide by 10 % of the MPC was associated with an increase in the number of hospitalizations by 2.9 cases. Thus, there is a relationship between the frequency of hospitalizations of patients with primary myocardial infarction and environmental pollution (the increase of the concentrations of oxide and nitrogen dioxide, phenol in the air). This pattern is more striking manifestation in winter period.

**Key words:** myocardial infarction, air pollution, cardiovascular disease

## INTRODUCTION

The problem of air pollution with various pollutants is becoming more relevant all over the world [1]. Major epidemiological studies show that inhalations of particulate matters are triggers of the development of acute cardiovascular events [2]. According to the data of the American Heart Association, exposure to increased levels of air pollutants for several hours a week increases cardiovascular-related death rate, and the number of nonfatal cardiovascular events. This interconnection is especially clearly seen at coronary artery disease (CAD), including hospital admission and mortality rate due to myocardial infarction (MI) [1–3].

The study objective was to examine the relationship between hospital admissions for acute myocardial infarction and environmental pollution in a large industrialised Siberian region (Kemerovo city).

## MATERIALS AND METHODS

The main indicators of environmental pollution (Table 1) in Kemerovo and number of MI admissions in the Kemerovo Cardiology Center (Table 2) were assessed for the period between December, 2010 and November, 2014. Additionally, the annual number of days with unfavourable meteorological conditions and their impact were considered. The regression analysis was used to assess the relationship between the parameters and to build the equations of correlation for continuous variables. The number of MI admissions was considered as a dependent variable; maximum average daily permittable concentration ($MPC_{da}$), as an independent variable. The results were presented as regression coefficient ($B$) and correlation coefficient ($R$). Differences were considered statistically significant if $p < 0.05$.

TABLE 1

Pollutant concentrations exceeding the average daily maximum allowable concentration in Kemerovo (MPC, average annual data)

| Substances | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|
| Nitrogen dioxide ($NO_2$) | 1.5 | 1.6 | 1.3 | 1.5 |
| Ammonia | 0.9 | 0.8 | 0.6 | 0.7 |
| Dust | 0.5 | 0.4 | 0.2 | 0.2 |
| Hydrogen chloride | 0.4 | 0.4 | 0.3 | 0.3 |
| Carbon monoxide (CO) | 0.7 | 0.7 | 0.4 | 0.4 |
| Soot | 1.2 | 1.0 | 0.7 | 0.7 |
| Sulphur dioxide | 0.1 | 0.1 | 0.1 | 0.1 |
| Nitrogen oxide (NO) | 0.7 | 0.8 | 0.6 | 0.7 |
| Phenol | 0.3 | 0.3 | 0.2 | 0.2 |
| Formaldehyde | 2.7 | 3.3 | 3.2 | 3.1 |
| Benzopyrene | 3.3 | 3.1 | 2.4 | 2.3 |

TABLE 2

Urgent hospital admissions to the Kemerovo Cardiology Center in the period from December, 2010 to November, 2014

| Characteristics | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|
| Total CV admissions | 5761 | 5710 | 5536 | 4886 |
| AMI admissions | 718 | 878 | 816 | 769 |
| Q-wave MI | 489 | 592 | 564 | 541 |
| Recurrent MI | 211 | 263 | 198 | 187 |

## RESULTS AND DISCUSSION

Associations between the increase of the number of hospital admissions for primary acute myocardial infarction and the elevated levels of nitrogen oxide and dioxide in the winter time in comparison with the summer time (Fig. 1) were revealed.

It was found that, throughout the follow-up period, the elevation of nitrogen oxide concentration by 10 % of MPC results in the increase of MI admissions of 1.4 cases ($B$ = 14.78, $r$ = 0.3592, $p$ = 0.0121), and the elevation of nitrogen dioxide concentration – by 0.9 cases ($B$ = 9.01, $r$ = 0.3104, $p$ = 0.0336). In the winter season, the elevation of the average monthly concentration of nitrogen oxide by 10 % from MPC was associated with the increase of the hospitalization number by 2.9 cases ($B$ = 29.41, $r$ = 0.6668, $p$ = 0.0066) (Fig. 2, *a*).

Then the interconnection between the concentrations of air pollutants and depth of MI was analyzed. A 10 % elevation of nitrogen oxide concentration results in the increase in the number of hospital admissions by 1.7 cases throughout the entire follow-up period ($B$ = 17.11, $r$ = 0.3834. $p$ = 0.0071) and of 2.4 cases in winter ($B$ = 24.21, $r$ = 0.6571, $p$ = 0.0077) (see Fig. 2, *b*).

When analysing the relationship between the concentrations of air pollutants and admissions for non-Q-wave MI, it was found that, as the levels of nitrogen dioxide, carbon monoxide and phenol elevated by 10 %, the num-

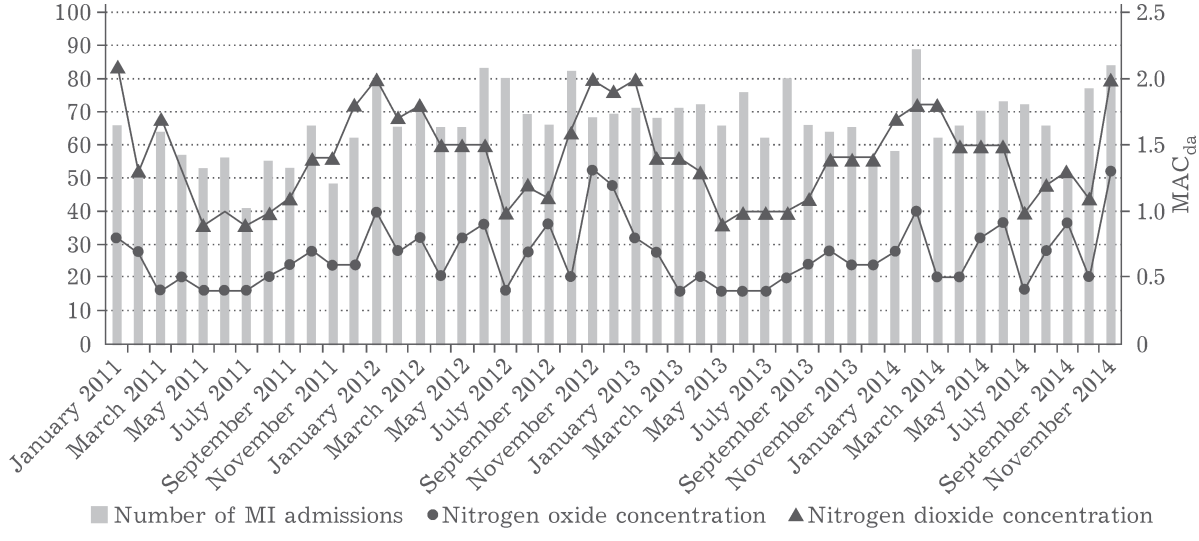


Fig. 1. Hospitalizations for the occasion of primary myocardial infarction and the concentration of NO and $NO_2$ during the period of 2011–2014.

ber of non-Q-wave MI increased by 0.4 ($B$ = 4.29, $r$ = 0.2881, $p$ = 0.0495), by 0.9 ($B$ = 9.61, $r$ = 0.3235, $p$ = 0.0249) and by 1.2 ($B$ = 11.92, $r$ = 0.3269, $P$ = 0.0265) cases, respectively.

Therefore, there is an association between the incidence of hospital admissions of patients for primary myocardial infarction and environmental pollution (elevated concentrations of nitrogen oxide, dioxide and phenol in the ambient air). This regularity has the brightest manifestation during winter seasons.

The results analysis of a large number of epidemiological studies have showed that the effect of pollutants on health is largely determined by regional, climatic, socio-economic characteristics of the studied groups [1–3, 12]. The climate pattern and the geographical location of the Kemerovo Region contribute to the fact that most part of the industrial emissions do not disperse in the atmosphere, but rather settle forming photochemical smog that has an adverse effect on public health [5].

Probably, precisely this fact explains the identified in the present study the availability of associations between a significant increase in the number of MI and an increase in the concentration of air pollutants in the winter time The days, unfavourable for the dispersion of contaminants, which result in changes of concentrations of air pollutants and their interaction, as well as extremely low temperature can contribute to this.

K. Metzger *et al.* [5] also indicated that the number of hospital admissions in cardiology clinics in Atlanta, GA, the USA increases in winter. The same group of authors showed the existence of significant connections between emergency admissions and the content of nitrogen oxide, carbonic oxide, organic carbon and oxygen-containing hydrocarbons in the air. One of the major researches in Germany discovered a correlation between low temperatures and the increased number of myocardial infarctions [6]. In Taiwan the increase in number of emergency calls due to cardiovascular diseases was associated with the cold weather and freezing temperatures [7]. A recent research in the Netherlands also identified low temperatures as a factor predicting expansion of acute myocardial infarction and rupture of abdominal aortic aneurism [8]. Chinese researchers [9] studying connection between cardiorespiratory mortality and temperature fluctuations in the northeastern regions of the country during 3 years showed that the number of cardiovascular diseases resulting in death increased by 2.3 % at when decreasing the air temperature by each degree.

The connection between the pollutants and myocardial MI differs depending on their depth. This research shows the association between hospital admissions due to Q-wave MI with the concentration of nitrogen oxide only. It was discovered that there were multiple connections

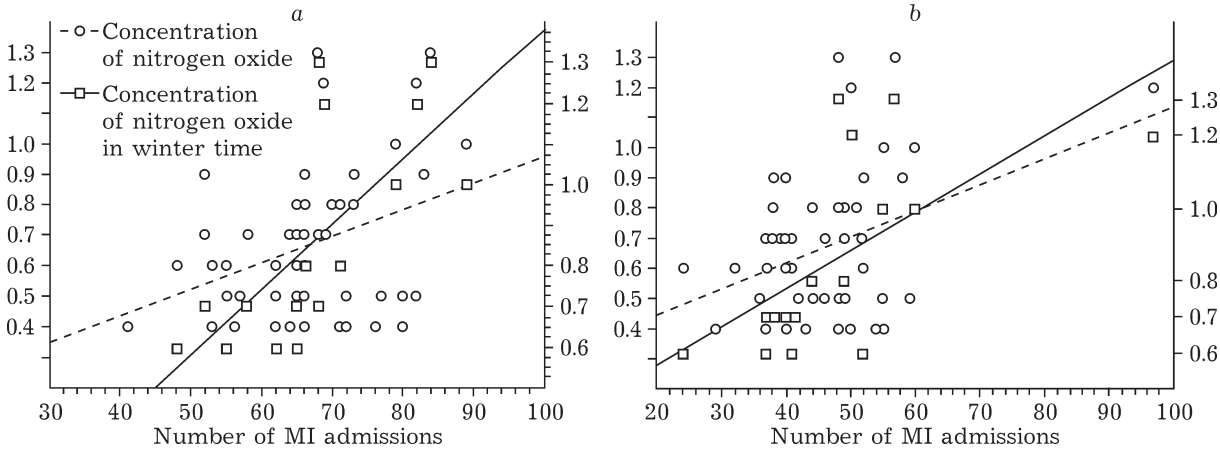


Fig. 2. Interconnection between the concentration of NO and number of MI admissions (*a*) and hospitalizations number in occasion of the forming MI (*b*).

between pollutants (nitrogen dioxide, carbon oxide, phenol) with the incidence of non-Q-wave MI. In the winter months, an increase in the degree of influence of pollutants on the frequency of MI was found. The rise of nitrogen oxide level was associated with the increased number of the Q-wave MI, while the elevated level of carbon oxide was associated with the non-Q-wave MI. At the same time, B. Gardner *et al.* [10] from Rochester, NY, the USA showed that the correlation between the air pollutants and infarctions is to a greater degree a characteristic of transmural myocardial infarctions. The researchers found out that the risk of the Q-wave MI development grows by 18 % when the air pollutants concentration increases by 7.1 $\mu g/m^3$. They also underlined that there is no such correlation for the non-Q-wave infarctions. In the authors' opinion, it is explained by different pathogenesis links of these coronary events. Besides, it was observed that the air pollutant-related myocardial infarction risk factor affects mostly people over 65, non-smokers, women, Caucasians, and also patients who had had arterial hypertension before MI occurred.

It is assumed that the impact of the inhaled particles on the cardiovascular system happens due to their effect on the autonomic nervous system, direct infiltration of the ultrafine particles into the systemic blood and initiation of systemic inflammation processes [30]. Believing that the effect of air pollutants is a risk factor in development of cardiovascular diseases, it is necessary to take into consideration an important particularity. Thus, the traditional risk factors, such as smoking, obesity, *etc.* have an effect on a limited population group – those people with the registered risk factors, while air pollution affects all the population.

## CONCLUSION

Therefore, the acquired data, as well as literature analysis indicate that the contribution of environmental pollution in the development of cardiovascular diseases may vary under the conditions of various countries and regions; therefore, it is necessary to assess both population and regional risk factors for development of this pathology.

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# Взаимосвязь между концентрацией аэрополлютантов и острым инфарктом миокарда в крупном промышленном регионе

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## Аннотация

Изучена взаимосвязь между госпитализациями по поводу острого инфаркта миокарда и загрязнением окружающей среды в крупном промышленном регионе Сибири (г. Кемерово). За период с декабря 2010 по ноябрь 2014 гг. проведен анализ основных показателей, характеризующих загрязнение окружающей среды в городе Кемерово; изучено число госпитализаций по поводу инфаркта миокарда в Кемеровский кардиологический центр. Также определено число дней в году с неблагоприятными погодными условиями. Оценка взаимосвязи и построение уравнений проведено методом регрессионного анализа. Результаты представлены в виде коэффициента регрессии B и коэффициента корреляции R. Различия считались статистически значимыми при $p < 0{,}05$. В ходе исследований установлена связь между увеличением числа госпитализаций по поводу первичного инфаркта миокарда и повышением уровня оксида и диоксида азота в зимний период по сравнению с летним. Выявлено, что за весь период наблюдений с повышением концентрации оксида азота на 10 % от ПДК число госпитализаций по поводу инфаркта миокарда возрастает на 1.4 случая, а превышение концентрации диоксида азота дает увеличение на 0.9 случаев. В зимний период превышение средней концентрации оксида азота на 10 % ПДК способствует увеличению числа госпитализаций на 2.9 случаев. Показана взаимосвязь между частотой госпитализаций по поводу острого инфаркта миокарда и загрязнением окружающей среды (увеличение оксида и диоксида азота, концентрацией фенола в воздухе), которая наиболее ярко проявляется в зимний период.

**Ключевые слова:** инфаркт миокарда, загрязнение воздуха, сердечно-сосудистые заболевания