

**EFFECTS OF FINE PARTICULATE MATTER (PM_{2.5}, PM₁₀) ON THE DEVELOPMENT OF
CARDIOVASCULAR DISEASES (LITERATURE REVIEW)**

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Abstract: *This literature review focuses on the topic “Late effects of fine particulate matter (PM_{2.5}, PM₁₀) on the development of cardiovascular disease”. The article analyzes epidemiological studies, biological mechanisms, and risk groups sensitive to air pollution and provides recommendations for public health.*

The conclusions and practical recommendations highlight the need to reduce the burden of cardiovascular disease by reducing pollution levels in industry, transport, and cities.

Key words: *PM_{2.5}, PM₁₀, cardiovascular diseases, epidemiology, exposure, hygiene, urban population.*

INTRODUCTION

Air pollution is one of the most significant environmental hazards that adversely affect human health worldwide. In particular, fine particulate matter—PM₁₀ (particles with a diameter ≤10 μm) and PM_{2.5} (particles with a diameter ≤2.5 μm)—has been shown in numerous epidemiological and experimental studies to be strongly associated with the development of cardiovascular diseases [Chow et al., 2006]. Environmental factors are also identified as key determinants of cardiovascular morbidity [Bhatnagar et al., 2006].

According to the findings of researchers, the effects of fine particulate matter on the cardiovascular system include inflammation, activation of prothrombotic pathways, oxidative stress, vascular dysfunction, and neurological impairments [Alain et al., 2013].

Epidemiological and experimental studies have demonstrated that both short-term and long-term exposure to PM_{2.5} particles are associated with an increased risk of cardiovascular diseases such as myocardial infarction, stroke, heart failure, arrhythmia, and venous thromboembolism [Martinelli N. et al., 2013].

Li and colleagues reported that exposure to PM_{2.5}, PM₁₀, nitrogen dioxide (NO₂), and other carbon-containing compounds is associated with cardiovascular diseases, stroke, and changes in blood pressure [Lee et al., 2014]. Similarly, Kälisch and co-authors investigated the long-term combined effects of fine particulate matter and traffic noise, finding that such co-exposure was associated with cases of thoracic aortic calcification (TAC). They concluded that simultaneous exposure to fine PM and nighttime traffic noise contributes to the development of subclinical atherosclerosis in humans [Kälisch et al., 2014].

Numerous research findings indicate that scientists and physicians should recognize environmental pollution as a serious and emerging factor in the development of cardiovascular diseases [Meo et al., 2015]. Studies conducted in Uzbekistan and the Central Asian region [Tursunov & Karimov, 2019; Ismoilova & Ergasheva, 2021; Mirzaeva & Yusupov, 2020] demonstrate a local association between air pollution and cardiovascular diseases. Although these studies were partially limited by the absence of continuous monitoring systems and incomplete exposure data, they nonetheless revealed a positive correlation between particulate matter (PM) concentrations and cardiovascular disease prevalence in urban environments.

According to the views of the aforementioned researchers, fine particulate matter (PM_{2.5} and PM₁₀), once inhaled into the upper respiratory tract, can enter the bloodstream and contribute to the development of cardiovascular diseases.

Methodology of studies related to this topic:

The relationship between long-term exposure to fine particulate matter (PM) and increased rates of overall and cardiovascular mortality was first demonstrated in the Harvard Six Cities and American Cancer Society (ACS) cohort studies [Pope et al., 1995]. In subsequent years, analyses covering 20 cities, as well as meta-analyses and global modeling studies [Burnett et al., 2018; Lim et al., 2012], confirmed that PM_{2.5} is a major factor contributing to elevated rates of ischemic heart disease, stroke, and all-cause mortality. Beelen et al. (2014), within the framework of the ESCAPE project, demonstrated a significant association between long-term exposure to particulate matter (PM) and natural-cause mortality across Europe. Similarly, Di et al. (2017), analyzing Medicare data in the United States, identified a clear relationship between PM_{2.5} exposure and all-cause mortality, showing that even low levels of PM_{2.5} exposure are associated with increased health risks.

Epidemiological outcomes often depend on socio-economic conditions as well as the health and demographic profile of the population. Forastiere et al. (2007) demonstrated, using the example of Rome, that the effect of PM₁₀ on cardiovascular diseases varies by season and region, and that socially vulnerable groups exhibit higher susceptibility.

Biological mechanisms: How does PM affect the cardiovascular system?

Inflammation and oxidative stress: PM enters the body and amplifies systemic inflammatory signals. This is manifested by increased levels of C-reactive protein and inflammatory cytokines, which accelerate the process of atherosclerosis [Brook et al., 2010].

Endothelial dysfunction: Particles and their associated toxic substances can damage endothelial cells, increasing vascular tone and the risk of thrombosis. This alters blood pressure and vascular permeability [Frampton, 2001].

Activation of thrombosis and platelets: Exposure to PM stimulates platelet activation and coagulation mechanisms, which increases the risk of acute coronary events and stroke [Chuang et al., 2005].

Translocation of ultrafine particulate matter: Experimental and clinical studies have shown that ultrafine particles can pass from the alveoli into the bloodstream and distribute throughout the body [Nemmar et al., 2002]. These particles can directly affect the myocardium and other organs.

Detailed analysis is of great importance when measuring fine particulate matter. The reason is that understanding the composition of these particles facilitates planning for prevention and management of their effects on the body.

Measurement of fine particulate matter and hygienic assessment recommendations:

A review of the literature shows that long-term exposure, particularly to PM_{2.5}, increases morbidity and mortality from general and cardiovascular diseases among urban populations [Pope et al., 1995; Brook et al., 2010; Di et al., 2017].

Even low levels of PM_{2.5} are associated with positive (adverse) health risks, indicating the need to revise existing standards [Beelen et al., 2014; Burnett et al., 2018]. Based on the above, the following recommendations have been developed:

1. Expansion of the monitoring network: Monitor PM_{2.5} and smaller particulate matter in urban areas.
2. Personal monitoring for sensitive groups: Implement individual exposure measurements for pregnant women, the elderly, and people with cardiovascular diseases.
3. Targeted control of emission sources: Apply technical and policy measures to traffic, industrial emissions, and biomass burning sources.
4. Health protection programs and prevention: Provide guidance during periods of poor outdoor air quality (masks, limiting outdoor activities), and promote a healthy lifestyle to reduce cardiovascular disease risk.
5. Updating laws and standards: Revise and improve national air quality standards in line with WHO recommendations and the latest scientific evidence.

Conclusion: Fine particulate matter in the air — PM_{2.5} and PM₁₀ — increases the incidence of cardiovascular diseases among urban populations through long-term exposure. Epidemiological, experimental, and modeling results provide evidence supporting this association.

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