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Review Article

Particulate

A Critical Review on the Effect of Particulate Matter (PM) in Air on Public Health

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According to the World Health Organization (WHO), particulate matter (PM) contamination causes around 800,000 premature deaths per year, ranking 13th in the world in terms of mortality. However, several findings revealed that the correlation is much stronger and more complicated than previously believed. PM is an element of emissions comprised of very small, acidic, organic compounds, metals, and particulate soil or dust particles or fluid droplets. The most consistent air quality component linked to human illness is PM, which is categorized by size. PM is likely to develop cardiovascular and cerebrovascular disorders due to the mechanisms of inflammation, overt and indirect coagulation activation, and direct translocation to the systemic circulation. The evidence on the cardiovascular system that shows a PM effect is strong. Coronary incidence and mortality rates in populations prone to long-term PM toxicity were significantly higher. Short-term acute emissions increase coronary incidence rates subtly within days of the pollution peak.

Keywords: Air Pollution, Suspended Particulate Matter (SPM), Respiratory Illness, Cardiovascular diseases, Cerebrovascular diseases

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Introduction

While specific associations have been perceived since ancient times between poor air quality and public health issues, air pollution has become evident in the twentieth century. In 1930, sulfur dioxide mixed with thick fog in the Meuse Valley in Belgium from nearby factories' pollution. For three days, several thousand people were infected, and 60 people lost their lives due to respiratory issues and acute pulmonary symptoms [1]. Dense smog full of sulfur and smoke particulate fell into London in December 1952 and resulted in over 3,000 unnecessary deaths over three weeks and 12,000 deaths up to February 195 [2]. It was recognizable, but not completely appreciated, the lethality of air emissions. Since air pollution impacts the community at present, the association between polluted air and wellbeing has not been recognized by many physicians still today. The Clean Air Act (CAA) of 1970 was the first major United States legislative initiative to research carbon and air quality limits. The CAA of 1970 established the national standards for environmental air quality. These pronouncements set limitations on six primary air pollutants: carbon dioxide, "lead, nitrogen dioxide; ozone; dioxide with sulfur; and particulate matter (PM).

Air pollution is a severe environmental issue. This is influencing the health of the population in developed and developing countries [3]. The United Nations Environment Program (UNEP) had evaluated that globally 1.1 billion people did not breathe healthy air [4]. In the past, so many studies have highlighted the significant contribution of ambient air pollution in human morbidity and mortality (5-11). In 2012, W.H.O reported that around seven million people died and one in eight people died because of air pollution [4]. Air pollution has contributed to about two-thirds of cardiac mortalities and one-third of deaths due to Chronic Obstructive Pulmonary Diseases (COPD) [5]. The acute symptoms are exacerbated, and the lung function is worsened in patients suffering from asthma and COPD because of acute exposure to air pollution with substantive and definite facts. However, we have not been sure about the long-term effects of certain air pollutants on public health, including biogenic ones [12,14].

Various health effects that have been suggested to occur due to various air pollutants such as particulates, bio-aerosols, ozone, carbon monoxides, VOCs, NO_2,and SO_2 are summarized" in the

Table 01: "List of important air pollutants, their sources and health effects"

"Pollutants	Sources	Health effects
PM	Biomass combustion, transportation, incinerators, and manufacturing industries.	Acute change in pulmonary functions, COPD, asthma, cardiovascular diseases
Biological pollutants	Pollens, dust, mites, animals' droppings and urine, pet hair, insects, fungi/mold spores, parasites, some airborne bacteria and viruses, dairy products, and food processing activities	Most often responsible for triggering respiratory illness (asthma, COPD, allergies), infectious diseases & skin diseases
SO_2	Coal and oil combustion or automobile and industrial emission	Causes chest constriction, headache, vomiting, and respiratory illness
NO2	Gas stoves and kerosene heater cooking or automobile and industrial exhaust	Respiratory and cardiovascular illness
CO	Burning of coal and gasoline or motor exhausts	Reduction in the oxygen-carrying capacity of blood, headaches, and fatigue
VOCs	Solvents and chemicals, perfumes, sprays, polishes, air fresheners, repellents, preservatives & smoke	Respiratory illness, headaches, eyes/nose/throat irritation & cancer
Ammonia	Tobacco smoke, cleaning supplies, litter boxes, or dustbins	Eye/skin irritation, headache, nose bleeds, and sinus problems"

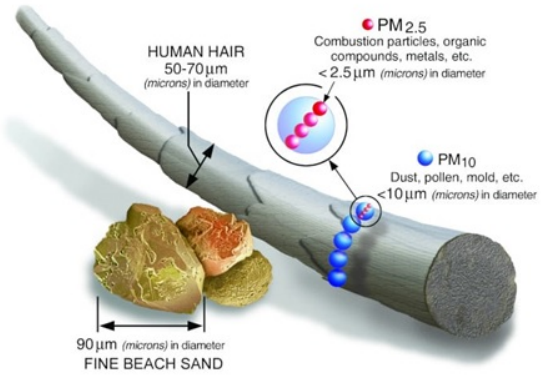
PM is a complex mixture of extremely small particles, and liquid droplets made up of acids, organic chemicals, metals, and soil or dust particles [15]. Both natural and anthropogenic sources of PM are available.

Manmade PM sources include mechanical and manufacturing processes, combustion, pollution of cars, and cigarette smoke. Vulcanoes, explosions, dust storms, and aerosolized sea salt are the natural causes of this.

The "aerodynamic equivalent diameter" can be defined as PM (AED). Sections "of the same AED have the same speed of resolution.

Traditionally, researchers subdivide particles in AED fractions depending on how particles are" formed or put in ""human airways, <10, <2.5 and <0.1 μm (PM10, PM2.5, and PM0.1, respectively) [15].

Figure 01: Comparison of diameters between a hair, a sand garden and $PM_{2.5}$ and PM_{10} particles (**Source:** https://www.encyclopedie-environnement.org/en/health/airborne-particulate-health-effects/) (16)



Particles of more than 10 μm of diameter have a comparatively short half-life suspension and filter off mainly through the nose and top airways [15]. The cumulative "number and surface area of these particles increase exponentially" with the particle diameter reduction in a mixed environmental sample. However, a substance's overall particulate mass typically decreases exponentially as the particle diameter decreases.

For example, in the PM10 sample, most particles are incredibly fine, but they constitute a minor portion of the sample's overall particulate mass. Studies have reported an improvement in PM sensitivity morbidity and mortality. While PM exposure risks are modest to any person, the cost of the global healthcare cost for communities is overwhelming.

The World Health Organization estimates that $PM_{2.5}$ is the world's 13th most significant mortality source and contributes about 800,000 premature deaths per year [15]. This article provides a review of the effect of ambient airborne PM on human morbidity and mortality. This review article finishes with public health recommendations based on a summary of the reported literature's findings.

Methodology

The authors have scientifically reviewed all available literature published in the last decade. Our primary purpose is to assess whether PM is correlated with human wellbeing or not. Our secondary goal was to summarize the pathways suggested for alleged correlations based on current human, animal, and in vitro research. We started a PubMed database search using the MESH terms "PM," "particulate matter," "air pollution," "ultrafine particles," "fine particles," "coarse particles," "PM10," "PM2.5," and "PM0.1." [15].

The authors had chosen and decided on the papers based on importance and effect. Where appropriate, attempts have been made to include both constructive and negative studies. Solid trials and epidemiological tests were underlined. Except for redundancy, experiments have been omitted. This paper concludes based on statistical evidence, after reviewing existing results, with human and public health guidelines.

PM and Cardiovascular Health Effects

Several large studies (Table 02) suggest that PM having effects on the cardiovascular system significantly [17,19]. Research on this topic has focused on both the effects of chronic PM exposure and the acute effects of increases in an ambient PM on cardiovascular mortality. In a previous analysis [20]. it was shown that for any increase in mortality caused by PM, two-thirds of the effect was counted for by cardiovascular diseases. Animal studies show a connection between chronic PM exposure and systemic inflammation to the development of atherosclerosis [21,22].

Human studies show that inflammatory cytokines IL 6, TNF Ú, and C reactive protein appear to mediate their effects (CRP) [23]. The development of acute myocardial infarction was linked to increases in both IL-6 and CRP [24]. Another study [25]. demonstrated that "transient IL-6 and TNFά elevations in diabetic patients for 2 days following PM_{10} exposure. In a prospective cohort study of German patients, Hoffman et al. [26]. associated exposure to PM 2.5 with elevations in CRP". Similar rises "in CRP from both combustion [27]. and organic matter exposure" have been seen by other researchers [28].

Acute PM presence triggers coagulation and platelet activation changes that make the PM and coronary artery disease more proximal. Many experts recognize fibrinogen as a significant cardiovascular risk factor [29].

Intra-tracheal diesel particle instillation culminated in increased platelets' increased activation in hamsters and rapid thrombosis initiation [30]. More experiments in the hamster have indicated small particles translocation and prothrombotic effects on the bloodstream [31].

Table 02: Effects of PM on the CVS

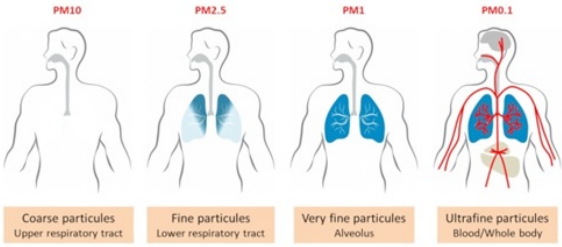
"Author	Year	PM	ΔPM (in µg/m3)	Outcome measure	Effect (95% CI)
Dockery et al.(27)	1993	PM10	18.6	All-cause mortality	26% (8–47)
Pope et al.(28)	1995	PM10	24.5	All-cause mortality	17% (9–26)
Miller et al.(32)	2007	PM2.5	10	Cardiovascular event	24% (9–41)
Toren et al.(33)	2007	PM2.5	Not measured	Cardiovascular mortality	12% (7–19)
Samet et al.(19)	2000	PM10	10	All-cause mortality	0.5% (95% CI, 0.1–0.9)
Pope et al.(34)	2006	PM2.5	10	Ischemic cardiac event	4.5% (95% CI, 1.1–8.0)
Omori et al. (35)	2003	TSP	20	All-cause mortality	1.0% (95% CI, 0.8–1.3)"
Neli et al.(36)	2012	PM10	10	Cardiovascular mortality	13% (9-22)
Ye X Peng L et al. (37)	2016	PM2.5	Not measured	Coronary Heart Disease	1.34% (95% CI, 0.53–1.34)
Xu A et al.(38)	2017	PM10	10	Ischemic heart disease	0.25% (95% CI: 0.10%, 0.39%)
X Jia et al. (39)	2018	PM2.5	10	Heart rate variability	13.96% (95% CI: − 18.99%, − 8.61%)

PM and Respiratory Health Effects

Since the cardiovascular system has been of great importance in PM [17]. several studies (Table 03) have evaluated the relation between PM exposure and respiratory" disease. Researchers have measured endpoints, including respiratory problems, opioid usage, lung capacity, health insurance, and death. The most regular inquiries and observations of respiratory tract dysfunctions were carried out in the study.

Figure 02: Lung penetration of particles

Source: (https://www.encyclopedie-environnement.org/en/health/airborne-particulate-health-effects/) (16)



"It varies from acute (pneumonia and bronchitis) to chronic diseases (such as asthma and COPD).

The study showed that adverse health effects had a tangible link to air exposure such as phlegm, tightness in the chest, allergic rhino, sinusitis, bronchial asthma, COPD, hypertension, elevated risk of headache, cardiovascular events, and eye irritation. Very few researches on air quality and its relation with health" have been done in Delhi. Joshi et al. [40].

Researched and identified the diseases caused by the contamination of Delhi vehicles during 1997. Extremely polluted urban areas (SPM, > 500 µg/m3) and less infected rural areas (supposed to be < 400 µg/m3) have, according to area sampling, been identified and serially numbered. The findings of both experiments revealed a three-fold susceptibility of metropolitan environments to vehicular emissions (in heavily contaminated areas). However, the two classes did not vary substantially with regards to asthma, heart disease, or allergies.

In elderly patients, PM_{10} and $PM_{2.5}$ increases were associated with decreases in PEFR [41]. Downs et al. [42]. demonstrated that a decrease in PM_{10} concentration might lead to an attenuated decline in lung function in adult patients. However, research on healthy adults has not as consistently shown an association between PM and respiratory compromise [43]."

Table 03: The effects of PM on respiratory admissions

"Author	Year	PM	ΔPM (in µg/m3)	Outcome Measures	Effect (95% CI)
Karr et al. (44)	2006	PM2.5	10	Infant bronchiolitis admissions	9% (4-14)
Medina-Ramon et al.(45)	2006	PM10	10	COPD admissions	1.47% (0.93–2.01)
Dominici et al.(46)	2006	PM2.5	10	COPD admissions	1.61% (0.56–2.66)
Ostro et al.(47)	2009	PM2.5	14.6	Pediatric respiratory admissions	4.1% (1.8–6.4)"
Vivian Chit Pun et al.(48)	2014	PM10	10	Ischemic Heart Disease (IHD) admissions	1.87% (95% CI: 0.66- 3.10)
Manojkumar N et al.(49)	2019	PM2.5	Not Measured	Respiratory and Cardiac hospital admissions	13.4% (5-9)
Ferreira TM et al. (50)	2016	PM2.5	12.9	Hospital admissions	7% (4-11)
Ji-Young Son et al. (51)	2013	PM10	Not Measured	Hospital admissions	2.14%
Colais P et al. (52)	2012	PM10	10	Cardiac disease and hospital admissions	1.23% (0.93 –2.16)
Dastoorpoor et al. (53)	2019	PM10	Not Measured	Cardiovascular (ICD) admissions	1.009 (1.004 – 1.014)
Salma et al. (54)	2019	PM2.5	15.8	Respiratory hospital admissions	1.70%

PM and Cerebrovascular Health Effects

Cerebrovascular and coronary systemic diseases share many pathophysiologic and risk factors and characteristics. CRP, for example, is also active in the genesis of stroke close to cardiovascular disease [55]. However, the evidence linking PM and stroke is more irregular and the mechanisms less understood. Dominica et al. [46]. reviewed air quality data for 204 US urban counties and showed that a 10-µg/m3 increase in ambient PM 2.5 increased the risk of hospitalization for cerebrovascular events by 0.8% (95% CI, 0.3–1.3%). A separate review [56]. of Medicare patients found an increase of 1.03% (95% CI, 0.04–2.04%) for hospital admission for ischemic stroke for each 10-µg/m3 increase in PM_{10}. Other investigators found a previous day PM2.5 increase of 5.2 µg/m^3 led to a 3% (95% CI, 0–7%) increase in TIA and ischemic stroke risk. In contrast, a recent large prospective multi-center stroke registry found no increase in the general population for ischemic stroke from exposure to PM 2.5. There was, however, an 11% (95% CI, 1–22%) increase in stroke risk in exposed patients with diabetes [57]. A major case-crossover study found a connection between other air pollution components (NO_2 and CO) and stroke, but no interaction with changing PM levels was observed [58]. Similarly, a large registry of first-ever strokes is not associated with PM_{10} for ischemic or haemorrhagic stroke [59].

Recommendations and Conclusion

A minimal yet clear and vital impact of PM on Human health appears to be present in the literature evaluation. In all, a significant global public health burden arises from the smaller human impacts. The implications for cardiovascular disease are particularly pronounced. Several studies have found that premature death and hospitalization have been raised. Related symptoms arise in respiratory conditions with lower amplitude. There are limits to most of the accessible PM studies. Many experiments do not use the exposure data separately. In particular, air sensors are used as replacements for human exposure in population centers.

Estimates may not be correct even after correction of these results for traffic time, exposure to secondhand smoke, etc. Despite these restrictions, there are common findings from multiple forms of research in different areas. A dose-response association has been established "between PM exposure and adverse effects, and" changes in health endpoints have been found in decreased PM exposures. Overall, the available data shows that long- and short-term exposure to PM is correlated with cardiovascular, respiratory, and mortality. Further analysis is essential to appreciate the effect of PM on human wellbeing truly. Although tests have demonstrated that an elevated PM concentration has harmful effects on health, the exact nature of noxious particles remains uncertain. More experiments are also needed in order to explain the length of the effects of PM.

Some symptoms tend to occur within hours in small trials, while others hit their highest PM doses within many days. The details on this "late time" effect will disagree, and it remains an imperfect understanding of this phenomenon.

There is more investigation into the real biological processes that contribute to PM-induced pathology. Besides, while regional exposure data have become normal PM epidemiology, actual individual exposure studies still have to be thoroughly performed. Finally, research that identify vulnerable populations will help form more guidelines depending on the population.

The Air Quality Index (AQI) [60]. offers the latest statistics on local PM and other pollutant concentrations. Although government agencies have suggested PM exposure reduction, the execution of these recommendations with peer-reviewed monitored evidence is constrained.

Table 04: Air quality index and recommendations

["Air quality index: a guide to air quality and your health. EPA, August 2019" AQI air quality index "a" People with heart or lung disease, children, or older adults - EPA-456/F-19-002]

"AQI level	AQI value	PM2.5	PM10	Actions to protect your health from particle pollution
Good	0–50	0–15	0–50	None
Moderate	51–100	16–35	51–154	Unusually sensitive people should consider reducing prolonged or heavy exertion
Unhealthy for sensitive groups	101–150	36–65	155–254	Susceptible groupsa should reduce prolonged or heavy exertion; everyone else should limit prolonged or heavy exertion need the same reference as the previous table
Unhealthy for sensitive groups	151–200	66–150	255–354	Susceptible groupsa should avoid all physical activity outdoors; everyone else should avoid prolonged or heavy exertion
Very unhealthy	201–300	>150	>354	Susceptible groupsa should remain indoors and keep activity levels low. Everyone else should avoid all physical activity outdoors"

Although the sensitivity to PM is all-embracing, the healthy amount is uncertain and researched. The general advancement of wellbeing will lead to medical education and behavioral change interventions. These data will also encourage legislators to enact or improve current laws restricting the exposure to PMs after weighing the economic effects. Volcanoes, forest fires, and other causes of natural PM are and are indispensable to our environment. However, we will potentially see a decrease in morbidity and mortality by reducing modifiable PM radiation.

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