

Air pollution and chronic respiratory diseases: a modern challenge for sustainable urban mobility

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Abstract. Uncontrolled urbanisation and continued population growth are increasing air pollution levels and the burden of chronic respiratory diseases. The transport sector is responsible for a quarter of total emissions. A shift towards sustainable transport solutions is needed to reduce high concentrations of air pollutants that are harmful to human health. This review examines the role of urban planning and transport on respiratory health. A literature review was conducted on the challenges facing urban planning and urban design to reduce air pollution and prevent chronic respiratory diseases. The main search sources were via Science Direct, Pub Med and The Lancet journal, using keywords such as “sustainable urban mobility”, “urban planning”, “air pollution”, “chronic respiratory diseases”, “green infrastructure” and “15-minute city”. The recent literature shows that there are no definitive results on how the built and natural environment contributes to the worsening of chronic respiratory diseases. There are a variety of factors and parameters that interact with respiratory diseases and vary from study to study. However, the 15-minute city concept, walkable neighbourhoods and green infrastructure have been proposed for their benefits to human health and well-being. These urban planning approaches promote active mobility and reduce pollution from transport. As mentioned it is important to adhere to the strict air quality guidelines set by the World Health Organization and European Union. So, integrated policies for sustainable cities require cooperation and participation of all stakeholders in decision-making. Having a holistic approach, strategies can be implemented to mitigate the effects of air pollution aimed at health-promoting urban planning

1 Introduction

Intense traffic congestion caused by the excessive use of private cars is a major problem worldwide due to the uncontrolled urbanization in many cities. This contributes to environmental degradation and thus to deterioration of urban life quality [1]. Air pollution is a modern and serious threat to public health. Nine out of ten people breathe air highly concentrated in harmful substances that exceed the limits set by the World Health Organization (WHO) guidelines [2].

Air pollution causes and exacerbates many diseases, especially respiratory diseases, such as Chronic Respiratory Diseases (CRDs) [3]. The WHO aims to reduce premature mortality from CRDs by 1/3 until 2030 [4]. The adoption of sustainable development strategies for the improvement of air quality is imperative. It is worth mentioning that transportation is responsible for a quarter of greenhouse gas emissions, which is confirmed in the 2019 European Green Deal [5]. So, a shift towards sustainable solutions, it is crucial to achieve significant reductions in air pollution levels in cities [1, 6, 7].

In this case, it is important to shape an affordable and healthy built and natural environment for citizens. This can be achieved by transitioning from conventional planning to modern planning through innovative planning practices [8]. This article examines the challenges of reducing air pollution and preventing chronic respiratory diseases through urban planning and design.

2 The Institutional Context

Cities consist of a complex setting and attractive structures for all kinds of activities [9]. However, they come up with significant challenges. Especially, greenhouse gas emissions, air pollution, and traffic congestion in transportation and motorized mobility have a negative impact on society, health, the economy, and the environment [10].

As early as 1992, reference was made in the White Paper on carbon dioxide reduction and efficient transport. The 2011 White Paper reiterated the target of reducing emissions by 60% by 2050 [11]. Almost ten

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years later and after various European policy documents with targets for sustainable development, zero emissions, active mobility, alternative fuels, we are still facing related problems and perhaps even greater risks. According to the WHO, eighty percent of urban residents are exposed to levels of air pollutants that exceed the WHO guidelines [12].

Realizing the target that the WHO set until 2030 [4] involves adopting sustainable development strategies to improve air quality and improving factors related to access to and effectiveness of health care and pulmonary rehabilitation. This target is included in Sustainable Development Goal (SDG) 3 and sub-goal 3.4.1. In addition, there is a reference to SDG 13 emphasizing that mitigation of climate change is an urgent need, as greenhouse gas emissions, largely due to transport, are 50% higher than in 1990. Finally, in SDG 11, the second specific objective 11.2 aims to reduce environmental impacts, with a focus on air pollutants, which is a phenomenon that has been strongly observed in recent years especially in large urban centers [4, 13, 14]. Air pollution is the greatest environmental threat to human health and well-being.

Even so, in the Sustainable Development Goals (SDGs), there is no single goal that focuses exclusively on mitigating air pollution. It is necessary to include in the 17 Global Goals a "clean air" target that is aligned with the recent WHO air quality guidelines.

3 Air Pollution Burden

Air pollution is one of the greatest modern threats to global public health [15, 16]. Every year more than two million premature deaths are associated with pollution. Pollution is a major environmental problem as road traffic has increased dramatically in recent decades due to motor vehicles, which are the dominant source of pollution. [17].

The WHO reports that transport is responsible for about a quarter of greenhouse gas emissions. The effects of air pollution on human health depend on the geographical area, the season, the sources of pollutant emissions and the time period of human exposure [16].

3.1 Atmospheric Pollution Types

Anthropogenic activity (industry, transportation) and natural sources (volcanic eruptions, natural disasters, African dust, smog, pollen) are the two main causes for toxic pollutants emissions in the air. These pollutants are divided into the categories of gases, particulate matter and micro-organisms [15]. Hazardous pollutants are made up of these categories, either separately or in combination. Pollutants are:

- sulphur dioxide (SO₂)
- nitrogen dioxide (NO₂)
- ozone (O₃)
- carbon monoxide (CO) & dioxide (CO₂)
- volatile organic compounds (VOCs)
- heavy metals (Pb, Cr etc.)
- particulate matter (PM_{2.5}, PM₁₀)

Toxic gases NO₂, CO₂ and O₃ and Particulate Matters (PMs) are the most harmful air pollutants as they affect the highest negative health impact compared to other pollutants and have been associated with premature death and disease [18]. PMs, due to their small diameter, permeate through the respiratory tract into the bloodstream, resulting in the onset and worsening of respiratory diseases such as chronic obstructive pulmonary disease, ischemic heart disease, lung cancer, stroke and asthma. Symptoms of exposure to pollutants include coughing, wheezing, chest pain, irritation of the eyes, nose and throat [16, 19, 20, 21].

PM₁₀ and PM_{2.5} are two indicators commonly used to monitor PMs. Diesel exhaust [22-24] is responsible for up to 90% of airborne PM in the world's major cities. Road-related air pollution (TRAP) is a complex mixture rich in PMs that contributes to respiratory dysfunction [15, 19, 25-28].

3.2 Air Pollution Concerns

According to the WHO, more than eighty percent of urban residents are exposed to levels of air pollutants that exceed the WHO guidelines [19].

Air pollution mainly affects those who living in large urban areas, where road emissions contribute most to air quality deterioration. In developing countries, the problem is more severe due to overpopulation and uncontrolled urbanization along with the development of industrialization [20].

In recent years, the effects of air pollution on human health and its impact on the population morbidity and mortality rates have been intensively researched. The risks and health consequences vary according to the type and duration of exposure to inhaled pollutants and include vascular diseases, ischemic heart disease, and respiratory diseases [15, 16, 19, 26, 29-31]

Short-term exposure effects are temporary and range from simple discomfort, such as irritation of the eyes, nose, skin, throat, wheezing, coughing, chest tightness and breathing difficulties, to more serious conditions such as asthma, pneumonia, bronchitis, lung and heart problems [21]. Short-term exposure to air pollution can also cause headaches, nausea and dizziness. These symptoms can be exacerbated by prolonged term exposure to pollutants, which is harmful to the respiratory system causing cancer and even, rarely, leading to death [20].

4 Chronic Respiratory Diseases (CRDs)

Exposure to elevated levels of air pollution leads to pro-inflammatory conditions in the respiratory system, affecting lung structures such as the airways and the bronchioles. As a result, loss of lung function is being experienced. Among the most common diseases are COPD, asthma and pulmonary arterial hypertension [21].

Chronic obstructive pulmonary disease: COPD is defined as a frequent, progressive and life-threatening lung disease. It's exacerbation is manifested by increased dyspnea, severe cough and increased sputum, and is

usually triggered by infections, environmental factors and polluted air [29-32]. Globally, it is estimated that 1 in 10 adults over 40 years of age suffer from COPD. In 2019, COPD was the third leading cause of death worldwide, contributing to 3.23 million deaths [30, 33, 34].

Asthma: Asthma is characterized by respiratory symptoms of wheezing, shortness of breath, chest tightness and coughing. It possesses the second highest prevalence and mortality rate after COPD among chronic respiratory diseases worldwide. Long-term exposure to PMs is associated with poorly controlled asthma and reduced lung function in children and adults. Pollution exacerbates onset of asthma, symptoms and response to treatment [19, 25]. In 2017, its estimated prevalence reached 273 million [35-36].

Other Chronic Respiratory Lung Diseases: Directly exposure to air pollution also leads to the development of pulmonary arterial hypertension (PAH). PAH is a disease characterized by vasoconstriction and obstructive changes in the small pulmonary arteries, leading to right ventricular failure and death. Exposure to PM_{2.5} has been associated with disease severity and outcome [37-39]. In addition, air pollution appears to have a negative impact on cardiovascular function as well as being associated with the development of lung cancer. Numerous studies have examined the association between acute and chronic exposure to outdoor air pollutants with the occurrence of acute cardiovascular events. Pollutants have been found to promote cardiovascular diseases such as myocardial infarction, arrhythmias, heart failure, stroke and high blood pressure [31]. At the same time, lung cancer is one of the most common cancers in the urban population. Air pollution, specifically PMs and NO₂ pollutants, has been associated with a higher risk of lung cancer, particularly adenocarcinoma [15, 19, 27].

Chronic respiratory lung diseases are not curable. Medications are available to increase airway diameter and relieve breathlessness, helping to control symptoms and improve patients' daily lives. However, medication alone is not enough to combat respiratory disease and improve public health. [26, 40-41]. Even today, air pollution is still a major factor in the increase of respiratory diseases [19,31]. For this reason, the contribution of urban planning in designing appropriate built environments with a view to sustainable development is also important. The aim is to reduce air pollution and thus reduce the symptoms of chronic respiratory diseases.

5 Urban Planning & Public Health

A challenge for urban planning is the continuous growth of the population and its concentration in large urban centers. Population is increasing, and so is mobility and transport within cities. Meeting daily needs and access to jobs, services, food, education, and recreation requires spatial interactions, or 'journeys' to and from a destination [42]. This means that a large proportion of the population is dependent on motorized means of transport, even for moving short distances. This leads to

serious congested conditions, noise pollution, air pollution, accidents, and the overall degradation of both the natural environment and people's well-being. [1].

In this article, more attention is given to the issue of air pollution and the responsibility of urban planning. In recent years and after the COVID-19 sanitary crisis, there has been a great need for healthier, cleaner, greener, smarter, and more sustainable cities [10, 43-44]. Respiratory tract infections and asthma exacerbations are more common in urban regions than in rural ones. That's the result of densely populated areas, inadequate urban and transport planning, excessive traffic congestion and vehicle emissions [45-46]. Thus, it is important to emphasize the need for better urban planning and quality of life in order to enhance public respiratory health [47].

6 Solutions to Shape Urban Environments

Urban design promises to enhance public health by improving the built environment, focusing on respiratory health [48]. Different interventions to achieve this goal are highlighted and proposed following a literature review.

According to studies carried out [1, 47, 49-53] in the last 10 years, it is observed numerous urban interventions. For instance, alternative and soft forms of mobility, such as non-motorized transport (bicycles, scooters, etc.), pedestrian streets, bicycle lanes, low-traffic and exclusive vehicle crossings, walkable neighborhoods, green and blue infrastructure, enough open green spaces (parks, squares), 15-minute cities and super-blocks are often proposed [1, 10, 54-58]. Of those mentioned, only three of these are presented with the highest frequency in the literature and are associated with an improvement in respiratory health. These are green infrastructure, walkable neighborhoods, and the 15-minute city concept. All of them have a positive impact in terms of society, economy, environment, and public health.

6.1 Green Infrastructure

The implementation of green infrastructure-based planning methods is widespread in cities worldwide. Trees, green walls, and green roofs are examples of green infrastructure that is frequently utilized to alleviate air pollution by controlling greenhouse gas emissions and decreasing harmful airborne pollutants. Air quality is improved through the absorption and deposit of pollutants through green infrastructure [54, 57]. Urban greenery, particularly leaves, acts as a bio-filter by absorbing significant amounts of carbon dioxide [7, 59]. Urban greenery not only has a direct positive impact on cities but also in-direct health effects, especially respiratory, including heart and lung disease, asthma, cardiovascular disease and overall mortality.

When combined, these methods have a positive social, economic, and environmental impact [54, 57, 59]. Their maintenance and operation costs are restricted from an economical point of view.

Furthermore, through the installation of green walls and roofs, buildings save energy, adapt to the local climate conditions, cool cities during hot periods, increase the availability of public space, and absorb carbon dioxide [54, 57]. There are many constraints that need to be considered, rather than a single factor on its own. For instance, just planting trees along a street won't achieve healthy and green cities [59].

Nevertheless, more research is needed to determine the best ways to apply strategies either separately or in combination to get the best outcomes, which would greatly improve air quality and decrease air pollution [54, 57].

6.2 Walkable neighborhoods

A large proportion of carbon dioxide emissions [26] are produced by road transport and are expected to be increased globally [55-56]. A shift towards active mobility, such as walking and cycling, is imperative. Creating walkable neighborhoods [1, 60] is part of the Smart Growth-driven approach to urban planning that aims to mitigate urban problems such as traffic congestion, air pollution, inefficient energy use, loss of open space and natural resources, etc. [61]. A pedestrian-friendly neighborhood should be supported by a properly designed network of sidewalks as well as basic services encouraging citizens to choose walking to meet their needs [10].

Such areas stimulate the regeneration of public spaces, open spaces, and local shops [61]. There is evidence to suggest that neighborhoods designed around the concept of walkability can encourage physical activity, which has many benefits, such as reducing the risk of cardiovascular disease, obesity, and the health effects of air pollution in both young people and adults, as well as creating economic benefits [55, 58]. At the same time, they improve social equity in cities [60], increase social interactions, and create cohesion by creating trust within the neighborhood [54, 56, 58]. Access to jobs and many recreational options make areas attractive for walking and maximize the "value" of the neighborhood [62].

Except that, the characteristics of a neighborhood can significantly influence people's decision to walk [63]. Walking is the most sustainable form of transport [8, 64]. Choosing to walk reduces the concentration of air pollutants emitted by cars. In addition, independence from motorized vehicles offers economic benefits to households, as their operation and maintenance costs are significantly reduced [56]. It is important to mention that walking cannot compete with motorized means when it comes to long distances [60, 65]. Neighborhoods are dynamic systems that promote local lifestyles and reinforce localism [10].

6.3 The concept of 15-minute cities

In this context of dynamic systems, cities need to be more resilient and sustainable [55-56]. Sustainability means enhancing urban well-being and public health

while producing notable social, economic, and environmental advantages. Resilience is needed to cope with future shocks and crises, such as the COVID-19 epidemic in 2019, which can expose vulnerabilities that offer opportunities [10, 55-56].

The idea of the 15-minute city was first conceived in 2016 by Professor Carlos Moreno [52]. This idea was supported by the mayor of Paris, Anne Hidalgo [67] by offering Parisians what they need in a close distance from their home. This idea first gained interest during the COVID-19 pandemic, when it became necessary to minimize short-distance travel [10]. The 15-minute city concept claims that, most residents will be able to cover their needs within a 15-minute distance by walking or cycling or using some other form of public transport [68]. Cities that focus on pedestrian mobility, adopt interventions such as pedestrianization, promotion of alternative modes of transport, urban greenery and the natural environment, creating more attractive structures for citizens and visitors [10]. 15-minute cities can act as a tool against air pollution, significantly reducing the volume of daily driving, while also minimizing traffic congestion [66, 69].

Though, in order to collectively achieve active mobility, appropriate planning and design of an attractive and safe built and natural environment for people to meet and serve their daily needs, easily and quickly [59, 70], is needed. Furthermore, the 15-minute cities have a substantial positive impact on social cohesiveness because they foster more in-person interactions and relationships among neighbors. The economic influence of cities within 15 minutes stimulates small and medium-sized businesses and increases job prospects in the area. As a result, these cities improve both their image and the quality of life for their citizens [55-56, 58].

To sum up, the literature review suggests that further research is needed on how the built and natural environment contributes to the deterioration of air quality and consequently to chronic respiratory diseases.

7 Discussion

Global public health is threatened by anthropogenic and environmental air pollutants [15]. Both short- and long-term exposure to pollutants [37-41] is responsible for the development and worsening of symptoms of chronic respiratory diseases. Non-infectious respiratory diseases are a common component of multi-morbidity due to poor air quality [3]. In recent years, despite efforts to improve urban air quality, the problem of air pollution has remained crucial. According to the WHO's report, the percentage of the world's population living in urban areas will increase from 55% to 68% by 2050 [71]. In large urban centers, pollutant concentrations are rapidly increasing, sometimes exceeding the acceptable limit values [12].

Identifying cities as complex systems, it is clear that there are a variety of factors that interact with each other and greatly affect the built and natural environment, causing adverse effects on public health [9, 10]. In order

to enable policymakers to make integrated decisions, they need to identify these factors, assess them, prioritize them, and propose long-term solutions, actions, and strategies [1]. This requires coordination, cooperation, and involvement of all stakeholders from different sectors, such as health, education, environment, urban design, urban planning, and even direct stakeholders such as citizens [3, 72]. A key requirement is the existence of appropriate tools to facilitate decision-making and help design targeted policies based on sustainable development and smart, green, and healthy cities [45,47,73]. While planning new cities, decision-makers should take into account potential future crises that may have adverse health impacts, such as the COVID-19 pandemic [10]. Some crucial challenges include an increase in the frequency and intensity of extreme weather conditions such as volcanic eruptions, heat waves, Saharan dust storms, wildfires, smog, and even pollen, which significantly affect air quality and respiratory health [74-76].

The entire above list is a major challenge for urban planning and the implementation of appropriate policies. For better urban planning that protects and promotes public health, a multi-faceted and holistic approach should be taken into consideration [47]. A healthy city can't be developed according to a specified pattern, though. Therefore, the tools and techniques that are used to initiate an alternative, healthy urban planning process will undoubtedly vary from study to study [77].

8 Conclusion

Urban sprawl and increasing population density in urban centers create the need for sustainable solutions. Sustainable urban development requires policies that can be implemented immediately and adapted in time to new circumstances.

Therefore, more research is needed in order to analyze the relationship between urban planning and public health with modern planning tools in order to prevent respiratory health issues. Moreover, multi-sectorial methods are needed to address the issues, demonstrating that cross-sectorial systems approaches can benefit everyone through innovative, concrete, and practical policies. The cities of the future must be social, environmentally friendly, livable, and healthy.

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