

The relationship between asthma and air pollution

Mohammed Dhafer Al Yami¹, Christy Kane²

Yami MDA, Kane C. The relationship between air pollution and asthma. *J Chest Lung Res.* 2023;4(1):1-6.

ABSTRACT

Asthma is prevalent worldwide. Asthma is a serious disease which threatens many people's lives and prevents them from exercising their daily activities. According to World Health Organization (WHO) estimates, there were 417,918 deaths due to Asthma at the global level and 24.8 million Disability Adjusted Life Years (DALYs) attributable to Asthma in 2016. It was estimated that more than 339 million people had Asthma globally in 2016. Asthma is the most common non-communicable disease among children. Asthma is a public health problem not only for high-income countries; it occurs in all nations regardless of the level of development. Most asthma-related deaths occur in low-income and lower-middle-income countries. Asthma is

not diagnosed and should be treated. It creates a significant burden on individuals and families and often restricts individuals' activities for life. It keeps growing because of variety of reasons. One of which is air pollution. There are many types of research done to address the problem, but it is still controversial that air pollution is a leading cause of Asthma. Picking this topic is trying to clear out the relationship between air pollution and developing Asthma through reliable studies conducted in different places around the world. As the relationship between them is questionable, it is important to disclose it to educate the audience about the possible danger of air pollution in developing Asthma since its prevalence continues to increase. Air pollution exists in both developing and non-developing countries.

Key Words: Asthma, Air pollution, Global warming, WHO

INTRODUCTION

The relationship between air pollution and asthma is questionable, especially because while individuals may blame the disease on such factors as genetics and allergies, the environment plays a similarly significant role in the incidence of the disease. Asthma is a chronic inflammatory disease of the airways that is associated with bronchial hyper-responsiveness and reversible airflow limitation [1]. The disease primarily affects the lungs and causes sporadic difficulties in breathing. It is important to note that while the disease is widely believed to affect the lungs, asthma affects the whole respiratory tract. This is evident since it frequently coexists with a variety of atopic disorders such as allergic rhinitis. Some of its symptoms include coughing (with or without sputum), breathlessness, wheezing, and chest tightness. Asthma triggers include allergic and non-allergic stimuli, which lead to chronic airway inflammation in the long run.

Asthma may be caused by many reasons. These include genetics, tobacco use, obesity, psychosocial stress, microbial or parasitic infections, perinatal exposures, diet, and indoor and outdoor pollutants [2]. All in all, the disease has a significant effect on healthcare systems and the quality of life of those suffering from it and their families. According to Zheng et al, patient with asthma

frequently require hospital admissions and urgent care visits [3]. Apart from that, a persistence of asthma symptoms leads to an increased absence from work and school (overall limitations to daily activities) by the patients as well as an increase in morbidity. The disease currently does not have a cure; however, medication is used to control the symptoms. Wayne exposure to wildfire emissions is a significant and growing public health problem and clinical problem that affects tens of millions of people in the United States [4]. One notable challenge is the prevalence of asthma globally.

LITERATURE REVIEW

Purpose

The purpose of this literature review is to determine the connection between air pollution and asthma. Human beings have progressed throughout the centuries by identifying problems that hamper their progress and coming up with measures to solve these problems. Problem identification is the most important part as it reveals what exactly needs to be rectified. In this case, the paper takes an in-depth analysis of the relationship between air pollution and asthma. Sun & Zhu agree that air pollution causes various health effects [5]. Asthma, being a respiratory disease, is highly likely to have a connection with air pollution. This paper will examine the literature regarding asthma

¹Senior Respiratory Therapist, Respiratory Therapy Leadership, MHS Bellarmine University, Registered Respiratory Therapy RRT at KFGHJ on MOH, Lecturer in Respiratory Therapy. Jeddah, Makkah, Saudi Arabia; ²PhD, RRT, RRT-NPS, RRT-ACCS, AEC, FAARC Dean, Lansing School of Nursing and Clinical Sciences, Saudi Arabia.

Correspondence: Mohammed Dhafer Al Yami, MSRT, RRT, Senior Respiratory Therapy, Graduated from Bellarmine University, USA, E-mail: alyami9855@gmail.com, ModhAlyami@moh.gov.sa

Received: 13-Dec-2022, Manuscript No. PULCLR-22-5889; Editor assigned: 22-Dec-2022, Pre QC No. PULCLR-22-5889 (PQ); Reviewed: 26-Dec-2022, QC No. PULCLR-22-5889 (Q); Revised: 27-Dec-2022, Manuscript No. PULCLR-22-5889 (R); Published: 10-Jan-2023, DOI:10.37532/pulclr.2023.4(1).1-6.



This open-access article is distributed under the terms of the Creative Commons Attribution Non-Commercial License (CC BY-NC) (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits reuse, distribution and reproduction of the article, provided that the original work is properly cited and the reuse is restricted to noncommercial purposes. For commercial reuse, contact reprints@nulus.com

and air pollution and try to determine whether there is substantial evidence to support the thesis.

Background

Asthma is prevalent worldwide. Asthma is a serious disease which threatens many people's lives and prevents them from exercising their daily activities. Asthma is the most common non-communicable disease among children. Asthma is a public health problem not only for high-income countries; it occurs in all nations regardless of the level of development. Most asthma-related deaths occur in low-income and lower-middle-income countries. According to AIR Louisville, propeller sensors collected 1.2 million data points, including over 251,000 medication puffs. Researchers combined these data with over 5.4 million environmental data points to help Louisville learn what causes asthma for citizens of Louisville [6]. Picking this topic is trying to establish the relationship between air pollution and developing Asthma through reliable studies conducted in different places around the world. As the relationship between them is questionable, it is important to disclose it to educate the audience about the possible danger of air pollution in developing asthma since its prevalence continues to increase.

Prevalence of asthma worldwide

Asthma is prevalent around the globe. According to World Health Organization (WHO, 2018) estimates, there were 417,918 deaths due to Asthma at the global level and 24.8 million Disability Adjusted Life Years (DALYS) attributable to Asthma in 2016. It was estimated that more than 339 million people had Asthma globally in 2016. Ardura et al, state that it is the most common chronic disease in children and affects more than 300 million globally [7]. According to Orellano et al, there are an estimated 623 million people living with some degree of asthma-related symptoms [1]. While the disease attacks people of all ages, it is commonly found in children. According to Dick et al, there are an estimated one million children in the United Kingdom with asthma [8]. In addition to that, between 50 and 100 British and Scottish children are admitted to hospital daily due to asthma.

Studies have shown that childhood asthma is more prevalent among boys, while women suffer more from adult asthma. The asthma epidemic is still ongoing and is higher in low to middle-income countries and has decreased in some developed countries. This may be due to the fact that in most developing countries, there is still a widespread use of kerosene for cooking and lighting purposes. The combustion of kerosene during these activities emits a substantial amount of carbon monoxide, sulfur dioxide, nitric oxides, and particulate matter. According to Lam et al, some studies on kerosene use for these activities show that its emissions are likely to impair lung function as well as cause or increase the likelihood of illnesses such as tuberculosis, cancer, and asthma [9]. As such, it is no surprise to find that most asthma-related deaths are found in low and lower middle income countries.

Examining the prevalence of asthma rates in rural areas as well as urban areas is also important. While perception from an increase in pollution in urban areas would have people assume that asthma would be more prevalent there, the reality is that rural areas have

high cases of asthma. According to Lowe et al, asthma rates are not lower when compared to urban areas [10]. The authors also state that the increase in asthma cases and severity found in rural areas may be a result of exposure to indoor and outdoor pollution that is found in rural areas and not in urban areas. An estimated 13% of Alaska Native children have asthma whereas 8.6% of all children in the U.S. suffer from the same. In addition to that, asthma morbidity is also higher in rural areas as compared to urban areas. This is evident since 67.3% Alaska Native children reported an asthma attack during a one-year period. On the other hand, 60.7% of the general population reported an attack. Alaska has some of the worst air quality in the country. Many Alaskans live in areas with unhealthy air, with wood-burning stoves and wildfire smoke contributing to poor air quality. The 2017 study showed that factors such as wood-burning stoves, indoor cooking, tobacco smoke, indoor allergens, coal-fired power plants, diesel exhaust, mining, and dust were the causes of these high numbers. The statistics from rural areas and urban areas show that asthma is bound to be prevalent in any type of area around the globe.

Irritants and asthma exacerbation

Asthma exacerbations are often classified as mild, moderate, and severe. Moderate and severe asthma generally require hospital visits or even hospitalization. It is important to note that asthma generally leads to an increase in healthcare costs [11]. Asthma is known to be triggered by various irritants. Tobacco smoke is one of the most common asthma triggers. Indeed, there is a strong link between smoking and allergic diseases [12]. According to Dick et al, environmental tobacco smoke, is likely to exacerbate asthma symptoms [8]. In addition to that, it could also affect the control of asthma and the quality of life of asthmatic children. The authors argue that tobacco smoke exposure damages epithelial cells in the bronchial passages and causes inflammation. Children who have bronchial asthma are more at risk of tobacco smoke exposure since tobacco smoke amplifies the effect of other airway irritants. As such, this increases the incidences of exacerbation and aggravates the disease. Various studies have also shown that passive exposure to tobacco smoke leads to increased asthma prevalence, an increase in symptoms, and poorer asthma control. Therefore, tobacco smoke exposure is leads to the severity of asthma and its exacerbations.

Apart from tobacco smoke, studies show that outdoor air pollution is likely to induce or aggravate asthma. According to Orellano, et al, observational studies suggest that outdoor air pollution has a high chance of inducing or aggravating asthma. The risk factors identified in children for asthma exacerbations include individual susceptibility, allergen exposure, outdoor air pollution, poor asthma control, viral infections, and environmental tobacco smoke. They concluded that major outdoor pollutants cause moderate or severe asthma exacerbations [1].

Industrial air pollution in developed and developing countries

The fact that the planet's atmosphere has been gradually changing over the past years is irrefutable. However, man started affecting these changes over the past two to three decades during the industrial revolution in North America and Europe. It is important to note that these changes have recently increased as more countries embark on rapid economic development. Man's pursuit for prosperity through

economic development has caused changes to the atmosphere through air pollution. Air pollution introduces chemicals, particles, or biological materials into the atmosphere. These foreign materials cause discomfort, various diseases, or death to human beings. According to Filho et al, Air pollution is a significant risk factor for and contributor to the major chronic diseases that increase the severity and risk of death from COVID-19 [13]. Air pollution is a considerable risk factor and contributor to morbidity and mortality from major chronic diseases. Poor air quality has been related to an increased prevalence of clinical manifestations of allergic asthma. Many different pollutants, such as Ozone (O₃), Particulate Matter (PM), Sulfur Dioxide (SO₂), and Nitrogen Dioxide (NO₂), have irritating effects that can induce cough, increased mucus, and bronchial hyper-responsiveness, which result in a more significant number of visits to the emergency department for asthma. Manisalidis, et al, note that pollutants penetrate the respiratory system through inhalation, causing asthma [14]. The primary source of air pollution is traced back to the burning of fossil fuels. The burning of fossil fuels takes place in homes, industries, electricity generation, and transportation. In China, for example, a major source of air pollutant emissions is caused by the transport sector [15].

Most developed countries have experienced the prevalence of air pollution since the industrial revolution [16]. The quality of air has significantly declined since then. However, with many developing countries rapidly developing their economies, there is a shift in air pollution prevalence. Developed countries have also come up with measures to curb widespread air pollution, hence their superior air pollution ratings. Traffic is considered the main pollutant in developed countries, especially in cities and large urban areas. Interestingly, indoor air pollution in schools and homes is a major cause for children's respiratory health in Australia. This is also true in the US where areas that use indoor wood-burning stoves experience high cases of asthma [10].

In developing countries, air pollution is much worse. This could be associated with the fact that most of these countries are developing their urban areas rapidly, whereas developed countries are not focused on urban development. Apart from that, it is important to note that there is also rapid economic development in these nations from mining, increasing industries, etc. For example, according to Manisalidis et al, pollution occurs in both rural and urban areas in India because of the fast urbanization, industrialization, and increase in motorcycle transportation use [14]. Apart from that, households in the rural areas use biomass combustion for their cooking and heating needs hence contributing to air pollution. These factors, coupled with the fact that these countries have not invested in measures to reduce air pollution, could be the reason for high air pollution concentration.

Moreover, it is important to note that many households around the world still use kerosene as an important fuel especially in the developing world. According to Lam et al, approximately 500 million households use kerosene fuel for lighting [9]. This fuel emits pollutants such as carbon monoxide, sulfur dioxide, particulate

matter, and nitric oxides, which are known to cause, exacerbate asthma.

Natural and man-made pollution

Air pollution can be both natural and man-made. Generally, there is increasing pollution such as carbon monoxide, particulate matter, nitrogen dioxide, etc. through extreme heat events, wildfires, and high aeroallergen concentration [17]. Volcanic eruptions contribute to air pollution. According to the agency, volcanic eruptions produce gases such as carbon dioxide, sulfur dioxide, and hydrogen fluoride, which are hazardous. In addition, the volcanic ash from these eruptions is abrasive, gritty, corrosive, and generally unpleasant. The ash can be a hazard to grazing livestock and could even force the closure of drinking water and wastewater treatment facilities through damaging or clogging the equipment.

Another common natural air pollutant is radon gas. The gas is produced due to the radioactive decay in the Earth's crust. More specifically, it is produced as a result of radium decaying. In most cases, radon accumulates in buildings and is most prevalent in basements. The gas is prevalent inside homes, schools, and workplaces where it is most lethal. When outdoor, the gas is not hazardous. Underground miners consistently demonstrate an increase in lung cancer due to radon.

Volatile Organic Compounds (VOCs) are also common natural air pollutants. According to Vardoulakis et al, VOC levels are associated with respiratory symptoms such as asthma [18]. It is important to note that the vegetation in some areas is known to emit substantial VOCs on warmer days. These pollutants then react with other primary anthropogenic pollutants such as Sulfur Dioxide (SO₂), Nitrogen Oxides (NO_x), and anthropogenic organic carbon compounds, hence producing secondary pollutants. Finally, Wayne, admits that there is a positive association between the exposure of human beings to wildfire smoke and respiratory morbidity, which includes asthma [4].

While air pollution does occur naturally, human beings are also culprits in the increase of air pollutants. This is partly because 3 billion people worldwide are reliant on polluting technologies and fuels for domestic heating and cooking [19]. Among the most prevalent human activities causing air pollution is coal combustion. Coal is considered an important element in the development of industry and is a readily available energy source worldwide. However, when burned, coal produces pollutants. This is caused by the oxidizing and reducing properties due to carbon, oxygen, and carbon monoxide. Air pollutants produced by coal combustion include NO_x, HC, Sox, Carbon Monoxide (CO), and particulates [20].

Apart from coal combustion, motor vehicles are also a major source of air pollution. Motor vehicles are prevalent in urban cities, especially in the developing world. According to Brandt et al, exposures to Traffic Related Air Pollutant (TRAP), decrease lung function, trigger asthma exacerbation [21]. Traffic-related air pollutants are known to cause the development, persistence, and exacerbation of asthma. Kheris et al, as well as Kheris & Nieuwenhuijsen state that childhood exposure to traffic-related air

pollutants contribute to asthma development [22,23]. First, respirable particulate matter is often produced by diesel-powered vehicles, two-stroke motorcycles, and 3-wheelers. Secondly, motor vehicles that run on leaded gasoline are known to produce lead aerosol during combustion. In addition to that, gasoline vehicles produce carbon monoxide, which is a well-known air pollutant. Lastly, some carcinogens such as benzene and poly nuclear aromatic hydrocarbons are emitted from motor vehicle exhausts. It is interesting to note that road freight and passenger transportation account for substantial air pollution. While air and railway transport came in third and fourth, air freight pollution was more than railway freight, while railway passenger transportation was more than air passenger transportation. Despite this, Dick et al, state that no single exposure of a certain pollutant causes asthma [8].

Relationship between asthma and certain air pollutants

Grazyna et al, while there are six substances in the atmosphere that negatively impact health, small dust particles (PM 2.5) since they easily penetrate the lower respiratory tract [24]. One of the major air pollutants is carbon monoxide. As such, it is an important element in detecting the presence of asthma and detecting the degree of asthma control. Exhaled carbon monoxide is a potential marker of asthma among adults and children with asthma. Medical studies have shown that during asthma exacerbations, carbon monoxide levels are elevated. In addition to that, the average carbon monoxide levels are higher in children who have asthma compared to children without the disease. Higher carbon monoxide levels can be linked to greater chances of partially controlled or uncontrolled asthma. Therefore, there is a positive association between the average level of carbon monoxide and one's asthma status. According to Pollock et al, many studies have found that there is a consistent link between carbon monoxide and asthma [17]. In the case of sulfur dioxide, studies show varying results. While some studies concluded that there is significant association between the pollutant and asthma, others found no significant association. However, one study found that the pollutant is associated with asthma in only in the summer.

According to Pollock et al, Ozone (O₃) is also widely studied in its relationship with asthma [17]. Some studies that the authors highlighted concluded that exposure to ozone increased asthma outcomes. Similarly, studies also pointed towards an increase in medical costs associated with ozone and its causation of illnesses. Generally, most studies pointed towards a positive association between the pollutant and asthma. In spite of these, it is important to note that one study found a negative association between asthma exacerbation and the pollutant's concentration. However, the studies did not agree on the seasonal pattern between the two. Nitrogen dioxide is also commonly associated and studied in regard to its role in asthma exacerbation. Pollock et al, analyze eleven studies that examined the pollutant and its association with asthma. One study highlighted the pollutant's effectiveness in causing asthma during the cold season [17]. All in all, 10 papers of the 11 papers that were examined pointed towards the existence of a significant and positive association between the pollutant and asthma.

Apart from these pollutants, inhalable particulate matter is also a well-known environmental hazardous pollutant. Studies have shown that a high concentration of particulate matter is linked with elevated

mortality rates as well as an increase in the incidences of many diseases. Pollock et al, note that asthma among children was thought to be brought about by three major types of particulate matter [17]. These are PM 2.5, PM 10-2.5, and PM 10. PM 2.5 caused worsening asthma symptoms as stated in eleven studies. In addition to that, the pollutant increased oxidative stress. Interestingly, some studies did not find significant or positive associations between the pollutant and asthma. In general, most studies (11/13) confirmed a positive association between the pollutant and children. Some of the diseases caused by high concentration levels of particulate matter include inflammation, cardiovascular diseases, respiratory diseases, and central nervous system diseases. In developed countries such as China, particulate matter contributes substantially to air pollution. Studies have shown that exposure to particulate matter within one or two weeks significantly increased the risk of asthma exacerbation in children [25]. Other studies have shown that concentrated or high exposure of particulate matter leads to an increased risk of asthmatic exacerbation and admission rates. The study concluded that short-term exposure to particulate matter for one or two weeks increased asthmatic children's asthma exacerbation risk. Therefore, particulate matter does have a significant effect on asthma.

DISCUSSION

From the literature, one can easily make out the adverse effects that asthma has on the world. With millions suffering from it and hundreds of thousands dying, the disease is lethal. First, it is important to note that certain factors trigger asthma. Generally, air pollution causes and aggravates asthma in patients. While asthma is classified as mild, moderate, and severe, the risk factors identified for asthma exacerbations include individual susceptibility, allergen exposure, outdoor air pollution, poor asthma control, viral infections, and environmental tobacco smoke. Air pollutants are a major source of asthma [18]. It is important to note that there is an increase in air pollution across the globe. An increase in urbanization in developed countries has led to the rise in air pollutants. Industries continue to come up in the urban areas while the rural areas continue to burn harmful fuels. In developed countries, pollution is slightly lower but still present. As such, asthma continues to spread worldwide. Studies show that certain air pollutants are closely linked to the disease. Carbon monoxide and particulate matter are common air pollutants that are associated with asthma. An increase in these pollutants causes increased asthmatic children's risk of asthma exacerbation.

RECOMMENDATION

Seeing the widespread nature of the disease as well as the mortality rates associated with it, it is important to try to curb the spread of the disease. First, it is important to raise awareness of the disease. This helps people get familiar with the symptoms and the dangers associated with the disease. Sensitizing people helps them to take charge of their health. As such, people will seek medical attention early; hence they are able to control the disease. Parents are also more likely to take their children to seek medical advice in case their infants exhibit such symptoms thus reducing the impact of the disease on the infants. It is also important to note that asthma can be controlled or avoided altogether by taking medicine as prescribed by a medical professional and avoiding things that can cause an attack. Local authorities can help in the fight against asthma by

implementing various decisions. For example, an increase in the tree coverage in high risk asthma areas should be considered. As such, local authorities can ensure trees are planted in various parts of their jurisdiction. Apart from that, they should identify alternative truck routes that would route trucks from neighborhoods thus reducing diesel emissions.

CONCLUSION

In conclusion, based on the statistics and results from the studies reviewed, there is a significant association between air pollution and developing asthma. The sources of air pollution contribute to varying degrees of Asthma. Asthma has a wide range of triggers including Traffic Related Air Pollutant (TRAP), Particulate Matter (PM), other aerosolized industrial gases as well as indoor triggers. To reduce the impact of these triggers on asthmatic patients, various measures can be employed such as avoidance of high traffic routes, personal protection, increasing the level of hygiene at home, and refraining from highly vigorous physical activity as recommended by the Centers for Disease Control and Prevention (CDC) and Global Initiative for Asthma (GINA). An asthma action plan, which should be given to all asthma patients, should help them manage their condition and guide them when an asthma attack occurs even before they report to a doctor's clinic. Asthma is a chronic disease requiring much self-protection, it can be successfully managed by managing triggers. The study highlights the urgent need for evidence-based policymaking and decision making to reduce the substantial burden of disease associated with air pollution, particularly in low-income and middle-income countries. In summary, air pollution is a major cause of asthma. Literature shows that there is a connection between air pollution and asthma. It is important to note that irritants that cause asthma exacerbation are also air pollutants. This includes tobacco smoke and carbon monoxide. Additionally, one should keep in mind that the disease affects low-income as well as high-income individuals showing that it does not attack a certain group of people. Developing countries, as well as developed countries, suffer the same fate in regard to asthma. A major cause for this similarity is that air pollution exists in both worlds. Urbanization and industrialization are major causes of air pollution and, consequently, asthma. However, while human beings could be blamed for asthma prevalence, one should keep in mind that some pollutants occur naturally in the atmosphere.

REFERENCES

1. Orellano P, Quaranta N, Reynoso J, et al. Effect of outdoor air pollution on asthma exacerbations in children and adults: Systematic review and multilevel meta-analysis. *Plos One*. 2017;12(3):1-15.
2. Forno E, Gogna M, Cepeda A, et al. Asthma in Latin America. *Thorax*. 2015;70(9):898-905.
3. Zheng XY, Ding H, Jiang LN, et al. Association between Air Pollutants and Asthma Emergency Room Visits and Hospital Admissions in Time Series Studies: A Systematic Review and Meta-Analysis. *Plos One*. 2015;10(9):138146.

4. Cascio W. Wildland fire smoke and human health. *Sci total environ*. 2018;624:586-95.
5. Sun Z, Zhu D. Exposure to outdoor air pollution and its human health outcomes: A scoping review. *Plos One*. 2019;14(5):1-18.
6. AIR Louisville. Air Louisville results summary. 2016.
7. Ardura C, Stolbrink M, Zaidi S, et al. Predictors of repeated acute hospital attendance for asthma in children: A systematic review and meta-analysis. *Pediatr Pulmonol*. 2018;53(9):1179-92.
8. Dick S, Doust E, Cowie H, et al. Associations between environmental exposures and asthma control and exacerbations in young children: a systematic review. *BMJ Open*. 2014;4(2):3827.
9. Lam NL, Smith KR, Gauthier A, et al. Kerosene: a review of household uses and their hazards in low- and middle-income countries. *J toxicol environ health*. 2012;15(6):396-432.
10. Lowe AA, Bender B, Liu AH, et al. Environmental Concerns for Children with Asthma on the Navajo Nation. *Ann Am Thorac Soc*. 2018;15(6):745-53.
11. Park J, Bae S. Modeling Healthcare Costs Attributable to Secondhand Smoke Exposure at Home among South Korean Children. *Int j environ res public health*. 2020;17(12):4496.
12. Saulyte J, Regueira C, Montes-Martínez A, et al. Active or passive exposure to tobacco smoking and allergic rhinitis, allergic dermatitis, and food allergy in adults and children: a systematic review and meta-analysis. *Plos Med*. 2014;11(3):1001611.
13. Rosário Filho NA, Urrutia-Pereira M, D'Amato G, et al. Air pollution and indoor settings. *World Allergy Organ j*. 2021;14(1):100499.
14. Manisalidis I, Stavropoulou E, Stavropoulos A, et al. Environmental and Health Impacts of Air Pollution: Review. *Front Public Health*. 2020;8(14).
15. Wang J, Wu Q, Liu J, et al. Vehicle emission and atmospheric pollution in China: problems, progress, and prospects. *Peer J*. 2020;7:e6932.
16. Arbex MA, Santos U, Martins LC, et al. Air Pollution and the Respiratory System. *Braz J Pulmonol*. 2012;38(5):643-55.
17. Pollock J, Shi L, Gimbel RW. Outdoor Environment and Pediatric Asthma: An Update on the Evidence from North America. *Can respir j*. 2017:1-16.
18. Vardoulakis S, Giagloglou E, Steinle S, et al. Indoor Exposure to Selected Air Pollutants in the Home Environment: A Systematic Review. *Int j environ res public health*. 2020;17(23):8972.

19. Lee KK, Bing R, Kiang J, et al. Adverse health effects associated with household air pollution: a systematic review, meta-analysis, and burden estimation study. *Lancet Glob Health*. 2020;8(11):1427-34.
20. Centers for Disease and Control and Prevention (CDC). *Asthma-Management and treatment*. 2020.
21. Brandt E, Myers J, Ryan P, et al. Air pollution and allergic diseases. *Curr Opin Pediatr*. 2015;27(6):724-35.
22. Global Initiative for Asthma (GINA). *Global Strategy for Asthma Management and Prevention*. 2020.
23. Khreis H, Kelly C, Tate J, et al. Exposure to traffic-related air pollution and risk of development of childhood asthma: A systematic review and meta-analysis. *Environ int*. 2017;100:1-31.
24. Grazyna A, Krasinski A, Malinowski J. 'Smoging kills' - Effects of air pollution on human respiratory system. *Ann agric environ med*. 2020;27(1):1-5.
25. World Health Organization (WHO). *Asthma*. 2020.