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Environmental Influences on Pediatric Asthma: The Role of Social Determinants of Health in Costa Rica

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Environmental Influences on Pediatric Asthma:
The Role of Social Determinants of Health in Costa Rica

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Table of Contents

Abstract	3
Introduction	3
Background	4
Methods	9
Discussion	10
Conclusion	15
References	19

Abstract

Pediatric asthma is one of the leading causes of morbidity and mortality among children worldwide. In Costa Rica, rates of childhood asthma are among the highest in the world. Many factors contribute to the rising prevalence of asthma, including increasing urbanization and westernization, indoor and outdoor air pollution, diet, and lifestyle. According to the WHO, air quality in Costa Rica is considered moderately unsafe, with a disproportionate exposure to air pollution in low-income urban areas. Social inequalities further contribute to the development and progression of asthma in Costa Rica. Children living in low socioeconomic neighborhoods have greater exposures to air pollution through higher traffic density and proximity to landfills and powerplants. Increasing rates of obesity and limited access to antioxidant-rich fresh produce also contribute to asthma presence and severity. While Costa Rica has implemented a National Asthma Program, much of its efforts have been focused on optimizing asthma treatment, rather than reducing occurrence. Addressing the social determinants of health within the country, by specifically focusing on living conditions and equitable access to clean air, water, and fresh produce, will help to improve the overall health of Costa Ricans and reduce the socioeconomic burden of childhood asthma.

Introduction

Pediatric asthma is one of the most common chronic diseases in childhood and affects over 300 million people worldwide.¹ Globally, rates of asthma have been steadily climbing and in many parts of the world, including Costa Rica, the prevalence of asthma remains high. Data from the International Study of Asthma and Allergies in Childhood (ISAAC) show that Latin

American countries have one of the highest rates of asthma per capita, matching many high-income countries. In Costa Rica, approximately 22-33% of children have asthma.²

The rates of asthma around the world are alarming and the financial burden of pediatric asthma should not be overlooked.³ Those with severe asthma account for over 50% of the total healthcare costs attributed to asthma. There are numerous factors that influence the development of asthma, including genetics, history of atopy, and many different environmental and infective exposures.⁴ Air pollution is widely recognized as a major risk factor for asthma, however, less is known about lifestyle influences such as weight status and dietary patterns. Furthermore, there is mounting evidence that social determinants of health, such as access to clean air, quality housing, and nutritious food, play a large role in the development of disease.⁵

Exploring the factors that influence both the development and progression of asthma will help to improve the quality of life of many individuals in Costa Rica and around the world. This paper aims to identify how different social determinants of health influence the relationship between environmental exposures and the development of pediatric asthma. While multiple environmental factors exist, this paper specifically explores the impact of air pollution, wood burning stoves, weight status, and diet on pediatric asthma rates within Costa Rica.

Background

Overview of Asthma

Asthma is considered an obstructive lung disease, characterized by airway inflammation, airflow obstruction, and bronchial hyperresponsiveness. Asthma may be triggered by

environmental allergens, in the case of atopic asthma, as well as other non-specific precipitants, such as exercise, upper respiratory tract infections, gastroesophageal reflux, air pollution, and tobacco.⁴ Furthermore, obesity and poor nutritional status are also now recognized as risk factors for asthma.⁶ There are numerous factors contributing to the pathogenesis of asthma; these include airway inflammatory cell infiltration, goblet cell hyperplasia, bronchial smooth muscle hypertrophy, airway edema, and mast cell activation. These in turn, result in bronchoconstriction, mucous production, and smooth muscle spasm, all contributing to the symptoms of asthma, such as intermittent wheezing, dyspnea, and cough.⁴

Asthma is among the top twenty causes of Disability Adjusted Life Years (DALYs), a metric used to determine years of life lost and years of life lived with disability. Additionally, numerous adverse outcomes have been associated with asthma, including more frequent school absences, lost work days, reduced exercise ability, poor sleep, and reduced quality of life.³ The burden of disease is higher in low-middle income countries and underserved communities within higher income countries, thus asthma and its negative outcomes further contribute to social inequalities seen in many countries.⁷

Environmental Exposures

Asthma is a multifactorial disease, with a substantial impact on the health of many children globally. With the significant rise in asthma rates in the late 20th century, and continued high numbers seen today, the increased prevalence cannot be attributed to genetic factors alone. Many environmental influences are now well documented as major contributors to the increase seen in asthma prevalence and asthma exacerbations. These include improved

hygiene, increased indoor allergen exposure, air pollution, lifestyle changes such as physical inactivity and poor diet, as well as climate features and environmental toxicants.^{2,6,8} Many of these environmental factors and exposures likely contributed to the high rates of asthma seen in Costa Rica.

Air Pollution

Air pollution is defined as the presence of substances in the air that are considered harmful to human health.⁹ They are classified into two major categories, natural and man-made. Natural pollutants comprise forest fires, dust storms, pollen, radon, fog, mist, and ozone, however these often impart only a minimal effect on the environment and human health. Anthropogenic pollution has a much more significant impact on environmental and human health and arise from emissions released from power plants, waste disposal facilities, landfills, agricultural burning, and transportation.¹

There are six major classes of air pollutants; these include nitrogen oxides, sulfur oxides, carbon monoxide, lead, volatile organic compounds (VOCs), and particulate matter. Nitrogen oxides are primarily produced by fossil fuel combustion and road transport, which contribute up to 80% of ambient NO₂. These are known irritants of the respiratory system, inducing bronchospasm, dyspnea, wheezing, and cough.^{9,10} Sulfur oxides are also associated with impairment to the respiratory system and even low-dose SO₂ exposure has been associated with a decline in lung function and an increase in asthma exacerbations in children 0-18 years old.^{1,9,10}

Air pollution is classified and measured by particulate matter (PM). Coarse particulate matter has a diameter of 2.5-10 $\mu\text{g}/\text{m}^3$. Fine particulate matter has a diameter of $< 2.5 \mu\text{g}/\text{m}^3$ ($\text{PM}_{2.5}$) and ultrafine particulate matter has a diameter of $< 0.1 \mu\text{g}/\text{m}^3$ ($\text{PM}_{0.1}$). $\text{PM} < 10 \mu\text{g}/\text{m}^3$ is of most concern for human health, reaching the bronchi and alveoli in the lungs. $\text{PM}_{2.5}$ can reach the bronchial capillary wall, impede gas exchange, and even cross cell membranes and interfere with cellular functioning.^{9,11} Inhaled particulate matter can elicit oxidative stress and activate inflammatory response pathways. Air pollution is associated with a high risk for premature deaths due to cardiovascular disease, chronic obstructive pulmonary disease, asthma, lower respiratory tract infections, and lung cancer.⁹ Even short-term exposure to air pollution has been associated with worsening asthma symptoms and impaired asthma control.^{9,10}

According to the World Health Organization, 91% of the world's population live in places where air pollution levels exceed the recommended limits.¹¹ In Costa Rica specifically, air quality is considered *moderately unsafe*, with a mean concentration of $\text{PM}_{2.5}$ of $16 \mu\text{g}/\text{m}^3$, $6 \mu\text{g}/\text{m}^3$ over the WHO recommended limit. However, it is important to note that this average air quality marker is an average for all of Costa Rica and air quality for specific regions, such as lower income neighborhoods and other urban regions are likely higher given increased traffic, proximity to powerplants, garbage disposal facilities, landfills, and use of indoor woodburning stoves.¹²

Use of Woodburning Stoves in Costa Rica

Biomass fuels are still one of the more common fuels sources used globally, with approximately 50% of the world's population still utilizing biomass fuels, such as wood and agricultural residues, for heating and cooking.¹³ Many rural and low-income communities within Costa Rica still utilize biomass fuels. In a study conducted in a rural town in Costa Rica, the authors found emissions released from woodburning stoves resulted in extremely high levels of particulate matter during cooking.¹⁴ In La Carpio, an impoverished urban community in a remote section of San Jose, wood-burning stoves were frequently used indoors for the production of tortillas and other commercial food products. The use of wood-burning stoves are a large factor contributing to indoor air pollution in certain areas of Costa Rica, including low income communities such as La Carpio.

Lifestyle: weight status and dietary patterns

Increasing obesity rates and changes in diet and lifestyle have been linked to increased asthma prevalence across the globe.⁷ In Costa Rica, the prevalence of overweight and obesity is 68.5% in adults and 34% in children. Urban areas often have higher rates of overweight and obesity, likely due to decreased physical inactivity and a transition to a more westernized diet.^{15,16} In a study exploring the relationship between asthma and obesity in Puerto Rican children, the researchers found that BMI and waist circumference were significantly associated with asthma and indicators of asthma severity.⁶ The authors theorized that the additional adipose tissue may play a role in asthma severity through tissue-mediated inflammation and

immune responses. Furthermore, obesity may also lower the threshold for allergic sensitization, thus further contributing to the development of asthma.

Fruit and vegetables contain antioxidants that help combat oxidative stress from air pollution. In a multicenter cross-sectional study in Latin America, only 7.2% of the 9200 participants reached the WHO recommendations for fruits and vegetable intake.¹⁷ While fresh produce is widely available in Latin America, the cost of these foods compared with the cost of processed foods likely contribute to low intake reports. Interestingly, low vitamin D status (< 30 ng/mL) is also associated with an increase in asthma exacerbations and asthma-related emergency department visits.¹⁸ While it may seem counterintuitive, vitamin D insufficiency is often seen in urban warm climate regions due to sunscreen use, dress habits, and sunlight avoidance.

Methods

The PubMed and Google Scholar databases were utilized to complete a literature search related to pediatric asthma prevalence and environmental exposures in Latin America, and specifically Costa Rica. Search terms included: pediatric asthma prevalence in Costa Rica, air pollution in Latin America, woodburning stoves in Costa Rica, air pollution and asthma, childhood obesity and asthma, dietary patterns in Costa Rica, and social determinants of health.

In addition to the literature review, information from guest speakers during the *2021 Healthcare, Leadership and Universal Responsibility: A Costa Rica Experience* study abroad trip was used as a foundation for this paper. Observations during the lectures and tours of the La

Carpio community were included to provide context for the role of social determinants of health and their influence on environmental exposures and subsequently respiratory diseases, such as asthma. An interview with a local community member of La Carpio was also conducted via email after returning to the United States.

Discussion

The relationship between air pollution and asthma has long been established. Many studies have provided evidence for an association between poor air quality and asthma incidence in children. However, additional environmental influences, such as obesity and nutritional status also likely contribute to the steadily high rates of pediatric asthma seen globally. Children are particularly vulnerable to air pollution. Children inhale more air per unit of body weight and therefore inhale higher levels of airborne pollutants compared to adults. Furthermore, their lung and immune systems are continuing to develop and immaturity of these systems appear to predispose children to an increased susceptibility to air pollution.¹⁰ When considering the impact of weight and nutritional status on asthma rates, children who are overweight and obese have a double burden from air pollution. In a large cross-sectional study, the effects of air pollutants such as NO₂ and SO₂ have a significantly greater effect on overweight and obese children.⁹

In addition to ambient air pollution, indoor air pollution also poses a concern for asthma rates in developing countries, such as Costa Rica. The World Health Organization estimates indoor air pollution from fires for cooking and heating account for 3.8 million deaths.¹⁰ As discussed in the previous section, wood-burning stoves are utilized in many low income

communities as a primary source for cooking and heating. For many individuals, alternative fuel sources are not possible due to financial limitations. In La Carpio, for instance, wood-burning stoves are still used for *Tortillerias*, tortilla making shops. Cooking the tortillas on a woodburning stove is part of the traditional recipe and preferred by many tortilla makers. Making tortillas and selling them in the community is a means of financial independence for some residents and switching to a gas stove may present both economic and cultural barriers, despite the indoor air pollution and impact on respiratory health from wood-burning stoves.

Social determinants of health, such as socioeconomic status, are a common denominator for the influence of environmental exposures on asthma rates. Low socioeconomic communities continue to bear a disproportionate burden of air pollution compared with communities of higher income. This is reflected in rates of asthma, as well as premature deaths due to cardiovascular disease, chronic obstructive pulmonary disease, lower respiratory tract infections, and lung cancer.^{9,12}

Low income and minority communities often live near heavy traffic areas. In one study, the authors explored the relationship between respiratory health, traffic, and air pollution, stratifying by socioeconomic status. Results of this study found that increased traffic density within 200 m of the subject's home was associated with higher levels of ambient air pollution and increased respiratory symptoms, such as wheezing and asthma.¹⁹ When stratifying by socioeconomic status, the authors found low income and minority communities were more likely to be located near high traffic areas and therefore had a greater exposure to air pollution.

Additional studies also confirmed these findings, showing children living in environments near dense traffic had an increased risk of asthma symptoms, asthma exacerbations, school absences, and hospitalizations.³ Furthermore, aside from geographic proximity, other socioeconomic factors also influence air pollution exposure, such as utilization of public transportation (vs private transportation), outdoor work environments, and poorer in-home air filtration systems.¹² While Costa Rica is considered to have *moderately unsafe* air quality, regions where traffic density is highest are often located within low-income neighborhoods.²⁰

Additionally, low-income communities often reside near additional contributors to air pollution, such as garbage disposal facilities, landfills, and power plants. In La Carpio, the community is bookended by environmental contaminants, having a sewage facility to the north and a landfill to the south. In an interview with Bethel Meza, a community member of La Carpio, she discusses her observation regarding environmental exposures and respiratory diseases.

“From my personal experience I can say that certainly there is a correlation between air pollution and respiratory diseases around La Carpio. Although I am not aware of other official cases besides my mother, I know this is affecting people. I think the reason why we don’t know more about [these] cases is because there is not enough awareness towards this situation even when it is right in front of our eyes. Neither the government nor the Ministry of Health or Ministry of Environment and Energy have considered the consequences of having a raw sewage plant right when you access La Carpio or having a

landfill at the end of the community (right behind my home). Even when our people were opposed to both since the very beginning and our community went on a strike against these, we were ignored, and they continue to remain there”.

Low socioeconomic status also influences food access and thus nutritional status. As discussed above, low intakes of antioxidant-rich fruits and vegetables may contribute to an increased susceptibility to airway irritants, thus predisposing children to higher rates of asthma. Studies from low, middle, and high-income countries have all shown a positive correlation between socioeconomic status and consumption of fruit and vegetables.²¹ This is often attributed to access and cost barriers found in many low socioeconomic communities. It should be noted, however, that the ability to follow a “western” dietary pattern is also related to socioeconomic status. Despite fast-food chains becoming more abundant in low- and middle-income countries, they remain cost prohibitive for many. However, certain foods, such as sugar-sweetened beverages are very affordable and have been found to be of higher prevalence in the dietary patterns in both low and upper socioeconomic families.²² These foods now commonly replace more expensive options, such as fresh produce, therefore still resulting in the low rates of fruit and vegetable intake seen in low and middle income countries.¹⁷

The term *Solidarity* is often heard when discussing Costa Rican politics and policies, as it is part of the basis for the social welfare system that Costa Rica was founded on. In Costa Rica, the idea of solidarity applies to the way Costa Ricans care for and support one another. It’s often considered one of the reasons Costa Ricans are content paying a higher percentage in

taxes for many of the social security benefits offered, even if they themselves may not utilize all the services.

While the social welfare system has allowed Costa Rica to provide many public programs that benefit its citizens, critics of Costa Rican politics argue that the transition to more neoliberal policies has resulted in a regression for social equality, resulting in more socioeconomic division within the country. As Karina Vargas discussed in her lecture, *Costa Rica History: An Update*, the neoliberal political framework has resulted in a restructuring of governmental spending, with less money going toward education and other social programs. This shift in spending contributes to differences in the quality of education and healthcare across the country, thus impacting employment and other socioeconomic opportunities within the country.²³ This political restructuring may be a contributing factor to the high prevalence of asthma seen in Costa Rica.

It is no question that social determinants of health influence health inequality throughout the world. In 2021, the World Health Organization launched a multi-country “Special Initiative for Action on Social Determinants of Health for Advancing Equity” in response to the differences in health outcomes seen across the globe from COVID-19. According to the WHO, individuals living in high-income countries have an average life expectancy 18 years higher than low-income countries.²⁴ Within countries, those of lower socioeconomic status have worse health outcomes to non-communicable diseases, such as cancer, asthma, and cardiovascular disease.

These differences are attributed to what are known as social determinants of health, including access to quality housing, education, employment opportunities, safe environments, clean water and air, food security, and healthcare. Using La Carpio as an example, low-income communities within Costa Rica are directly impacted by these social determinants of health, including poor quality housing and environmental exposures from contaminated water and air. The high rates of asthma seen in Costa Rica are therefore likely influenced by these social determinants of health. Air pollution, use of wood-burning stoves, and limited access to fresh fruits and vegetables, for example, all influence the development of asthma, and are also most seen in low-income communities, such as La Carpio in Costa Rica.

In order to address the high prevalence of asthma, the Costa Rican government created the National Asthma Program (NAP), focused on early diagnosis, treatment guidelines, avoidance of common allergens, and environmental exposures.² Since its implementation, the National Asthma Program has seen a reduction in deaths due to asthma; down from 25 in 2000 to 5 deaths in 2011. This reduction has been attributed to the change in asthma treatment guidelines which now include the use of inhaled corticosteroids for children with persistent asthma. While the NAP has shown benefit in reducing asthma-related deaths, the rates of asthma remain high, and will likely continue to stay elevated until these social determinants of health and environmental exposures are addressed across the country.

Through its social welfare program, Costa Rica has made access to quality healthcare a universal human right for its citizens. While this has undoubtedly made a difference in the overall health of the country, there are still many additional factors that negatively impact the

health of Costa Ricans. Addressing the social determinants of health and specifically focusing on improving living conditions and air pollution exposure for all people is another universal human right that would make a significant impact on the health and wellbeing of all Costa Ricans.

Conclusion

Asthma continues to be one of the most common chronic diseases among children, resulting in significant financial, mental, and physical burdens for the individual and family members. Air pollution remains one of the strongest contributors to the development of asthma through particulate matter exposure to the bronchial epithelium and airway inflammation and bronchospasm.^{2,25} Additionally, children appear more susceptible to the impact of air pollution due to their immature lung and immune systems. This, in combination with additional environmental influences, such as low fruit and vegetable intake and higher rates of obesity, are likely contributing to the high rates of asthma seen globally.

In Costa Rica specifically, asthma rates are among the highest in the world, and more commonly seen in low-income communities due to several environmental influences, including higher exposures to air pollution, such as traffic density and landfill emissions, as well as reduced access to fresh produce.^{2,7} While Costa Rica has implemented a National Asthma Program, rates remain high likely due to socioeconomic factors that have not been addressed since the transition to the neoliberal platform.

This paper focused on two specific environmental influences on asthma, air pollution and lifestyle. However, there are many other factors that also contribute to the development of

asthma in Costa Rica, such as indoor allergens, physical inactivity, and other environmental toxicants. There is a wealth of information on air pollution, yet it was difficult to find research on additional environmental pollutants. For instance, Costa Rica is one of the main producers of pineapple, and significant amounts of agrochemicals are used in the production of pineapple. It would be interesting to learn whether there is an association between inhalation of agrochemical products and respiratory diseases, such as asthma.

Globally, secondhand smoke exposure is another significant risk factor for asthma. Numerous studies have provided evidence for increased asthma symptoms and exacerbations in children with secondhand smoke exposure.^{26,27} However, whether this is a significant risk for children in Costa Rica is not well understood. In March 2012, Costa Rica passed legislation consistent with the WHO Framework Convention on Tobacco Control, helping to reduce tobacco use and secondhand smoke exposure throughout the country.^{28,29} While this has likely reduced tobacco exposure and its risk to pediatric asthma, additional research may help clarify whether this is an additional opportunity for intervention.

This paper also focused on the influence of social determinants of health on asthma rates and environmental exposures. Currently, there is limited data on social determinants of health within Costa Rica. Additional information on how Costa Rican governmental policies influence social determinants of health would be useful not only in the study of asthma, but in understanding how socioeconomic factors influence all health outcomes in Costa Rica.

By exploring the relationship between air pollution, food access, and asthma, this paper provides insight into how social inequalities within Costa Rica influence the development of

non-communicable respiratory diseases. Given the strong influence of air pollution on asthma rates, continued emphasis on improving the air quality in urban areas would provide significant benefit for children and adults with asthma. Future research focusing on air quality initiatives may provide governments, such as Costa Rica, with evidence on effective policies to help curb fuel and landfill emissions. Additionally, research on food access throughout Costa Rica and programs to promote increased intakes of fruits and vegetables would not only benefit asthma rates, but also other chronic diseases such heart disease and diabetes.

Social determinants of health are at the root of both acute and chronic diseases throughout the world. A return to the solidarity political platform and an emphasis on promoting equal access to clean air and water, healthcare resources, education, and adequate nutrition will help address the social inequalities and improve health and quality of life for all Costa Rican citizens.

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