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Air Pollution in South Texas: A Short Communication of Health Risks and Implications

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Communication

Air Pollution in South Texas: A Short Communication of Health Risks and Implications

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Abstract: Air pollution is a major public health concern. The region of South Texas in the United States has experienced high levels of air pollution in recent years due to an increase in population, cross-border trade between the U.S.A. and Mexico, and high vehicular activity. This review assesses the relationships between human health and air pollution in South Texas. A thorough scientific search was performed using PubMed, Science Direct, and ProQuest, with most of the literature focusing on the source apportionment of particulate matter that is 2.5 microns or less in width ($PM_{2.5}$), Carbon Dioxide (CO_2), carbon monoxide (CO), Black Carbon (BC), and associated health risks for children and pregnant women. Findings from the source apportionment studies suggest the role of industries, automobiles emissions, agricultural burning, construction work, and unpaved roads in the overall deterioration of air quality and deleterious health effects, such as respiratory and cardiovascular diseases. This review demonstrates the pressing need for more air pollution and health effects studies in this region, especially the Brownsville–Harlingen–McAllen metropolitan area.

Keywords: air pollution; health; South Texas; $PM_{2.5}$; CO; BC

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1. Introduction

The South Texas region of the United States of America has undergone enormous economic and population growth due to the signing of the North America Free Trade (NAFTA) agreement [1]. Over the years, the number of automobiles and trucks crossing to and fro between the United States and Mexico for international trade have also increased substantially [1]. Industrialization and population growth leads to an increase in particulate matter (PM) and volatile organic compounds (VOC) emissions [1]. In order to assess the air quality, numerous Continuous Ambient Monitoring Station (CAMS) sites have been installed by the Texas Commission on Environment Quality (TCEQ), as mandated by the provisions of the Clean Air Act of 1970 and amendments thereof, to monitor various meteorological and pollutant parameters. Some of the pollutants measured are $PM_{2.5}$ (particle size less than 2.5 µm in diameter), PM_{10} (particle size less than 10 µm in diameter), ground-level ozone (O_3), carbon monoxide (CO), lead, nitrogen oxides, sulfur dioxide (SO_2), and VOCs [2]. In the past, many researchers have used these ambient real time data to characterize the spatial, as well as the temporal, relationships between these pollutants.

Air pollution is not only a regional issue, but it is a well-known global issue that has both direct and indirect negative effects on human beings. Air pollution and climate change are interrelated with each other [3]. Various pollutants such as Black Carbon, methane, CO_2, and aerosols effect the amount of heat in the atmosphere, which results in climatic changes such as melting of icebergs, increase in sea levels, and temperature rises [4]. The World Health Organization reported that an estimated three million deaths are caused annually by ambient (outdoor) fine particulate matter air pollution or $PM_{2.5}$ [5]. It is very important to monitor the particulate matter emissions in areas of industrialization and high population.

Texas—the second largest state in the United States—has varying topographic and climatic features. The region of South Texas comprises of 28 counties and has a population of 4.5 million. Many of the counties run along the Texas–Mexico border. It is a low-resourced region, with a predominantly Hispanic/Latino population. Approximately 25% of people living here are without health insurance [6]. It has 10 International Ports of Entry (POE), which account for 17% of the U.S international trade [6]. The region is also frequented by many tourists; approximately 100,000 American and Canadian tourists visit the area every winter.

South Texas is a region with an area of 37,800 square miles. The region includes areas between Cameron County in southern Texas, Val Verde County in the northwest, Bexar County (containing San Antonio), Webb County (including Laredo), and the Lower Rio Grande Valley (a set of four counties—Cameron, Willacy, Hidalgo, and Starr—which were formerly studied independently from the rest of South Texas) [7]. The area is shown in Figure 1. South Texas has a diverse climate with semi-arid climate around the Mexican border, although the humid subtropical climate extends from the coast inland to just west of San Antonio. In the winter, temperatures rarely drop below freezing, and snowfall is uncommon. Summers in this zone are hot and humid, with the daily average temperature exceeding 90 °F (32.2 °C).

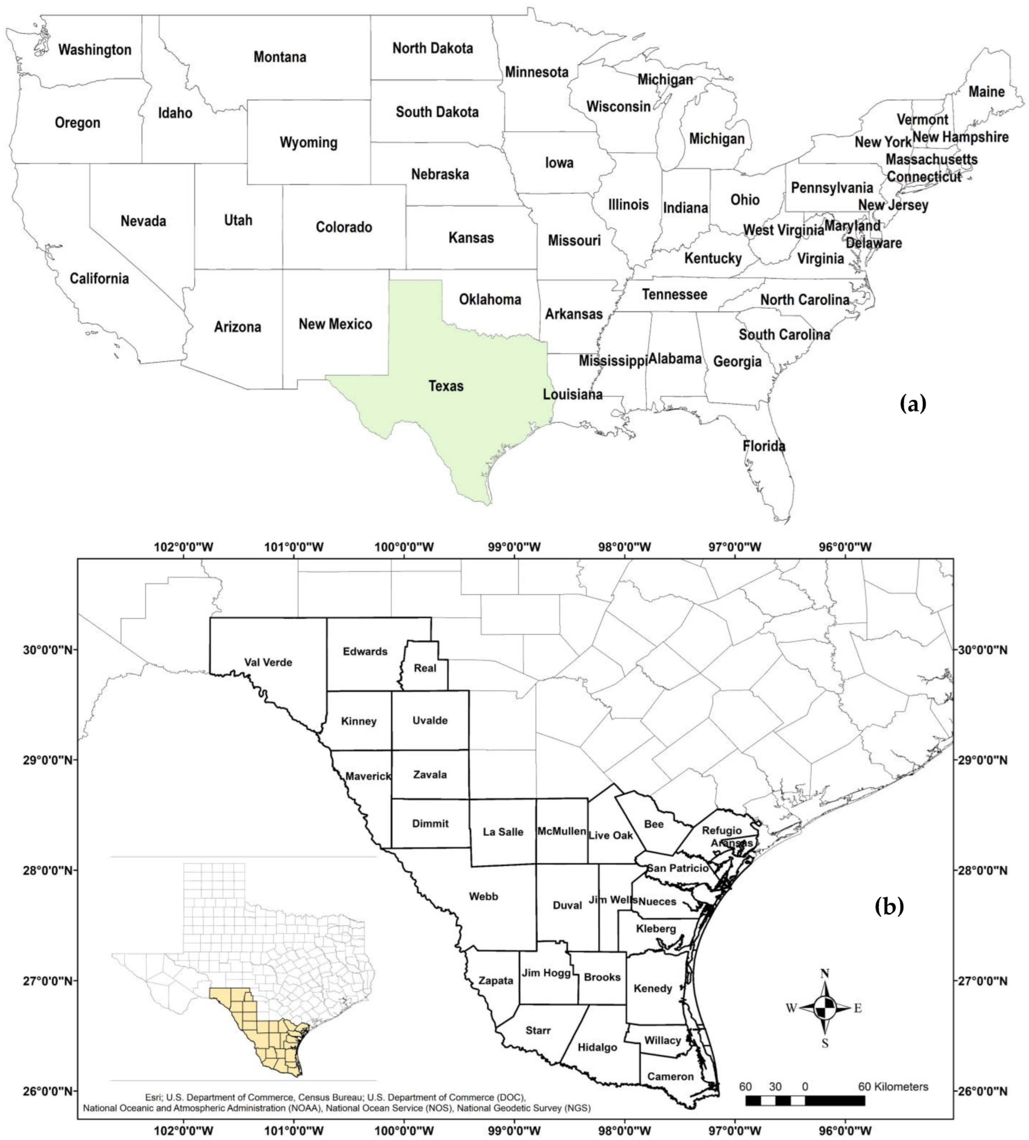

Figure 1. Geographic location of (**a**) Texas and (**b**) South Texas Study Area with selected cities highlighted.

The region of South Texas is also very rich in agricultural activity. The Rio Grande River forms the natural boundary between Mexico and the state of Texas in this region. The growing population, high industrial and agricultural activity, high traffic pollution, and other fugitive sources of air pollution from both sides of the border accentuate the importance of studying air pollution in this region, with potential health implications. The current study examined all the potentially identified literature from cities in the Lower Rio Grande Valley, Bexar, Webb, Cameron, Nueces, and Val Verde Counties.

2. Materials and Methods

Different studies conducted in the region of South Texas, with emphases on traffic, industrial, and agricultural emissions, source appointment, and associated health implications, were considered for the review. This review considered article publications from early 1993 up to 2022. We included and examined all the publications with full texts that employed a proper methodology and data analysis to describe air pollution and its health implications in South Texas. Air pollution studies focusing on other study regions were not included. Duplicate articles found in more than one database were eliminated, as were studies that were not published in English. The resulting literature review focuses exclusively on pollution studies from South Texas.

A systematic thorough search of the published literature was conducted using PubMed, Science Direct, and ProQuest. A complete search of peer reviewed journals was emphasized using multiple key terms. The literature search items with databases and search filters are shown in Table 1. The primary search used a combination of search terms to identify air pollution studies and their health implication. "PM2.5" OR "PM10" AND "South Texas," "Air pollution" AND "South Texas," "Ground level ozone" AND "South Texas," and "Air pollution" OR "PM2.5" OR "PM10" OR "Ground level ozone" AND "South Texas" were some of the terms utilized. All studies found relevant to the scope of this review were saved in a reference manager EndNote X9 and 20.

Table 1. Literature search terms.

Database	Search Filters	Results
PubMed	(Air pollution) AND ($PM_{2.5}$) OR (PM_{10}) OR (PM) OR (NO) OR (BC) AND (South Texas)	1225
ProQuest	"Air pollution" and "$PM_{2.5}$" and "PM_{10}" and "NO" and "South Texas"	88
Science Direct	"Air pollution" and "PM_{10}" and "Ozone" and "PM" and "$PM_{2.5}$" and "South Texas"	129
Total		1442

The combined search consisted of 1442 articles, out of which 1225 were from PubMed, 129 were from Science direct, and 88 were from ProQuest. A total of 1422 articles out of 1442 were excluded because they were not related to South Texas. Twenty articles went under full review to further analyze air pollution and health implications in this region. The PRISMA flow chart detailing this information is shown in Figure 2.

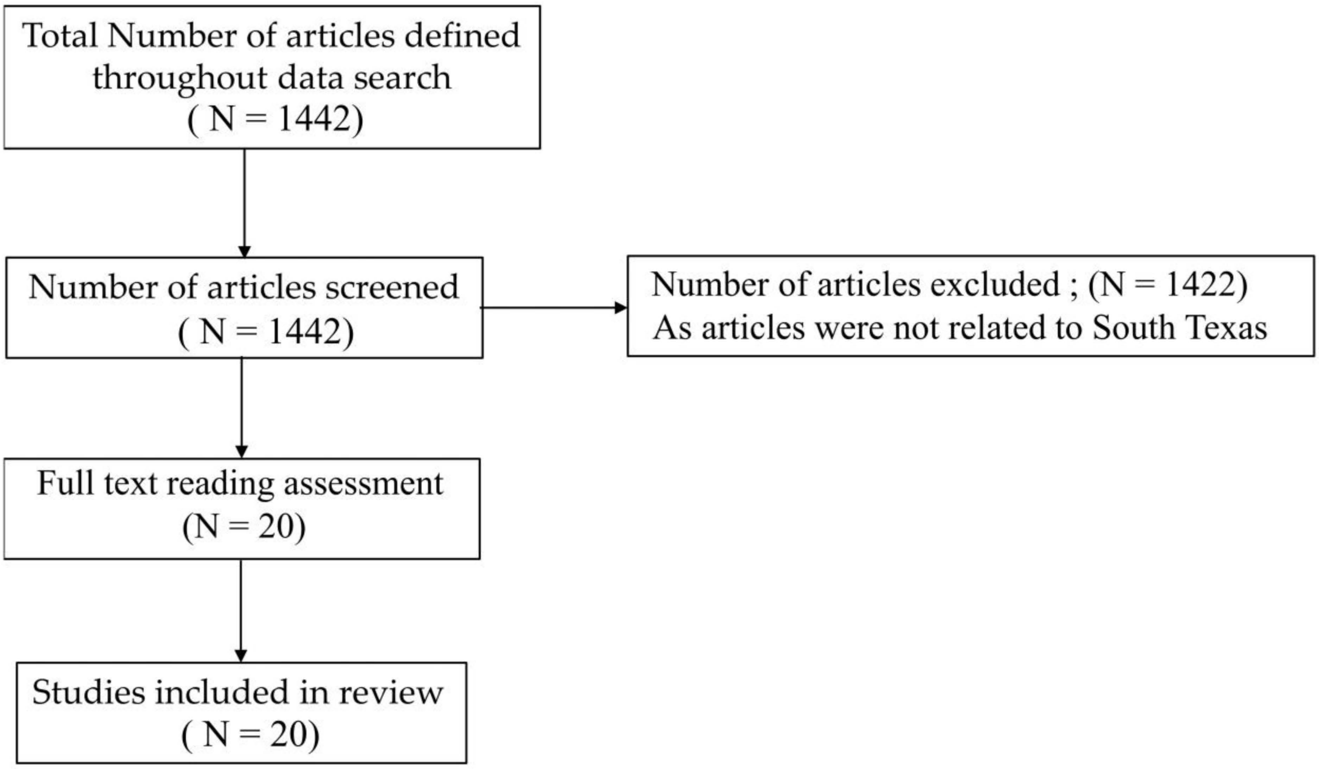

Figure 2. PRISMA flow chart.

3. Results

The air pollution studies from this region are summarized in Table 2. The articles reviewed pertain to populous, industrial, and border cities such as Corpus Christi, McAllen, Edinburg, Brownsville, Beeville, and Mission. These studies measured different parameters, which included $PM_{2.5}$, PM_{10}, Black Carbon (BC), Volatile Organic Carbon (VOC), Ozone, Ultra Fine Particles (UFP), Benzene, CO_2, NO_2 and Polycyclic Aromatic Hydrocarbons (PAH), Hazardous Air Pollutants (HAP) and the subsequent health effects in South Texas [1,8–26].

The most studied parameter was $PM_{2.5}$ [1,8–20,25,26]. Source apportionment studies were conducted by using $PM_{2.5}$ data to evaluate the effect of different emissions on air quality [1,8–10,15]. The data of $PM_{2.5}$ in Corpus Christi, an industrialized coastal urban area, was analyzed for source apportionment, and the study concluded that agricultural burning activities in Mexico and Central America during the months of April and May were the major $PM_{2.5}$ sources [1]. A study of Lower Rio Grande Valley (LRGV) [8] measured $PM_{2.5}$ at three TCEQ CAMS sites to evaluate the U.S.–Mexico cross-border air pollution in 1997. The study concluded that the air quality of the US side of LRGV region was not majorly affected by cross-border emissions of anthropogenic nature, rather it was dominated by biogenic or anthropogenic sulphates. Another study of LRGV [9] measured particulate matter of different sizes and volatile organic carbon for source emission characterization in the border area. The study concluded that field burning and cooking activities accounted for most of the emissions, and more than 60% of the emissions contained carbon in them. A source apportionment study [10] for $PM_{2.5}$ was conducted in Brownsville from 2010 for three years and concluded that majority of the emissions were secondary sulphates and non-sea salt sulphates. These were typically emitted by various power plants using fuel and oil. Waste burning activities, automobile emissions, and field burning activities were concluded as possible sources of carbon in the LRGV region by a 1993 study [15].

Table 2. Summarization of characteristics studies of air pollution in South Texas.

Focus Area	Duration	Pollutant Studied	Major Findings	Reference
Corpus Christi	July 2003–December 2008	$PM_{2.5}$	• Agricultural stubble burning in Mexico and Central America during April and May are major sources of $PM_{2.5}$ affecting Corpus Christ;	[1]
LRGV (Brownsville and McAllen)	March 1996–March 1997	$PM_{2.5}$ and VOCs	• Air quality on the US side of LRGV is not majorly impacted by cross-border emissions of anthropogenic nature but dominated by regional and wind-blown dusts and biogenic or anthropogenic sulphates;	[8]
LRGV	N/A	$PM_{2.5}$, PM_{10}, and VOCs	• Higher abundances of lead in motor vehicle exhaust and field burning profile shows majority emissions are composed of carbon;	[9]
Brownsville	2010–2013	$PM_{2.5}$	• Secondary sulphate emissions accounted for the majority of the emissions;	[10]
South Texas	2010–2014	$PM_{2.5}$ and O_3	• $PM_{2.5}$ was positively associated with length of stay in hospital among children aged 5–11 years old;	[11]
Beeville	18–20 March 2008 and 20–28 March 2008	Ultrafine Particles, BC, $PM_{2.5}$, PM_{10}, CO, and CO_2	• Air pollutant concentrations decreased with increasing bus driving speeds, and passenger load has a positive correlation with in-cabin air pollutant concentrations;	[12]
McAllen, Edinburg, Mission	June 2015–April 2016	$PM_{2.5}$, BC, and Nicotine	• Cooking emissions were found to be a significant $PM_{2.5}$ source;	[13]
Counties of Hidalgo, Cameron	Spring and Summer of 1993	$PM_{2.5}$, VOCs, Pesticides, and PAHs	• Use of natural or propane gas results in higher $PM_{2.5}$ and PAH levels;	[14]
Brownsville	Spring and Summer of 1993	$PM_{2.5}$, VOCs, Pesticides, and PAHs	• Waste burning activities, automobile emissions, and field burning activities are possible sources for the observed carbon;	[15]
South Texas	2010–2016	$PM_{2.5}$ and O_3	• Positive correlation between high levels of air pollution in neighborhoods and number of asthmatic children's hospitalizations;	[16]
South Texas	2010–2014	$PM_{2.5}$ and O_3	• The short-term exposure to air pollutants affects the risk of preventable hospital readmissions of pediatric asthma patients;	[17]
McAllen	June–November 2019	$PM_{2.5}$	• Asthma education leads to increase in indoor air quality and improved health outcomes of children with asthma;	[18]
25 counties	March 2012–December 2016	VOCs and PAHs	• Hispanics are more exposed to gas flares when compared to non-Hispanic whites;	[19]

Table 2. *Cont.*

Focus Area	Duration	Pollutant Studied	Major Findings	Reference
Texas	2000–2010	PM, VOCs, and PAHs	• Positive correlation between natural gas development and pediatric asthma hospitalizations;	[20]
McAllen, Edinburg, Mission	3 days over 6 week's period April–June 2016	PAHs	• Individual $PM_{2.5}$ mass concentration had higher levels due to cooking emissions than those due to vehicular emissions if one spent more time indoors;	[21]
Brownsville	October 2005–February 2006	PAHs	• Women and their fetus were continuously exposed to Polycyclic Aromatic Hydrocarbons;	[22]
Hidalgo County	October 2014–May 2016	HAPs, Benzene, NO_2, SO_2, and O_3	• Prevalence of asthma in students of Hidalgo County students was slightly more than the state prevalence rate;	[23]
Hidalgo County	October 2010–October 2011	Organochlorine (OC) and organophosphate (OP) pesticides	• The metabolic pesticide levels are under the limit in most participants, but some outlying values suggest the probability of underestimation of true variability;	[24]
Hidalgo County	October 2015–May 2016	$PM_{2.5}$	• More exposure to $PM_{2.5}$ while travelling compared to that in other microenvironments;	[25]
South Texas	February 2009–2010	UFP size distribution, $PM_{2.5}$, and CO_2	• The indoor PM concentration was higher than the outdoor PM concentration was.	[26]

Ambient air pollution is one of the major environmental risk components for global diseases [27,28]. Various studies evaluated the relationship between the asthma cases in children and neighborhood or regional air quality [11,16–18,23]. In one study, 711 children aged 5–18 were admitted to different hospitals across South Texas with asthma [11]. The study analyzed the relation between the ambient air pollution and the length of stay in the hospital for all these children. It was concluded that both the ozone levels and $PM_{2.5}$ levels had an association with a prolonged hospital stay for children aged 5–11 years old [11]. Another study [16] examined the different health characteristics of 902 children who were admitted to hospitals at least once from 2010 to 2016. A high level of outdoor air pollution ($PM_{2.5}$ and O_3) was one of the factors associated with high number of hospitalizations in the region [16]. A positive correlation between the number of hospital readmissions and elevated levels of ozone $PM_{2.5}$ was suggested in a study among 111 pediatric asthma patients who were readmitted [17]. A 2019 study involving sixteen low-income households from McAllen examined the influence of household intervention of improving indoor air quality and corresponding asthma health outcomes [18]. The study documented that the $PM_{2.5}$ levels dropped an average by 1.91 $\mu g/m^3$ post-intervention, with a direct and positive effect on children's asthmatic health.

Maternal exposure to air pollution in the region of South Texas was evaluated in different studies [13,21,22,25]. A study [13] in Hidalgo County evaluated 17 participants in different microenvironments, i.e., Residential, vehicular, Commercial, and Miscellaneous. The study concluded that albeit the participants stayed in their homes for major time periods, the $PM_{2.5}$ levels were more than twice as high as the ambient concentrations were [13]. This suggests that activities such as cooking have a significant impact on indoor air quality [21].

4. Discussion

The goal of this review was to summarize the studies evaluating the health effects associated with poor air quality in South Texas. The sampling period during the studies varied from a period of 3 days to 6 years. Different air pollution sources with varying health outcomes in this region of South Texas was studied.

In total, twenty publications were systematically reviewed to assess pollutant contaminants such as hazardous air pollutants (HAP), PM, VOCs, pesticides, CO, CO_2, O_3, benzene, NO_2, SO_2, and PAH in the South Texas region [1,8–26]. Based on the search criteria, three studies were conducted before 2000 [8,14,15], six studies were conducted between 2000 and 2010 [1,9,12,20,22,26], and 11 studies were conducted between 2010 and 2022 [10,11,13,16–19,21,23–25]. This indicates that the number of air pollution studies in South Texas has been steadily increasing. The studies primarily evaluated the source apportionment of pollutants [1,8–10,15], relationships between childhood asthma and air quality [11,16–18,23], and pregnant women's exposure to insalubrious and polluted air [13,21,22,25]. Other studies evaluated the air quality in school buses [12], cooking [14], gas flares exposure burden between Hispanic and non-Hispanic whites [19], and natural gas development drilling practices [20].

Increases in $PM_{2.5}$ and O_3 levels were observed to have an impact on children's health in the 5–11 years age group by increasing the length of stay at hospitals or by increasing the frequency of visits to hospitals [11,16–18,20]. PAHs levels impact pediatric asthma hospitalizations and causing illness in maternal mothers along with their fetuses [20,22]. A study conducted at 16 low-income households in McAllen reported that increasing the knowledge of asthma leads to an improvement in indoor air quality, subsequently resulting in better health levels in asthmatic children [18]. With 35.2% of the total population residing in South Texas either being in the age group below 14 or above 65, even short-term exposure to $PM_{2.5}$ levels poses a threat to peoples' health [7].

The major air pollution sources in South Texas could be attributed to biomass burning, industrial emissions, diesel engine emissions, vehicular traffic emissions, agricultural activities, and long-range transboundary emissions [1,8–10,15]. Major sources of non-sea salt sulphates in this border region could be apportioned to north-eastern parts of Mexico, which is home to various power plants operated with the help of fuel and oil [10]. Whereas the indoor microenvironment is typically considered to be a shield against outdoor air pollution, studies from this region have documented that residing at home for longer periods can have effects on human health due to emissions from cooking and other activities such as cleaning, vacuuming, dusting, etc. [13,21].

In the coming decades, South Texas is predicted to see an increase industrial activity and population growth. It therefore becomes incumbent upon the scientists, researchers, public health officials, and local and state government agencies to provide the necessary educational air pollution toolkits to the common citizenry of this region to offset the deleterious health effects because of air pollution. TCEQ should also increase the number of CAMS stations across the South Texas landscape to accurately capture the air pollution exposure burden of the population. In this review, three studies were conducted between 1990 and 1997, six were conducted between 2000 and 2010, and 11 were conducted between 2011 and 2016. Even though there has been a substantial increase in the number of studies over the years, there has been no study conducted in the past seven years. This indicates a substantial research gap in the topic of air pollution in this region, thereby warranting future air epidemiologic studies not only in the field of source apportionment, but also indoor and outdoor sources of air pollutants.

5. Conclusions

This study discusses the important topic of air pollution in South Texas and the associated health effects. A total of twenty peer reviewed publications were studied in detail. PM, PAHs, and VOCs were among the most common pollutants impacting this region of South Texas. Industrial emissions, biomass burning, and automotive emissions were among the major sources of air pollution in South Texas, and these pollutants were linked to asthma symptoms and lengthier hospital stays for children with asthma. $PM_{2.5}$ and O_3 are pollutants that were observed to be the cause of illness in children, lengthening the stay in hospitals, and PAHs were the cause for illness among maternal women. The review contributes to the ever-expanding field of air pollution literature. Future studies should investigate the role of COVID-19 on air quality and health, as well in this region.

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