



Health Status in Fence-Line Communities: The Impact of Air Pollution

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Abstract

The objective of this study was to evaluate the impact of long-term air pollution on the health status of individuals living in fence-line communities. Previous research has focused on cancer risk in fence-line communities, showing a link between air pollution and several types of cancer. This study is focused on the health status of fence-line communities, including COVID-19 mortality. An 11-parish study area in Louisiana, known as Cancer Alley, was compared with the U.S. Louisiana, Harris County, Texas, Los Angeles County, and Philadelphia. Data were obtained from secondary sources, including the Centers for Disease Control and Prevention and the U.S. Census. Behavioral Risk Factor Surveillance System and the National Environmental Public Health Tracking System data were analyzed. Study findings were that fence-line communities demonstrated high rates of premature death, greater number of unhealthy mental days, and COVID-19 death rates. The differences in death rates for Blacks and Whites were staggering. The risk of COVID-19 death for Blacks in the 11-parish study area ranged from 1.5 times to 11.4% higher than Whites. Fence-line communities are an example of environmental injustice and the effects of slow violence from air pollution. These environmental injustices have been ignored for decades, calling for action today.

Keywords: Health status; Air pollution; Environmental injustice; COVID-19; Population health

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Introduction

Fence-line communities are those that are adjacent to industrial facilities and are characteristically areas of long-term air pollution. The length of time of exposure to excessively high levels of air pollution directly related to the impact on health. The longer a population is exposed to high level of pollution, the more deleterious its effect on the health of fence-line communities [1]. These communities can be found in areas across the world. The populations in fence-line communities typically consist of low-income minorities and present health disparities [2].

Fence-line communities can be found across the U.S. and the world, but along the Gulf Coast this term is used to describe areas adjacent to petrochemical facilities. These fence-line communities include homes, parks, schools, and commercial facilities. All forms of pollution are present, at all times, in these communities. Not only is long-term air pollution a major concern, but water and noise pollution are prevalent [3]. Fence-line communities have existed for many decades, and may be separated from industrial facilities by only a chain link fence [4].

In a study of a fence-line community in Texas, researchers found high benzene levels, which is a rare occurrence. Findings indicated that these benzene levels were constantly present for a long-period of time. The health effects of the benzene exposure have not been directly measured [5]. The study also identified so-called Natech events, which are natural hazard-triggered technological disasters caused by hurricanes or floods. These Natech events may result in infrastructural failures which compound the detrimental effects of the facilities on the nearby fence-line communities.

Another study in Texas evaluated the effect of metal aerosols on health. Metal recycling has been shown to cause emission of metal aerosols, as well as dusts, noise, and fires [6]. Typical components of metal aerosols are iron, chromium, manganese, and nickel [7]. The study investigated citizen air quality complaints during a five-year period. The study's design consisted of community-participatory research which was related to the air monitoring system, which focused on cancer,

neurodevelopmental and cardiovascular issues [8-11]. Air quality monitoring occurred over a 20-month period and measured daily metal concentrations in the air. The results of study indicated that metal levels in the air were slightly elevated, with nickel and iron presented the greatest health risks.

A different study of metal aerosols in the Houston, Texas area showed that metal recycling facilities were located near minority and low-income communities [12]. This is due, in part, to the absence of formal zoning codes in Houston. This resulted in mixed land use, which is disadvantageous to minority populations [13]. Air quality monitoring in the fence-line communities found increased cancer risks, although the facilities were operating within legal regulatory limits [14]. The results of the study included the development of collaborative relationships between the communities and industry, as well of establishment of public health actions.

Other studies of metal pollution have found interesting results. Exposure to toxic metal exposure has occurred in children who live in fence-line communities adjacent to metal works facilities. Previous result identified the following contaminants from the metal works industry: Lead, arsenic, cadmium, manganese, antimony, and chromium [15]. Soil is a primary source of contamination from lead and manganese, as well as dust [16]. The risk of exposure to metal contaminants for children is increased by resuspension of soil [17]. These metal contaminants have been associated with neurocognitive defects, diminished immune response, respiratory effects, as well as cardiovascular issues in children [18].

A study evaluated toenail clippings from children from arsenic, cadmium, mercury, manganese, and lead [19]. Study findings included the identification of metal concentrations of lead, selenium, arsenic, and cadmium. The source of these metal contaminants was known airborne emissions from industry. The level of contamination varied in children according to their age. Other children had higher concentrations than those younger. Demographic analysis of the children in the study revealed that they lived in areas which were in the top 10% most polluted communities in California.

Research also provides evidence on association of air pollution to the increased risk of many diseases and conditions, such as diabetes, hypertension, cardiovascular disease, and acute respiratory viral infection [20-24]. These diseases and conditions are often used to explain disease and mortality rate disparities. However, the air pollutants are also suspected of being contributors to these diseases and conditions.

This study was focused on fence-line communities near petrochemical facilities. Petrochemical facilities have been identified as being responsible for long-term air pollution and the release of carcinogens and toxic compounds [25]. Hematological malignancies have been suspected to be linked to air pollution, especially among petrochemical workers [26]. Benzene exposure, for example, has been associated with an increased risk of hematological malignancies at low levels [27]. A meta-analysis of petrochemical facility fence-line communities found that communities within 3 miles of a petrochemical facility have nearly a one-third increased risk of developing leukemia compared to other communities. This increased risk was present for all petrochemical facilities operating upstream, midstream, and downstream [28].

A study which compared exposure to air pollution from an oil refinery in an urban fence-line community with a community not

near an industrial facility and to evaluate the risk of breast cancer. Indoor and outdoor air quality was assessed from a sample of homes in both communities. Vanadium and nickel levels in the fence-line community were the highest in the state. These compounds in the air were correlated with industry related $PM_{2.5}$ levels, metals, and sulfates [29].

As was mentioned earlier, fence-line communities are typically composed of low-income minority, especially Blacks. Due to historical racism, which continues to exist today, as well as policies which are discriminatory in nature, Blacks and other groups of color have a lack of access to adequate health care services. Additionally, blacks have less access to education, which adversely affects their health [30]. In spite of the decades of evidence of the adverse health effects of pollution and toxic exposures to fence-line communities, little attention is focused on health in chemical evaluations of industrial facility [31].

COVID-19 infections and deaths have been studied in minority populations. It has been found that risk of death was correlated with age, ethnic and racial minorities, obesity, diabetes, hypertension, and low-income [32]. Several of these characteristics are found in fence-line communities. A comparison study of Europe and Cancer Alley found areas with long-term air pollution had a higher COVID-19 infection and mortality rates [33]. Other studies found elevated $PM_{2.5}$ levels are associated with increased COVID-19 deaths, after controlling for socioeconomic factors and comorbidities [34]. Blacks are more likely to live in areas with high $PM_{2.5}$ levels and a greater percentage of Blacks had higher COVID-19 deaths rates, which was confirmed by a previous study that evaluated the relationship between diabetes and COVID-19 deaths [35].

This issue of environmental injustice has been linked to adverse health effects of minority populations. A study of industry-produced biogas contaminants are emitted disproportionately in Black communities, resulting in adverse impacts physically, mentally, and economically [36]. It has been argued that government has little understanding of the adverse health effects on fence-line communities. Concentrated Animal Feeding Operations and its associated emission of contaminants, including ammonia, hydrogen sulfate, and other pollutants represent an environment injustice issue [37].

The focus of this study is Louisiana, which has been argued for many years as an example of the adverse health effects associated with the petrochemical industry. This has been a very controversial issue, with industry refuting the concerns of environmental advocates. The 11-parish area along the Mississippi in southern Louisiana has been called Cancer Alley [38]. The area accounts for 25% of the nation's petrochemical production and has the largest concentration of chemical plants in the western hemisphere [39-40]. This high incidence and prevalence rates of some cancers has earned it the label of "Cancer Alley" [41].

Cancer Alley is an 85-mile stretch along the Mississippi River between New Orleans and Baton Rouge. The racial mix of the area is 55.5% white and 42.5% black. A large percentage of the residents are low income, and fence-line communities are predominantly black. Cancer Alley is an industrial corridor with an abundance of petrochemical processing plants that emit air pollutants, causing justified alarm from residents, environmental researchers and activists. This study will not only evaluate cancer in these parishes, but overall health status and COVID-19 mortality will be assessed.

Materials and Methods

Data from several secondary sources were analyzed for Ascension, East Baton Rouge, Iberville, Jefferson, Orleans, Plaquemines, St. Bernard, St. Charles, St. James, St. John the Baptist, and West Baton Rouge Parishes. Additionally, data were compared to the U.S., Louisiana, Los Angeles County, Harris County, Texas and the City of Philadelphia. These sources included County Health Ranking, U.S. Census Bureau, America’s Health Rankings, Centers for Disease Control and Prevention, and the Louisiana Department of Health. Data from the 11-parishes was compared to the U.S., Louisiana, and Los Angeles County, Harris County, Texas and Philadelphia. Population demographics were obtained for the U.S. Census, 2019 estimates.

Health outcomes in this study include Potential Years of Life Lost (PYLL), an average measure of premature death. PYLL weights deaths at younger ages which may have been prevented. The age 75 years is used as the reference metric. PYLL is the number of years lost per 100,000 populations. PYLL is an age-adjusted rate [42,43]. The percentage of the population reporting is a measure of self-reported health -related quality of life. This is measured by the percentage of population that is reporting poor or fair health. Self-reported health-related quality of life measures how healthy people feel while they are alive [44,45].

The age-adjusted number of physically unhealthy days reported in the past 30 days is another measure of health status. The associated measure is the number of mentally unhealthy days reported in the past 30 days is also a measure of health status. This data is obtained from the Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System (BRFSS) [46].

Percentage of adults, over the age of 20 years, who are obese, was obtained from 2017 BRFSS data. Additionally, the percentage of adults, over the age of 20 years, who have been diagnosed with diabetes was acquired from 2017 BRFSS data. Obesity and diabetes

are indicators of health behaviors. Obesity and diabetes are closely related with a vast majority of obese people with diagnosed type 2 diabetes. Findings have found an association between diabetes, obesity, and carcinomas, especially endometrial, colorectal, and postmenopausal breast cancer [47].

Air pollution data were obtained from the Centers for Disease Control National Environmental Public Health Tracking System. As was discussed above, fine particulate matter has been associated with deleterious health effects. Long-term exposure to fine particulate matter increases the risk of premature death, especially in those 65 years and older [48]. The particulate matter has been found in emissions from power plants, petrochemical facilities, as well as other industries [49]. Average daily density of fine particulate matter in micrograms per cubic meter (PM_{2.5}) was obtained for the study areas.

Results

Table 1 presents the demographics and racial analysis, which shows a diverse relationship of percentages of blacks and whites across the study areas. In the comparison areas, the U.S. consists of 76.3% whites, including Hispanics. If Hispanics are removed from the percentage, 60.1% are whites. Interestingly, 70.7% of people in Los Angeles County are white with the majority being Hispanic. This is also the case in Harris County. The City of Philadelphia has an equal percentage of blacks and whites.

This analysis in the 11-parish study area showed several parishes have majority blacks: East Baton Rouge, Iberville, Orleans, St. James, and St. John the Baptist. Less than one-third of the population in Orleans and St. John the Baptist parishes are white. More than half of the populations in Ascension, Jefferson, Plaquemines, St. Bernard, St. Charles, and West Baton Rouge parishes are white.

Income is an important determinant of health. Studies have shown that as income increases, positive health status increases. This association exists across gender and race. In the comparison areas, median household income in the U.S., Harris County, and

Table 1: Demographics.

Area	White*	Black*	White Alone*	Median Household Income+	Per Capita Income+	Percent Living in Poverty*
U.S.	76.3	13.4	60.1	62,843	34,103	10.5
Louisiana	62.8	32.8	58.4	49,469	27,923	19
Harris County	69.6	20	28.7	61,705	32,765	15
Los Angeles County	70.7	9	26.1	68,044	34,156	13.4
City of Philadelphia	44.8	43.6	43.6	45,927	27,924	23
Ascension	72.6	24	67.5	80,527	34,168	9.6
East Baton Rouge	47.6	47.2	44	57,948	32,431	17.7
Iberville	49.7	48.4	47.7	50,161	23,751	18.7
Jefferson	64.9	28.3	52	54,032	30,374	14.6
Orleans	34.9	60.1	30.9	41,652	31,385	23.5
Plaquemines	69.4	21.3	63.1	57,204	29,258	15.1
St. Bernard	70.1	24	61.7	44,661	20,763	19.2
St. Charles	70.2	26.5	64.8	69,019	32,935	11.1
St. James	49.7	48.8	48.4	51,603	26,739	16.6
St. John the Baptist	38.4	58.4	33.1	57,429	25,968	16
West Baton Rouge	57.6	39.9	54.8	65,385	29,697	14.4

Sources: U.S. Census Bureau – www.census.gov/quickfacts/US

* Percent

+ U.S. dollars

Table 2: Health outcomes.

Area	PYLL [^]	Poor or Fair Health [†]	Physically Unhealthy Days ⁺	Mentally Unhealthy Days ⁺	Adult Obesity [†]	Adult Diabetes [†]	PM _{2.5} Levels [§]
U.S.	6,600	19	3.8	4.2	42	10.8	
Louisiana	9,500	21	4.3	5	36	12.6	8.7
Harris County	6,400	22	4.1	4	30	14.6	10.1
Los Angeles County	5,000	21	4.3	4.3	22	8.6	12
City of Philadelphia	10,000	24	4.8	5.6	29	11.4	10.5
Ascension	7,000	18	3.9	4.8	35	11	10.1
East Baton Rouge	10,000	19	3.9	4.8	34	11.6	12.1
Iberville	10,100	25	4.7	5.2	38	12.7	8.3
Jefferson	8,700	21	4.2	4.9	33	11.6	6.6
Orleans	10,100	22	4.5	5.2	31	11.9	7.5
Plaquemines	8,100	22	4.4	4.9	38	10.6	7.9
St. Bernard	11,100	25	4.8	5.2	42	13.8	8.2
St. Charles	7,400	18	3.9	4.8	42	11.3	8.7
St. James	10,100	23	4.5	5.1	43	14.6	9.1
St. John the Baptist	10,500	23	4.3	5	48	14.4	8.8
West Baton Rouge	8,200	21	4.2	4.8	34	14.2	9

Sources: Louisiana Department of Health– www.lhdh.la.gov
 County Health Rankings – www.countyhealthrankings.org
 America’s Health Rankings – www.americashealthrankings.org
 Centers for Disease Control and Prevention – www.cdc.gov

[†]Percent

⁺Days per month

[^]per 100,000 population

[§]µg/m³

Los Angeles County is greater than \$60,000 and per capita income greater than \$30,000. Louisiana and the City of Philadelphia have median household income less than \$50,000 and per capita income of \$27,924. Over 20%, and nearly 20%, of the people who live in City of Philadelphia and Louisiana live in poverty, respectively.

Across the 11-parish study area Ascension Parish has the highest median household and per capita income. Less than 10% of the people who live in Ascension Parish live in poverty. The income in the remaining parishes is much lower than in Ascension Parish. Per capita income is the lowest in St. Bernard Parish (\$20,763) and nearly 20% of the population lives in poverty. Orleans Parish has the highest percentage of people living in poverty (23.5%) and more than 15% of the people are living in poverty in Iberville, Plaquemines, St. James, and St. John the Baptist parishes.

Table 2 shows health outcomes data for the study areas. In the comparison area, PYLL is 6,600 years in the U.S. PYLL is 40% higher in Louisiana and both Harris and Los Angeles counties have lower years of premature death. However, PYLL in Philadelphia is 50% higher than in the U.S. PYLL in the 11-parish study area is higher than in the U.S. In fact, the PYLL is nearly 70% higher in St. Bernard Parish compared to the U.S. On average, the PYLL in the 11-parish study area is 40% higher than in the U.S. More than half of the study parishes have higher PYLL than in Louisiana.

The percentage of people who reported poor or fair health is higher in Louisiana, Harris County, Los Angeles County, and the City of Philadelphia compared to the U.S. Philadelphia has the highest percentage (24%), 26% higher than for the U.S. This similar finding is seen in nine of the 11 study parishes. Again, St. Bernard Parish shows the worse outcome with 25% of the population reporting poor or fair health. Interestingly, this is also the case with the age-adjusted

Table 3: COVID-19 mortality.

Area	Overall COVID-19 Death Rate [*]	COVID-19 Death Rate, Blacks [*]	COVID-19 Death Rate, Whites [*]
	U.S.	185.3	178.1
Louisiana	234.5	273.1	225.9
Ascension	139.5	269	106.3
East Baton Rouge	195	213.7	191.7
Iberville	303.4	370.3	240
Jefferson	210.9	282.1	204.5
Orleans	207.6	251.7	159.3
Plaquemines	115.5	167.2	100.8
St. Bernard	118.2	162.8	116.2
St. Charles	187.8	264.9	165.9
St. James	243.5	310.7	183.7
St. John the Baptist	324.5	305.9	388.7
West Baton Rouge	243.6	387.6	153.3

Data as of July 25, 2021

Source: Louisiana Department of Health – www.lhdh.la.gov

^{*}per 100,000 population

average of physical and mentally unhealthy days reported. The City of Philadelphia and St. Bernard Parish have the highest average number of physically unhealthy days (4.8) and mentally unhealthy days, 5.6 and 5.2 respectively.

The percent of adults over 20 years of age who are obese varied across the study areas. In U.S. has the highest percentage across the comparison area (42%) and Los Angeles County has the lowest (22%).

Among the 11-parish study area more than 40% of the adults are obese. Nearly 50% of adults in St. John the Baptist Parish are obese. Harris County has the highest percentage of adults with diagnosed diabetes, which is 35% higher than in the U.S. On average, 12.5% of the adults in the 11-study parishes have been diagnosed with diabetes. St. James Parish has highest percentage of adults with diabetes (the same as Harris County), closely followed by St. John the Baptist and West Baton Rouge parishes with percentages greater than 14%.

Long-term air pollution, measured by PM_{2.5} levels (µg/m³), vary across the study areas. In the comparison area, Harris County has the highest level of 12.0 µg/m³, which is at the upper bound of the allowable amount. In the 11-study parishes, East Baton Rouge Parish has a PM_{2.5} above the acceptable level. These two areas are characterized by a high number of petrochemical facilities. Harris County has the nation's largest petrochemical complex, including the largest petrochemical refinery. Three of the 11-study parishes have PM_{2.5} levels greater than 10 µg/m³.

Table 3 presents data on COVID-19 mortality in the U.S., Louisiana, and the 11-parish study area. The overall death rate is higher in Louisiana than in the U.S. The death rate is higher than the U.S. in eight of the study parishes. The most important comparison is to evaluate the differences in death rates by race. The death rate is highest among Blacks in all study areas, except for St. John the Baptist Parish. Not only is the death rate higher this difference is troubling. In the U.S., the death rate among blacks is 44% higher than among whites. The difference in Louisiana is 21% higher. The difference in the 11-parish study area is more prominent. The greatest difference is in Ascension and West Baton Rouge parishes where the death rate among Blacks and 1.5 times greater than among whites. Other differences range for 11.4% in Iberville Parish to 69.1% in St. James Parish. The higher risk among whites in St. John the Baptist Parish linked to a large number of deaths in nursing homes.

Discussion

Demographically, the distribution of race shows a majority of Blacks in five of the 11 study parishes. This is important to note because only 32.8% of the Louisiana population is Black. As is expected, mostly due to historical events and economic policy decisions, parishes with petrochemical facilities have Black majorities, especially in the fence-line communities [50].

Due to suburban sprawl, there are small areas in the 11-parish study area of higher income, especially in Ascension Parish. The median household income is approximately \$57,238 in the 11-parish study area compared to the state rate of \$49,469 and \$62,843 in the U.S. This is due, in part, to employment at the petrochemical facilities. The median household income for Orleans Parish, which includes the City of New Orleans, is only \$41,652, the lowest of the 11 parishes. However, the lowest per capital income is in St. Bernard Parish, which geographically abuts Orleans Parish. Not surprising, the percent of people living in poverty is highest in Orleans and St. Bernard Parishes.

Premature death is much higher in the 11-parish study area than comparison areas, except for the City of Philadelphia. It is important to note that City of Philadelphia has similar demographic characteristics as the 11-parish study areas. Given this, The City of Philadelphia has similar health outcomes. The average PYLL in the 11-study parish area is an indication of the adverse effect on health from long-term air pollution exposure. The other health outcomes

under study add to the argument of the detrimental health effects in the 11-parish study area, as well as in Harris County and the City of Philadelphia. Specifically, the effect of air pollution on type 2 diabetes is obvious when the percent of adults with diagnosed diabetes is evaluated. Every parish in the study, as well as in Louisiana, Harris County, and the City of Philadelphia, has higher percentages of adults with diagnosed diabetes than in the U.S.

Perhaps the most compelling finding is the COVID-19 mortality in this study. It has been previous found that long-term air pollution is associated with a greater risk of COVID-19 death [51-53]. The racial differences in COVID-19 death rates are more remarkable. The death rate among Blacks is higher in all study areas and is 1.5 times greater in Ascension and West Baton Rouge Parishes. The COVID-19 pandemic, in addition to physical problems, has caused mental health issues, including fear, stress, and panic. Stress has been associated with poor health outcomes, especially in minority populations [54]. The number of mentally unhealthy days per month in the study parishes shows the effect of COVID-19, as well as other factors, on mental health.

These findings add to the historical pattern of health inequities and environmental injustices that have plagued Cancer Alley of Louisiana for generations. The proliferation of petrochemical facilities in Cancer Alley over decades brought with it air pollutants at levels that even the Environmental Protection Agency described as exposing residents to higher risk of cancer from polluted air [55]. The slow violence of long-term exposure to toxic contaminants is a result of structural racism and a manifestation of environmental injustice [56]. COVID-19 analysis is illuminating the disparities and harmful health effects from the slow violence of air pollution in confirmable outcomes close to the advent of the virus.

From an environmental justice perspective, a pollution disparity warrants corrective action. In action has occurred for decades and is itself an injustice [57]. The PM_{2.5} exposure levels in the 11-parish study area are a modifiable risk factor that cannot be changed by the populations it adversely affects. If residents of fence-line communities work to modify health behaviors to decrease obesity, diabetes, and associated comorbidities, their efforts will fall short of addressing the health effects of long-term air pollution. Corporate and political leaders are culpable for the structural systems that created the injustice. Change can only occur through their efforts.

Conclusion

The health status, physical and mental, is adversely affected by long-term air pollution exposure. Premature death, mental health, and COVID-19 risk is higher in fence-line communities. Environmental injustice has been ignored for decades, especially in fence-line communities, from economic growth. The health status of fence-line communities has either been ignored or given little attention by corporate and political leaders. Policy and economic reforms are needed to address the health inequity and environmental injustices that exists across fence-line communities.

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