ORIGINAL RESEARCH

Decades in crisis: adapting a social-ecological framework to assess structural elements impacting asthma rates in the South Bronx

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Introduction

Disturbingly high rates of asthma in the New York City (NYC) borough of the Bronx have been documented for decades alongside a myriad of other health disparities that disproportionately burden NYC's socioeconomically vulnerable communities. Recent focus has been placed on asthma-related hospitalization rates that are five times higher in the Bronx than national averages and mortality rates from asthma that are three times higher in the Bronx than national averages.[1] Notably, across the five boroughs of NYC, the Bronx has the highest prevalence rate.[2,3]

Inadequate control of asthma is associated with a significant health-related quality of life (HRQoL) burden defined here as increasing frequency of symptoms, frequent night awakenings, loss of school days, and emergency hospitalizations.[4-9] Epidemiological studies have also shown a clear link between asthma and hazardous environmental exposures, such as urban poverty, overcrowding, heavy exposure to ambient air pollution, high rates of cigarette smoking, and extensive racial inequity in access to healthcare services.[1,4,5] Nonadherence to treatment regimens results in the debilitating respiratory symptoms associated with uncontrolled asthma, including wheezing, dyspnea, coughing, chest tightness and lung function decline.

Successful asthma control in clinical practice and in the delivery of healthcare services requires an understanding of health inequity, defined in part as the "differences in health that are not only unnecessary and avoidable but, in addition, are considered unfair and unjust."[10] [p.433] This is a perspective that departs from a clinical focus on individual health to consider the systems and structures that drive inequities in a population.[11] Therefore, a proper understanding of *structural violence*, described as the social arrangements that put individuals and populations in harm's way, is fundamental to a provider's understanding of the disease burden of poorly controlled asthma among racial minorities like those in the South Bronx.[12,13] Thus, healthcare providers should consider the adverse impacts on health perpetuated by inequitable economic, political, legal, religious, and cultural aspects of the social world.[12]

Environmental injustice in the South Bronx.

Environmental injustice occurs "when communities lacking wealth and sociopolitical representation are forced to bear a disproportionate amount of the environmental burdens [derived] from the industrial processes that benefit everyone else."[14] [p.3] In many urban areas, such as the Bronx, where African Americans and Hispanics account for 43.6% and 56.4% of the population respectively, minorities and impoverished communities are more likely to be concentrated in or near industrial zones that typically carry higher

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environmental burdens due to waste-related or other polluting land uses than do residentially zoned areas.[5,15] One of these environmentally burdened areas is NYC's community of the South Bronx, which for the purpose of this paper we have designated as the five Bronx ZIP codes that make up the neighborhoods of Mott Haven, Port Morris, Melrose and Hunts Point, all of which are part of the poorest congressional district in the U.S.[15]

Asthma exacerbation factors in the South Bronx.

A study by the New York State Comptroller found that Bronx county has the highest age-adjusted asthma death rate "by far" among all counties in New York State, with 43.5 deaths per million residents in the Bronx in 2014 in comparison with the state average of 13.1 deaths per million.[16] The Bronx is also a designated "nonattainment area" for fine particulate matter ($PM_{2.5}$),[17] a harmful byproduct of diesel combustion with proven links to respiratory infections, asthma and cancer.[18] Pollution from cars, garbage trucks, power plants, construction activity, and other chemical processes concentrated in certain Bronx neighborhoods produce high concentrations of ground-level ozone and $PM_{2.5}$ at levels that exceed the standards set by the U.S. Environmental Protection Agency (EPA) for harmful pollution.[1,17,18] The South Bronx in particular has the highest concentration of pollutants that are known to trigger asthma in New York City——between 2-7 times higher than even other areas of the Bronx.[18] Other toxic factors in the area include a large number of waste transfer stations and sludge depositories located in close proximity to densely populated neighborhoods of the South Bronx.

Quality of life due to asthma.

In the South Bronx, an estimated 20% of children have been reported to have asthma.[19] The quality of life of young children and adolescents is affected by the physical and psychological impact of frequent asthma attacks, hospital admissions, student absenteeism and visits to the school nurse.[20] Employed adults are forced to lose earnings due to missed work days, which in consequence puts the household at further risk of financial distress and poverty.[20] Thus, the costs of debilitating, uncontrolled asthma are high and go beyond medical expenses.

The magnitude of the morbidity associated with severe asthma is affected by a number of personal factors including age, employment, healthcare access, health insurance coverage, student absenteeism, comorbidities, and household poverty. Several sources have reported that every day in the U.S., asthma results in 40,000 missed school or work days, 30,000 asthma attacks, 5,000 emergency room visits, 1,000 hospital admissions, and 11 deaths.[20,21]

The prevalence of asthma in the Bronx is extremely high and diminishes the quality of life of affected people of all ages. A 2007 analysis using Geographic Information System (GIS) technology found that the asthma hospitalization rate for children in the Mott Haven/Hunts Point sections of the South Bronx is 23.2 per 1,000 children, nearly 140% higher than NYC's rate of 9.9 per 1000 children.[5] Research also found strong associations between high asthma hospitalization rates, poverty, percentage of Hispanic residents, proximity of schools to highways, large concentrations of industrial facilities, and other sources of environmental health risks in low-income Bronx ZIP codes.[1]

Targets for change: organizational thinking.

The decades-long asthma crisis in the South Bronx requires consideration of the sociohistorical, political and environmental health dynamics currently and historically at play, including the structural violence that perpetuates poverty, homelessness, education disparities, discrimination, and the lack of civil and political inclusion for the South Bronx. We propose the social-ecological model of examining health disparities as a tool for clinicians and healthcare workers to critically analyze how structural racism and health inequity pose significant barriers to patient asthma control and how this in turn has led to the emergence and continuation of the asthma crisis in the Bronx.

Methods

The Social-Ecological Model (SEM) is a theory-based framework that emphasizes the multifaceted and interactive effects of social and physical environments in strongly shaping patterns of disease and injury. [22] The SEM examines the

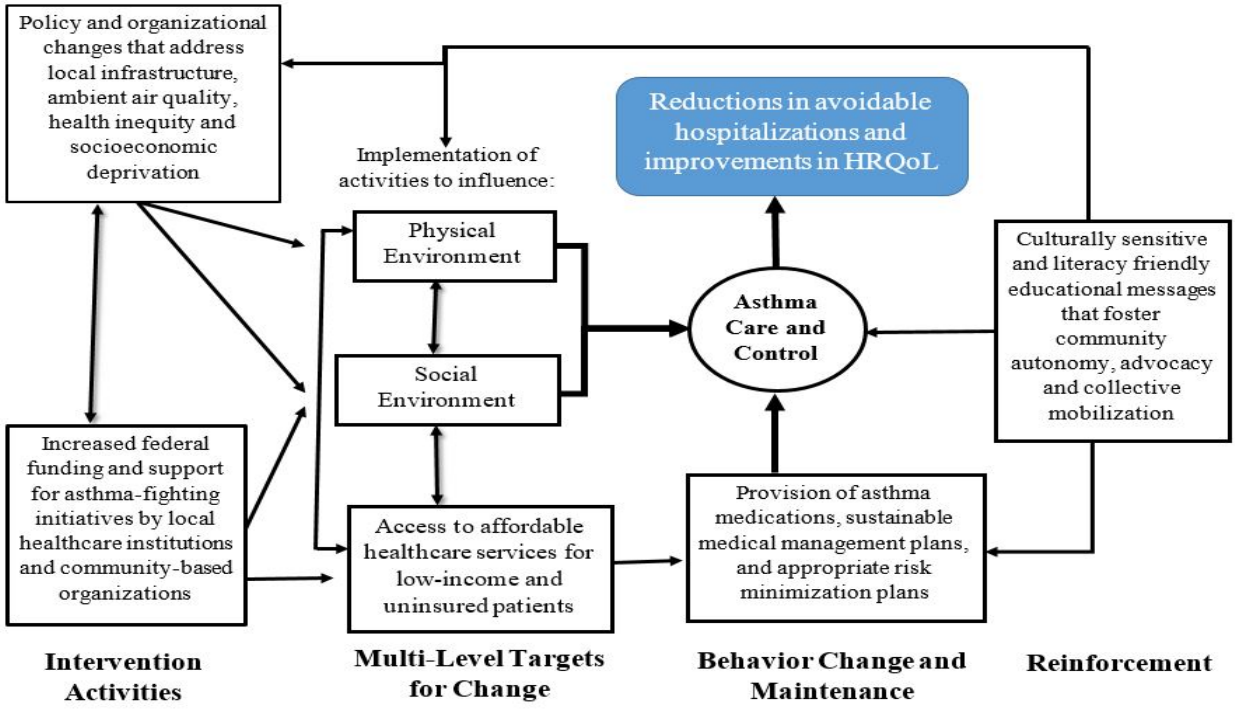
social and ecological determinants of health at the systems level, with a focus on issues such as poverty, social justice, education, employment, pollution, ecotoxicity, climate change, racism, the impacts of resource extraction, and social exclusion. This paper adopts the SEM framework to not only conduct a systematic review that describes the dynamics of asthma care in the South Bronx but also to highlight the broader application of SEM.

Good chronic asthma management and risk minimization will inevitably reduce avoidable hospitalizations and improve HRQoL in the South Bronx. This conclusion is based on clinical guidelines and research highlighting the negative impact of symptoms associated with severe asthma and the resulting significant decrease in a person's quality of life.[23]

In 2018, Bronx county was named the "least healthy" county of the 62 counties in New York State for the ninth consecutive year, with the lowest quality of life in the state, the worst social and economic factors (employment, income, community safety), physical environment (air quality, water quality, housing, transit) and among the worst health behaviors (diet, exercise, drug abuse) and clinical care (access to care, quality of care).[16]

Our adapted Social-Ecological Model[24] (Figure 1) describes three multi-level targets for change: the physical environment; the social environment; and access, quality, and affordability of medical care. It then expands on how these targets for change relate to past and present intervention activities; behavior change and maintenance; and reinforcement, particularly in the care and control of asthma. Each of the elements will be described with support from epidemiological, sociohistorical, and population data in an effort to contextualize interventions aimed at reducing avoidable hospitalizations and improving HRQoL due to chronic asthma in the South Bronx.

Figure 1.
Social-Ecological Model for asthma care and control in the South Bronx. SEM Diagram adapted from Elder et al.[24]



Analysis

Physical environment.

Proper evaluation of the residential environment of the South Bronx requires taking into account the different levels of pollution that expose residents to certain asthma risk factors and clinical outcomes as well as the machinations that perpetuate these pollution levels. Establishing a link between asthma and air pollution can be elusive. However, previous and current studies have demonstrated a link between ambient air pollution levels and increased prevalence of asthma.[5] Specific associated pollutants measured include carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and particulate matter 2.5 ($PM_{2.5}$) which exceeds current National Ambient Air Quality Standards (NAAQS) set by the U.S. Environmental Protection Agency (EPA).[5,19] In addition, sources of pollutants such as highways, vehicular emissions and waste disposal sites are disproportionately located in neighborhoods of the South Bronx.[1,5,19,25] Ozone is used as a measure of other pollutants and is therefore a good indicator of air pollution.[26] Simply stated, ozone is produced from photochemical reactions involving sunlight acting on emissions from cars, power plants, industrial boilers, refineries, and chemical plants.[1,19,26] According to the EPA, chronic exposure to ozone can cause permanent damage to the lungs and pleura, and aggravate asthma.[1,26,27]

Similarly, multiple literary sources have shown a connection between levels of $PM_{2.5}$ and the prevalence of asthma, as well as increased hospitalizations due to asthma.[1,5,10,19,25-28] $PM_{2.5}$ are fine particles less than 2.5 microns that are largely produced by diesel engines and vehicle exhaust.[27] The *Transform Don't Trash NYC Coalition* reported that diesel trucks transport around 8,000 tons of receptacles to 14 waste transfer stations located in the South Bronx.[18] These 14 stations represent a disproportionate amount of trash collection sites, receiving approximately 70% of the trash produced by the entirety of NYC.[1,5,18,19,29] In addition, the sheer amount of trucks needed to transport the garbage places neighborhoods in the South Bronx in a position where they receive at least one commercial waste truck every 24 seconds.[18] It is not uncommon to observe nearly 1,000 trucks per day destined for one transfer station.[5]

Social environment.

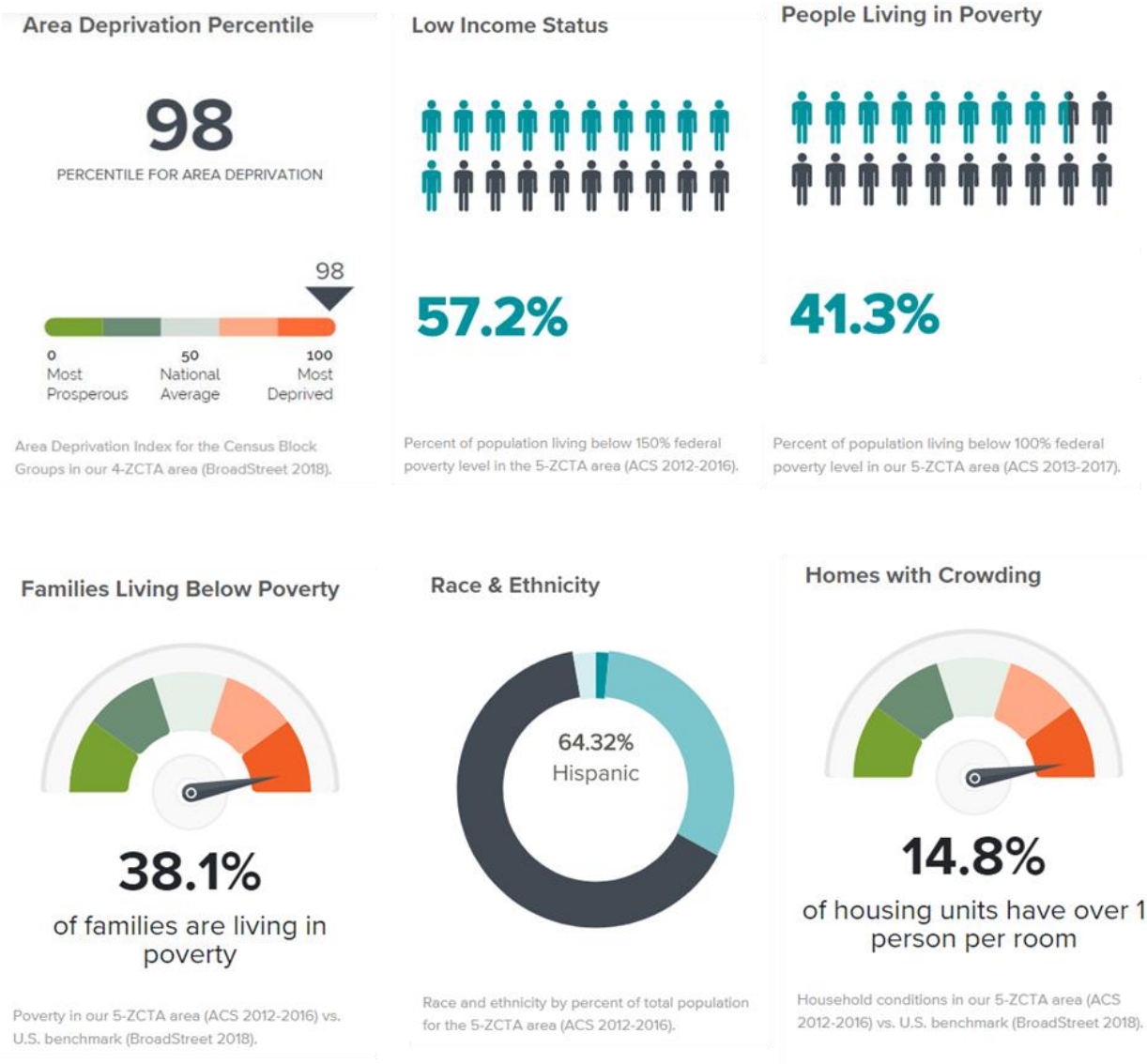
High rates of child poverty, adult unemployment, rent burden, and other social determinants that negatively influence a person's health in the South Bronx are among the highest in NYC and in the country as a whole, as reflected in the neighborhood's ranking at the 98th percentile of area deprivation for the U.S.[16,30]

Economic context and social factors. Some key demographic information to consider for the South Bronx neighborhoods in this study include:

- 57.2% of people in the South Bronx are low income and 41.3% are living in poverty.[28]
- 38.1% of families in the South Bronx live below the poverty line.[30]
- 64.32% of this area is Hispanic,[30] and 29% of the Bronx county population is Black or African American.[16]
- 14.8% of housing units are considered overcrowded[30] and an estimated 5.6 percent of renters in the Bronx live in units that are severely overcrowded.[16] In 2017, there were 91.4 serious housing code violations per 1,000 privately owned rental units, the most of any NYC borough.[16]
- Household income in the Bronx remains below the pre-recession peak after adjusting for inflation, and is much lower than the citywide median. One-third of borough households face a severe rent burden, devoting at least half of their incomes to rent.[16]

Figure 2
Area Deprivation Index (ADI) and Poverty Index for South Bronx Zip codes, 2018.

Data was gathered and reported through Broad Street for zip codes 10451, 10454, 10455, 10456 and 10474, corresponding to the South Bronx neighborhoods of Mott Haven, Port Morris, Melrose and Hunts Point.[30]



Access, quality and affordability of medical care.

The third target for change is access to affordable healthcare services for low-income and uninsured patients. Reports highlight inadequate health insurance coverage in the Bronx with clinical care (e.g., access to care, quality of care) and health outcomes ranking among the worst in New York State.[16]

Despite a long history of providing charity care for the nation's poor, the medical establishment in the U.S. also has a long history of opposing the

creation of public health clinics and centers, which was perceived as an attack on its economic interests.[31] The U.S. medical establishment has also taken measures to prevent legislation such as Medicare and Medicaid, which provide millions of vulnerable Americans with access to the most basic medical services.[31,32] In some states, this disparity is highlighted by the emergence of poor-quality "Medicaid mills" with fixed fees that are so low that providers refuse to participate in the program.[33]

Differential access to medical care and disparate health outcomes among various racial and ethnic groups are driven by such factors as cost and access to the healthcare system and preventive health services.[34,35] A 2008 report by NYU researchers found that hospitalization rates for asthma in Bronx County and East Harlem were 21 times higher than those of affluent parts of the city.[1] Such figures signal that despite the abundance of healthcare facilities, cutting edge technologies, and pharmacotherapeutics in the U.S., the best treatment modalities and preventive care are not financially accessible and distributed fairly to all segments of the American population.

Three components of our Social-Ecological Model have been outlined thus far: the physical environment; the social environment; and access, quality and affordability of medical care. Analysis of these multi-level targets for change considered research that has exposed the subtle role of bias, prejudice, stereotyping and discrimination in creating and/or exacerbating health disparities.[32,34-36]

The remainder of this section will focus on how these three targets for change relate to the dynamics of past and present intervention activities (i.e., policy and infrastructure, and federal funding for health care services); behavior change and maintenance; and reinforcement, particularly in the care and control of asthma.

Intervention activities.

Policy and organizational structures. A 1995 article in the *New York Times* reported on how doctors at Lincoln Hospital in Mott Haven were alarmed by an emerging epidemic of asthma in the South Bronx, stating that in recent years, hospitals were receiving close to 13,000 visits a year for asthma.[37] At the time, researchers believed that the most important factors were associated with household crowding and indoor air pollution, in particular dust, mites, cockroach feces and body parts, and rat and mouse urine.

The Bronx has a long legacy of *brownfields*, a term used for former industrial or commercial sites where future use is affected by real or perceived environmental contamination. In 1993, the Browning-Ferris/Bronx Lebanon Hospital medical waste incinerator was built in Port Morris and was designed to process the medical waste of 12 New York City hospitals.[14,3712,38] State regulators insisted that the incinerator was not an environmental hazard, despite the EPA's Clean Air Act of 1970 that made most incinerators illegal. However, it was noted that asthma-related hospitalization rates doubled within the two years since the incinerator opened and that the frequency of asthma-related illness among students in nearby schools doubled or tripled as well.[37]

The incinerator violated state pollution standards with minimal repercussions until it was finally torn down in 1999.[14] However, Stericycle, a biohazardous and infectious waste disposal company known for violating air quality standards, operates at the same site as the incinerator over two decades later.[38,39]

Factories and waste-related industries have historically been established in or near poor neighborhoods, where construction and overhead costs are lower, cheap labor is plentiful, and complaints about environmental toxicity are much easier to ignore.[14] In 1991, the New York Organic Fertilizer Co. (NYOFCO) began operating a facility in Hunts Point that accepted sewage sludge from NYC's sewage treatment plants and processed it into fertilizer pellets for sale to out-of-state agricultural operations.[39,40] In 2008, Attorney General Andrew Cuomo joined 10 community groups in filing a nuisance lawsuit against NYOFCO, with concerns that the stench had made simple activities like opening windows, walking to school or enjoying a local park not only unpleasant, but an actual health risk for nearly two decades. In 2010, the NYOFCO closed down permanently.

However, two years later in 2012, former Attorney General, now Governor Cuomo alongside Mayor Michael Bloomberg, Borough President Ruben Diaz and other city officials announced that the state, city and Bronx borough

would give an approximate $130 million benefits package with subsidies and incentives for the online grocer Fresh Direct to remain in New York, rather than move to New Jersey.[41-44] In 2018, Fresh Direct opened up its headquarters, a diesel trucking distribution center and warehouse on public land at the Harlem River Yards in Port Morris. The new facility brought in over 1,000 new diesel trucks to an already overly polluted and underserved area of the city. It is important to note that traffic congestion also adds to air pollution due to the idling of cars and trucks along the four expressways - the Cross Bronx, Major Deegan, Bruckner and Sheridan – and the Bronx River Parkway that run through or around the South Bronx.

Federal legislation in the 1960s and 1970s established a number of agencies charged with identifying environmental hazards and setting standards to protect human health. These include the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency.

In 2006, the EPA required that all states must bring their levels of fine-particle pollution into compliance by 2010 or risk losing federal highway money. Bronx county exceeded federal air quality standards at the time and continues to be a nonattainment area for criteria pollutants in 2019, highlighting the limited enforcement of environmental regulation.

In 2014, Intro 495A, a proposed law that would cap the amount of garbage that can be dumped in the South Bronx, North Brooklyn, and Southern Queens went from near-certain passage to imminent defeat due to backroom politics.[45-47] The fair share proposal lost support when one of New York State's most powerful lobbyists represented two Hunts Point-based waste transfer station operators and Bronx politicians turned their backs on the bill. However, in 2018, the NYC Council passed Intro 157C, a new waste equity bill that gave the Department of Sanitation authority to reduce capacity at private waste transfer stations in the South Bronx by 33%.[48]

Federal funding and support for asthma-fighting initiatives. In 1998, Mayor Rudolph Giuliani withdrew money from a multimillion-dollar asthma education and treatment initiative in the Bronx, managed by the Children's Health Fund in conjunction with Montefiore Medical Center.[49] The City favored community and physician education, while the health fund favored direct patient care.

In 2017, history seemed to be repeating itself as the federal government threatened to move ahead with plans to dismantle the Affordable Care Act (ACA) and eliminate funding for community-based programs like RESPIRAR, Lincoln Hospital's asthma-fighting initiative.[50] NYC public hospitals like Lincoln Hospital care for over 425,000 uninsured patients per year, roughly 70 percent of NYC's uninsured population. RESPIRAR monitored about 8,000 patients annually and had been successful in decreasing hospitalizations for patients enrolled in the program by 89 percent.

Behavior change, maintenance and reinforcement.

Individual and Community Perspectives. The 1995 article on the emerging asthma epidemic in the South Bronx started highlighting the burden of disease on men, women and children of all ages. At the time, asthma had begun to take "a psychological toll on a community already facing substantial burdens... [leading to] "family-wide, community-wide depression".[37]

Since the NYOFCO began operating its facility in Hunts Point in 1991, persistent noxious odors emanating from the facility have not only been cited for municipal and state odor violations, but have severely disrupted the quality of life of Hunts Point residents, with community members attributing severe headaches, nausea, vomiting, difficulty in breathing, and asthma attacks to the persistent noxious odors.[39,40]

Toxic dumping has turned the South Bronx into an "environmental sacrifice zone". While many residents have internalized this kind of oppression, community advocates, organizations and allies have mobilized for decades to protect the social, environmental and economic future of the South Bronx. The grassroots organization South Bronx United was at the forefront of the South Bronx community's fight against Fresh Direct since 2012 and has since been mobilizing and engaging people to respond to the problem of access to green spaces and other environmental justice concerns.[51] The Northwest Bronx Community and Clergy Coalition met with landlords to assess homes for possible indoor

environmental asthma triggers. Under the unified Natural Resources Defense Council, ten community groups, including Mothers on the Move, Sustainable South Bronx and The Point Community Development Corp. filed a suit against NYOFCO in 2008 to reduce the odors.

Community leadership, advocacy and grassroots approaches to fighting environmental racism should be legitimized and supported by the public health sector and medical providers. Sustainable asthma care and adherence to asthma control medications for persons with persistent asthma must be carried out in conjunction with improvements in air quality, sanitation, nutrition, and overall hygiene and health-caring behaviors.

Behavior change, maintenance and reinforcement goes beyond asthma control through risk minimization plans and medical management. It requires helping community members identify the health inequities and environmental hazards they encounter in their day-to-day lives. Community autonomy, advocacy and collective mobilization require the leaders within the community to first become "champions" for the needed behavior change and then promote the maintenance of that change.[52]

Discussion

Historically, the burden of New York City's environmental hazards has been "disproportionately imposed on Bronx communities, through biased land use policies instituted by the local government and corporate interests."[14] A robust conversation on the systems that drive health inequities in asthma care and control in the South Bronx must delve into the NYC borough's extensive history of structural violence, racism and environmental injustice.

Appreciating structural racism is a pressing issue. There are tragic consequences to taking an "a-historical stance," which physician and epidemiologist Dr. Camara Phyllis Jones identifies as a major barrier to achieving health equity in the U.S. She characterizes this as being how "[t]he present is viewed as disconnected from the past, and the current distribution of advantage and disadvantage is routinely viewed as happenstance despite the legacy of racism and its current manifestations".[53]

The devastation caused by the decades-long asthma crisis in the South Bronx and the health disparities that continue to fuel it have been made even more salient by soaring rates of coronavirus infection, hospitalizations and deaths due to the COVID-19 outbreak in the Bronx. Surveillance data on COVID-19 released by the NYC Health Department in 2020 reported that the virus has killed African Americans and Latinos in NYC at twice the rate that it has killed Whites.[54] Thus, the COVID-19 outbreak in New York exposes even further the physical and social vulnerabilities that ethicist Harriet A. Washington has posited leave Black and Latino communities in the U.S. less able to resist and survive infections such as the coronavirus.[55] In a manner reminiscent of the decades-long asthma crisis in the Bronx, it became apparent since the onset of the COVID-19 pandemic that communities of color in the Bronx would have to face a disproportionate burden of illness and death from the viral outbreak.

Conclusion

Asthma-related hospitalizations are avoidable, but only if patients are able to sustainably control asthma symptoms and reduce the burden of this chronic respiratory disease. Just as importantly, there is a need for medical providers and other healthcare workers to participate in the empowerment of grassroots movements that tackle urban environmental exposures to illness given how environmental racism and disparities in health play a critical role in asthma care and control. With this in mind, tracking the pervasiveness of structural violence at the systems level can be elusive and convoluted.

A targeted approach to systemic change in the South Bronx can benefit from the application of a social-ecological framework to policy and sociomedical issues. The SEM framework's utility in guiding organizational thinking can range from its use by individual players in a given system seeking to understand their role in the larger social-ecological structure to its use by interdisciplinary collectives and coalitions seeking to effectuate multi-level initiatives. The Social-Ecological Model provides a conceptual platform to review all salient contributors to a specific systemic problem while laying bare a dimension that awakens an important call-to-action for some of the most pressing social and medical issues of our time.

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