



Environmentally Marginalized Populations: the "perfect storm" for infectious disease pandemics, including COVID-19

## Journal of Health Disparities Research and Practice

Volume 13 | Issue 4

Article 6

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2020

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#### Recommended Citation

Meltzer, Gabriella Y.; Avenbuan, Oyemwenosa; Awada, Christina; Oyetade, Oluwakemi B.; Blackman, Tricia; Kwon, Simona DrPH, MPH; Erdei, Esther PhD; and Zelikoff, Judith T. PhD (2020) "Environmentally Marginalized Populations: the "perfect storm" for infectious disease pandemics, including COVID-19," *Journal of Health Disparities Research and Practice*: Vol. 13 : Iss. 4 , Article 6.  
Available at: <https://digitalscholarship.unlv.edu/jhdrp/vol13/iss4/6>

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### Abstract

COVID-19 has exacted a severe toll on the United States population's physical and mental health and its effects have been felt most severely among people of color and low socioeconomic status. Using illustrative case studies, this commentary argues that in addition to COVID-19 health disparities created by psychosocial stressors such as the inability to socially distance and access quality healthcare, environmental justice communities have the additional burden of disproportionate exposure to toxic contaminants that contribute to their higher risk of COVID-19. Environmental contaminants including heavy metals and persistent organic pollutants found contaminating their nearby environments can alter the immune response, produce an inflammatory response, and induce systemic adverse health effects that, alongside social stressors, create the "perfect storm" in environmental justice communities for COVID-19.

### Keywords

Environmental justice; COVID-19; health disparities; environmental contamination

### Cover Page Footnote

Support for this research was provided by a Core Center grant P30ES000260 from the National Institute of Environmental Health Sciences, National Institutes of Health

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**Journal of Health Disparities Research and Practice**  
**Volume 13, Issue 4, Winter 2020, pp. 68-77**  
© Center for Health Disparities Research  
School of Public Health  
University of Nevada, Las Vegas

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### **ABSTRACT**

COVID-19 has exacted a severe toll on the United States population’s physical and mental health and its effects have been felt most severely among people of color and low socioeconomic status. Using illustrative case studies, this commentary argues that in addition to COVID-19 health disparities created by psychosocial stressors such as the inability to socially distance and access quality healthcare, environmental justice communities have the additional burden of disproportionate exposure to toxic contaminants that contribute to their higher risk of COVID-19. Environmental contaminants including heavy metals and persistent organic pollutants found contaminating their nearby environments can alter the immune response, produce an inflammatory response, and induce systemic adverse health effects that, alongside social stressors, create the “perfect storm” in environmental justice communities for COVID-19.

**Keywords:** Environmental justice; COVID-19; health disparities; environmental contamination

### **INTRODUCTION**

The Coronavirus Disease 2019 (COVID-19) pandemic caused by the spread of the novel coronavirus has exacted a severe toll on the United States population’s physical and mental health,

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as well as its overall social and economic vitality. As of January 3, 2021, the U.S. had over 20.5 million confirmed cases of COVID-19, over 351,000 deaths, and the pandemic has forced one in four workers to apply for unemployment benefits (Dong, Du, & Gardner, 2020; Tappe, 2020). Rather than being “the great equalizer” due to universal lack of immunity, data have shown that the burden of COVID-19 has been disproportionately felt by racial/ethnic minority and low-income communities (Laurencin & McClinton, 2020; Mein, 2020; Webb Hooper, Nápoles, & Pérez-Stable, 2020). These health disparities are due to a variety of psychosocial stressors stemming from structural inequalities that place individuals of color and/or low socioeconomic status at greater risk for the contraction and increased severity of COVID-19. However, environmental justice (EJ) communities, “poor and minority communities that bear a disproportionate burden of environmental health risk,” not only face these psychosocial stressors, but are also unjustly exposed to disproportionate levels of environmental contaminants (Prochaska et al., 2014). According to the U.S. Environmental Protection Agency, environmental justice is “the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies” (“Environmental Justice,” 2020). EJ communities’ physical, social, and chemical environmental stressors place them at greater risk for severe adverse occurrences of COVID-19. Using case studies, we argue that in addition to COVID-19 health disparities created by psychosocial stressors, EJ communities have the additional burden of disproportionate exposure to toxic contaminants that could contribute to their higher risk of COVID-19 contraction and increased severity.

#### Social and Environmental Inequalities

Public health researchers have studied the complex socioecological pathways through which COVID-19 has unduly impacted low-income communities of color throughout the U.S. The vast majority of those deemed essential workers beyond the health care sector and who work without paid sick leave, including those employed at factories, farms, grocery stores, delivery services, restaurants, and hospitals, identify as Black or Latinx (Lancet, 2020). Their reliance on public transportation to commute to work, alongside crowded living conditions, create additional opportunities for virus transmission (Mein, 2020; Webb Hooper et al., 2020). Disadvantaged neighborhoods are often characterized by exposure to elevated levels of environmental contamination and poor indoor air quality, as well as limited access to affordable, nutritious food that bolsters the immune response to fight viral infections, including COVID-19 (Yancy, 2020).

Those filing for first-time unemployment, most of whom are low-income, are also losing employer-based health insurance for themselves and their families (Mein, 2020). Millions of others, especially undocumented workers in rural industries, remain uninsured and lack available testing and treatment facilities to obtain adequate and timely COVID-19 identification and follow-up care (Mein, 2020; Schmitt-Grohé, Teoh, & Uribe, 2020). In rural areas such as Native American reservations, most of which are located within three miles of a toxic Superfund site, members of households without indoor plumbing are unable to adhere to the scrupulous hygiene practices recommended to prevent and limit the spread of COVID-19 (Rodriguez-Lonebear, Barceló, Akee, & Carroll, 2020). Indian Health Service facilities have an insufficient number of hospital beds and intensive care units to respond to outbreaks and are located a far distance away from Tribal members’ residences (Kakol, Upson, & Sood, 2020). In addition, the cumulative stress induced by persistent external stressors such as interpersonal and institutional discrimination takes a physical

toll on the body and causes premature aging, or “weathering” (Chowkwanyun & Reed, 2020). This could partially explain the elevated prevalence of co-morbidities associated with severe COVID-19 (e.g., diabetes, obesity, hypertension, coronary heart disease, chronic obstructive pulmonary disease, and kidney disease) among racial/ethnic minorities and those of low socioeconomic status (Mein, 2020).

Many studies have addressed the aggregated risk of social determinants of health and environmental exposures (Prochaska et al., 2014). Adding to the pressure posed by these social inequities are environmental factors such as poor air and water quality that plague these marginalized communities and contribute extensively to their vulnerability and disproportionate disease burden. Environmental health disparities exist when communities exposed to a combination of poor environmental quality and social inequities have more sickness and disease than wealthier, less polluted communities, leading to the “perfect storm” for infectious disease pandemics, including COVID-19. Several studies have documented the association between exposure to criteria air pollutants, including particulate matter (PM), sulfur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>), volatile organic compounds (VOCs), and carbon monoxide (CO) and a greater incidence of COVID-19, particularly in densely populated urban areas with high proportions of African Americans (Bashir et al., 2020; Brandt, Beck, & Mersha, 2020; Wu, Nethery, Sabath, Braun, & Dominici, 2020).

#### Toxicant Burdens in Relation to COVID-19

EJ communities are disproportionately exposed to a variety of environmental contaminants released by current and former industrial and military activities, concentrated animal feeding operations, hazardous waste sites/Superfund sites, and mining operations. These toxic and carcinogenic compounds include (among other chemicals) heavy metals such as uranium, mercury, lead, cadmium, and arsenic, and persistent organic pollutants including polychlorinated biphenyls (PCBs), pesticides, and polycyclic aromatic hydrocarbons (PAHs). Many of these compounds have endocrine disrupting properties and can also adversely impact the immune response, especially against infections (De Coster & van Larebeke, 2012; Kavlock et al., 1996).

Environmental exposure to PCBs, for example, is associated with various diseases including myocardial infarction, hypertension, obesity, and stroke (Wahlang, Petriello, Perkins, Shen, & Hennig, 2016). PCBs, endocrine disrupters present in air, water, soil and products manufactured before they were banned in the U.S. in 1979, are persistent in the environment, easily absorbed by the body, and stored for many years in fatty tissue, which explains health effects observed long after exposure. Certain types of PCBs can also induce an inflammatory response through the activation of pro-inflammatory factors that aid in the over-production of cytokines (Eske et al., 2014). This is especially important because severe cases of COVID-19 are characterized by a “cytokine storm,” an uncontrollable inflammatory response due to an overproduction of specific cytokines. Thus, lifetime exposure to PCBs could increase the probability of a “cytokine storm” in the event of a symptomatic COVID-19 diagnosis.

Studies have also shown that exposure to another class of environmental contaminants often found in waste sites nearby EJ communities, organophosphate pesticides, are important risk factors for developing metabolic diseases, including diabetes and immune disorders (Lee & Choi, 2020; Starling et al., 2014). For example, ingestion of chlorpyrifos, a family of organophosphates, increases inflammatory mediators (such as interleukin [IL]-1 $\beta$ , tumor necrosis factor [TNF]- $\alpha$  and monocyte chemoattractant protein [MCP]-1) in the ileum and colon of mice (Liang et al., 2019).

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Such inflammation diminishes the integrity of the intestine, leading to insulin resistance and obesity (Liang et al., 2019). Also, like many other organophosphate pesticides, chlorpyrifos interferes with specific immunological functions.

Heavy metal exposure (e.g., cadmium, arsenic, lead) has been linked to a wide range of health effects, including lung and heart disease, cancer, and/or immune dysfunction (Rehman, Fatima, Waheed, & Akash, 2018). For example, chronic low-dose exposure to inorganic arsenic severely compromises the immune response to influenza A and increases morbidity in mice. More specifically, arsenic-exposed mice demonstrate altered cellular responses, decreased cytokine production, and increased viral load (Kozul, Ely, Enelow, & Hamilton, 2009). As arsenic can reduce immune responses to influenza A and increase morbidity in mice, it is feasible that individuals exposed chronically to arsenic-containing contamination could elicit similar immunocompromise and increased risk of other respiratory infections, like COVID-19. Other heavy metals, such as uranium in small dust particles from mining sites, can deeply penetrate the lungs, leading to pulmonary inflammation (Hettiarachchi, Paul, Cadol, Frey, & Rubasinghe, 2019). In addition, cadmium can alter synthesis and expression of some pro-inflammatory cytokines (Olszowski, Baranowska-Bosiacka, Gutowska, & Chlubek, 2012). Various studies have highlighted the ability of cadmium to modulate the innate, adaptive and mucosal immune responses in relations to the release of chemokine, gene expression, and susceptibility to microbial infections (Hossein-Khannazer et al., 2020). The adverse health consequences that arise from heavy metal exposure can thus leave EJ communities at higher risk of severe respiratory illnesses, including COVID-19.

In addition, other toxicants present in contaminated environments, like phthalates used in plastics, can affect enzymes involved in endocrine system functioning at numerous levels, producing hormonal imbalances that lead to various diseases and preclinical immune problems. Given the reported high prevalence of obese (63.5%) and diabetic (24.9%) patients who go on to need invasive mechanical ventilation from COVID-19, it is critical to identify the presence of such endocrine-disrupting chemical contaminants and understand their role in this capacity (Caussy, Wallet, Laville, & Disse, 2020; Yan et al., 2020).

The aforementioned chemicals are but only a few compounds commonly found in waste sites around EJ communities. These are meant only as a few examples of how chemical contaminants can exacerbate health outcomes in a “perfect storm” scenario. Many of the aforementioned toxicants can also induce systemic health problems and co-morbidities (affecting the cardiovascular, respiratory, and metabolic systems) placing those exposed at greater risk of contracting infectious diseases such as COVID-19 and therefore experiencing far more severe cases of the disease. Thus, there is a critical need for additional research to examine the emerging relationships between environmental contaminants and their association with COVID-19 outcomes in a diverse array of urban, rural, and indigenous EJ community contexts. The few examples provided below are not meant to be a complete list of environmentally-impacted communities, but only to provide illustrative examples of some diverse communities who bear increased and disproportionate exposure to environmental contaminants and thus face increased vulnerabilities and potentially higher risks of COVID-19.

#### Rural EJ Communities

Rural EJ communities throughout the U.S. “often live adjacent to a variety of point source polluters, ranging from confined animal feeding operations to under-regulated small businesses,

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illicit methamphetamine laboratories, or both” (Butterfield, Postma, & team, 2009). This is largely due to residential proximity to agricultural property with heavy pesticide use, relaxed zoning regulations, and lower property values (Butterfield et al., 2009). “Chemical Corridor,” also known as “Cancer Alley,” is the notorious 85-mile stretch between Baton Rouge and New Orleans, Louisiana along the Mississippi River that hosts over 140 chemical, fertilizer, and plastics factories, as well as oil refineries that account for nearly a quarter of the nation’s petrochemical production. The name Cancer Alley is derived from both statistical evidence and anecdotal accounts of elevated rates of cancer and other chronic conditions in this area, including skin rashes, respiratory ailments, reproductive problems, and headaches, all of which have “given the region a notorious reputation for illness” (Davies, 2018; Singer, 2011). The region is made up of rural parishes that are primarily home to low-income Black communities who trace their lineage to slavery (Davies, 2018). For example, St. John the Baptist Parish, which is 65% non-white with a median household income of \$54,821, has a death rate of 22.1 per 10,000 and is “consistently ranked among the top 30 U.S. counties with the highest COVID-19 death rates” (Jervis & Gomez, 2020). Elevated rates of COVID-19 documented among residents of Chemical Corridor are likely driven, in part, by their disproportionate exposure to environmental contaminants including ammonia, sulfuric acid, and chloroprene from polluting industries that are predominantly located in low-income, African American areas (Blodgett, 2006; Jervis & Gomez, 2020; Terrell & James, 2020).

#### Native American EJ Communities

According to the U.S. Centers for Disease Control and Prevention, the COVID-19 incidence and mortality (55.8 per 100,000) rates in Native Americans and Alaska Natives are 3.5 and 1.8 times those measured in Whites, respectively (Arrazola et al., 2020). Tribal lands are “attractive locations for extractive purposes to corporations who do not want to be indebted to the same level of environmental regulation and oversight as they would be in areas solely under state jurisdiction” (Meltzer, Watkins, Vieira, Zelikoff, & Boden-Albala, 2020). These practices were permitted to proceed due to the U.S. government’s abrogation of treaty rights that granted Tribes sovereignty over their land upon discovering the vast wealth of natural resources that could be extracted for economic gain (Lewis, Hoover, & MacKenzie, 2017). In addition, Tribal lands house 25% of the 1,322 Superfund sites in the United States, not including “orphan” waste sites not listed on the National Priority List (Hansen, 2014). Today, there are over 1,100 abandoned mines, milling sites, and waste piles scattered across over 50% of Navajo Nation chapters. These sites are not clearly demarcated nor have been adequately remediated, which has resulted in the leaching of uranium into unregulated wells that supply water to those homes without indoor plumbing (Charley, Dawson, Madsen, & Spykerman, 2004; Corlin et al., 2016). Over one-third of Navajo residents “live without electricity, paved roads, cellphone service, landlines, safe housing, or other essentials of modern life” (Linn, 2018), and roughly 77% are food insecure (Pardilla, Prasad, Suratkar, & Gittelsohn, 2014). The high prevalence of COVID-19 currently observed among younger Navajo individuals could be partially reflective of transgenerational uranium and mixed metal exposures and their potential adverse health effects that were demonstrated in the Navajo Birth Cohort Study, the largest birth cohort study ever carried out on the Navajo Nation (“COVID-19 in New Mexico,” 2020; Dooley, 2020; Erdei et al., 2019; Lewis et al., 2015).

#### Urban EJ Communities

Although most hazardous waste sites are located in rural areas, toxic release and transfer sites tend to be located near large population centers, disproportionately in low-income and minority neighborhoods that are residentially segregated due to discriminatory zoning and housing policies and economic divestment (Harner, Warner, Pierce, & Huber, 2002). These communities also tend to be in closer proximity to urban “waste sites, disposal facilities, transfer storage, incinerators, refineries, and other contaminating industries, known traditionally as locally undesirable land uses” (Anguelovski, 2016). For example, the largest New York City Housing Authority (NYCHA) properties in Gowanus and Red Hook, Brooklyn are located a mere several blocks away from the Gowanus Canal Superfund site contaminated with a combination of household waste, industrial effluent, and storm water runoff containing PAHs, PCBs, pesticides, toxic heavy metals, and VOCs that have permanently contaminated the sediment. Not unexpectedly, the COVID-19 fatality rate in NYCHA developments was over 19% in May 2020, twice that of New York City’s at the time (Cruz, 2020). South Brooklyn’s NYCHA residents also consistently complain of asthma, cardiomyopathy, renal failure, as well as contaminated drinking water, household lead paint, asbestos, and mold infestations, all of which could compromise their immune response against infectious diseases, including COVID-19 (Wong, 2019).

## CONCLUSION

Exposures to environmental contaminants, in combination with the psychosocial stressors associated with marginalized identities of racial/ethnic minority and low socioeconomic status, render EJ communities vulnerable to and highly impacted by the COVID-19 pandemic. A conceptual shift beyond traditional environmental health is critical to understanding the dynamics of environmental exposure and how it impacts members of already marginalized neighborhoods who are at greater risk. We believe it is imperative that additional research explore, in tandem, the epidemiological and toxicological mechanisms through which disproportionate exposure to environmental contaminants could place members of EJ communities at greater risk of COVID-19 and place them at disadvantage for experiencing poorer infection outcomes and greater severity of this disease. Taken together, epidemiological, toxicological, and public health evidence should serve as a call to action for urgent, multidisciplinary policymaking to protect EJ communities’ health and wellbeing during the COVID-19 pandemic and beyond.

## ACKNOWLEDGEMENTS

Support for this research was provided by a Core Center grant P30ES000260 from the National Institute of Environmental Health Sciences, National Institutes of Health

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