

The Unequal Distribution of Particulate Matter Exposure and Its Related Health Consequences Among Minorities and the Urban Poor in Los Angeles, CA

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I. Introduction

The environmental/sustainability movement has been gaining momentum for years in the United States. The focus of this movement is often on what we are doing to our planet instead of the consequences faced by our bodies. Even less attention is given to the consequences our polluted environment has on those who are socioeconomically disadvantaged or part of a minority racial or ethnic group. This paper will describe particulate matter as well as explain the consequences of its exposure. It will then define particulate matter in the context of Los Angeles and what it means for some residents of the city. Although the entire Los Angeles region is exposed to particulate matter pollution and the corresponding health consequences, minorities and the urban poor are more likely to be exposed to greater concentrations of particulate matter which causes profound physiological, social, and economic effects. This unfortunate reality of unequal distribution of particulate matter will lead to its discussion in the context of structural violence and the current healthcare system.

II. Particulate matter pollution

Particulate matter pollution is widespread throughout the world. The United States Environmental Protection Agency defines particulate matter, or PM, as “the mixture of solid particles and liquid droplets in the air.”¹ “Inhalable coarse particles” have diameters between 2.5 and 10 micrometers, whereas “fine particles” have diameters of 2.5 micrometers and smaller. PM is made up of hundreds of chemicals and is divided into two categories. Primary particles come from the source itself, such as construction sites, unpaved roads, fields, smokestacks, or fires. Secondary particles; however, are formed when chemicals such as sulfur dioxide and nitrogen dioxides (emitted from power plants, industries, and automobiles) react with the atmosphere.² These secondary particles make up a large portion of fine particle pollution in the country.

Particulate matter exposure is usually measured both in terms of exposure to PM_{2.5} and PM₁₀. PM_{2.5} comes from transportation and industry sources. Due to the small size of PM_{2.5}, they are more difficult to control and more widespread. Researchers have shown that they are also more detrimental to human health, because they get lodged deeper in the lungs than coarse PM and may go into the bloodstream. PM₁₀, on the other hand, originates from re-suspended dust and industrial coal combustion. The re-suspended dust can come from either natural sources such as dust storms or anthropogenic sources such as road dust, industrial production dust, and construction dust. Power plants and other large industries contribute to particulate matter via industrial coal combustion.³

The compounds within the particulate matter, such as polycyclic aromatic hydrocarbons (PAHs) and Bisphenol A (BPA), can also be very dangerous. Some PAHs are carcinogenic and can directly or indirectly damage an individual’s DNA. BPA is also very dangerous and is an endocrine disruptor. PM can be acidic and this acidity may have negative consequences on health, especially on lung function. The acidity of PM is due to the presence of sulfate and nitrate within the particles.

¹ "Particulate Matter (PM)." *EPA*. United States Environmental Protection Agency, 10 Sept. 2015. Web. 08 Dec. 2015.

² *ibid*, 2015, web.

³ Chen Z, Jiang J, Fajardo O, Wang S, Hao J. 2013. Characteristics and health impacts of particulate matter pollution in China (2001-2011). *Atmospheric Environ.* 65 (2013): 187-189.

When ammonium is present, it can act as a neutralization species. The balance between these three compounds determines the acidity of the PM.⁴

Studies have measured fluctuations in PM pollution based on changes in regional weather and have found that PM pollution decreases when precipitation increases.⁵ Los Angeles often has little or no precipitation. The region was marked by its fourth consecutive year of drought in 2015.⁶ This has grave consequences on air quality.

Automobile traffic has been shown to greatly increase PM pollution. Well known for its heavy traffic, Los Angeles' poor air quality coincides with this finding. A study was conducted in Los Angeles when a 15km section of a freeway in the city closed for two days. The closure decreased freeway traffic in the region. During these two days, there was a large decrease in the concentration of pollutants 50 m downwind of the closure. This included an 83% decrease in PM number concentration and 36% decrease in PM_{2.5} mass. Both PM_{2.5} and PM₁₀ had a statistically significant reduction in the surrounding region.

III. Physiological effects

There are many physiological effects that are associated with PM exposure. Urban air pollution is associated with thousands of premature deaths each year. The differing sizes of PM can produce different results within an individual's body. In general, PM is associated with cardiovascular death and asthma. PM from vehicular emissions, very prevalent in Los Angeles, exacerbates respiratory disease and increases cardio-pulmonary mortality.⁸

Due to increased environmental regulations in the United States, air pollution levels have been declining in recent decades. A study assessed the effects of long-term implementation of air quality control policies on the respiratory health of children. Linear-regression models examined the relationship between lung function development from 11-15 years of age and declining pollution levels. The results showed that long-term improvements in air quality are associated with significant improvements in lung function in teenagers⁹. Although this study shows the detrimental effects of PM pollution on developing lungs, it also shows that a decrease in pollution can improve lung function.

An association between exposure to air pollution and cardiovascular events also exists. Not only does increased exposure to PM pollution correlate with an increased likelihood to suffer myocardial infarctions, it also increases the likelihood of those who have survived a myocardial infarction to experience a subsequent event. A recent study found that in post-myocardial infarction individuals, a 50% increase in the reoccurrence of myocardial infarction, heart failure or stroke was associated with a 10µg/m³ increase in PM_{2.5} exposure.¹⁰ Therefore, PM pollution exposure greatly

⁴ Sangiorgi G, Ferrero L, Ferrini BS, Lo Porto C, Perrone MG, Zangrando R, Gambaro A, Lazzati Z, Bolzacchini E. 2013. Indoor airborne particle sources and semi-volatile partitioning effect of outdoor fine PM in offices. *Atmospheric Environ.* 65 (2013): 206.

⁵ Chen Z, et al., 2013, p. 189.

⁶ Stevens M. 2015. Water, 2015, California: The no-good, very bad year - now, 'pray for rain.' *LA Times*. Web. 09 Dec 2015.

⁷ Hong A, Schweitzer L, Yang W and Marr LC. 2015. Impact of temporary freeway closure on regional air quality: a lesson from Armageddon in Los Angeles, United States. *Env Sci & Tech.* 49 (5): 3212.

⁸ Corburn J. 2015. City planning as preventative medicine. *Preventative Medicine.* 77: 49.

⁹ Gauderman WJ, Urman R, Avol E, Berhane K, McConnell R, Rappaport E, Chang R, Lumann F, Gilliland F. 2015. Association of Improved Air Quality with Lung Development in Children. *N Engl J Med.* 372: 910.

¹⁰ Koton S, Molshatzki N, Yuval, Myers V, Boday D, Brory Y, Steinberg D and Gerber Y. 2013. Cumulative exposure to particulate matter air pollution and long-term post- myocardial infarction outcomes. *Preventive Medicine.* 57 (2013): 342.

increases cardiovascular mortality. This finding is significant in that it shows that although biomedicine can assist someone in surviving cardiovascular events, those individuals are then placed at a greater risk to experience a subsequent event. While biomedicine prides itself in using technology to improve health outcomes, there may be a limit to how many times this technology can continue to save the same patient.

Particulate matter exposure may also impact fetal growth during pregnancy. A study was conducted in Los Angeles, CA that found a correlation between increased maternal exposure to traffic-derived air pollution during 29 to 37 weeks gestation with a decrease in fetal head size measured as biparietal diameter in late pregnancy.¹¹ This finding is especially significant in light of another study demonstrating the consequences of this fetal characteristic.

In Tongliang, China, a coal-fired power plant emitted PM containing carcinogenic substances such as PAHs from the combustion of coal. When this power plant announced its expected closure, it provided researchers the opportunity to compare two cohorts of infants, 30 months before and after the plant closure. The first cohort, researched in 2002, showed decreased head circumference, birth weight, and birth height compared to the 2005 cohort¹². A correlation was found between overall reduced fetal growth and adverse cognitive outcomes. Decreased head circumference was associated with decreased neurodevelopment outcomes and increased head circumference was related to improved childhood learning capabilities. There was no significant difference in head circumference growth rate between the two cohorts, which caused the persistence of a small head into childhood for the 2002 cohort. The associated developmental delays were found to have later impacts on school performance. Prenatal exposure to PAH was also correlated with decreased IQ at age five.¹² This study shows that the decrease in fetal head circumference found in the Los Angeles study has significant developmental cognitive consequences.

While PM exposure is especially dangerous for the developing brain, it can also seriously affect the adult brain when exposed to pollution later in life. Exposure has been shown to anatomically change brain structure. Magnetic resonance imaging showed associations between exposures to PM_{2.5} with measures of total cerebral brain volume, hippocampal volume, white matter hyper intensity volume, and covert brain infarcts¹³. Even in dementia and stroke-free individuals, enhanced structural brain aging may occur if exposed to high levels of particulate matter.¹³

One of the difficulties in determining the health consequences of PM exposure is the differing chemical compositions of PM. The chemical components of the PM in Los Angeles may be different from those in Tongliang, China and other regions. However, across populations studies have shown an increase in hospitalizations when there is an increase in PM_{2.5} exposure.¹⁴ Although the exact physiological responses may be different depending on the type of chemicals the body is exposed to, it seems that there are damaging health consequences across all populations. Not only does PM exposure cause physiological effects, but social consequences also result from the negative effects on development and health. It is reasonable to believe that a decrease in the cognitive ability

¹¹ Ritz B, Qiu J, Lee P-C, Lurmann F, Penfold B, Weiss RE, McConnell R, Arora C, Hobel C and Wilhelm M. 2014. Prenatal air pollution exposure and ultrasound measures of fetal growth in Los Angeles, CA. *Environmental Research*. 130: 12.

¹² Tang D, Yu Li T, Chow JC, Kulkarni SU, Watson JG, Hang Ho SS, Quan ZY, Qu LR, Perera F. 2014. Air pollution effects on fetal and child development: A cohort comparison in China. *Environmental Pollution*. 185 (2014): 95.

¹³ Wilker EH, Preis SR, Beiser AS, Wolf PA, Au RA, Kloog I, Li W, Schwartz J, Koutrakis P, DeCarli C, Sesadri S and Mittleman MA. 2015. Long-Term Exposure to Fine Particulate Matter, Residential Proximity to Major Roads and Measures of Brain Structure. *Stroke*. 46(5): 1161.

¹⁴ Bell M and HEI Health Review Committee. 2012. Assessment of the health impacts of particulate matter characteristics. *Res Rep Health Eff Inst*. 161: 36.

of exposed individuals may be positively correlated with educational and employment opportunities.

IV. Unequal distribution

As previously discussed, PM exposure is widespread and has significant health consequences for anyone exposed. Although all bodies negatively react to PM pollution, many studies have shown that individuals of minority groups and of low socioeconomic status are more likely to be exposed to PM pollution and experience adverse health outcomes. Data shows that the health of minorities and people of low socioeconomic status in the United States is getting worse much faster than that of whites of higher socioeconomic status.¹⁵ Minorities and people of low socioeconomic status experience increased infant mortality rates, decreased birth weights, stunted physical and cognitive development, early on-set of chronic illnesses, and increased rate of infection.¹⁶

This data suggests that there are large inequities in our society which allow for the distinction between populations. Helen Keller, after studying the effects that socioeconomic status had on disability, “. . . learned that the power to rise in the world is not within the reach of everyone.”¹⁷ Many citizens of the United States experience pride in being from a nation founded on principles of equality, believing that all have the opportunity to succeed. When American high school students were asked why the poor are poor, the majority of students blamed the victim. They described the poor as not being successful due to their own faults.¹⁸ Many U.S. students do not learn in school or from their parents that opportunity is not equal in America due to social structures. This unawareness of the consequences of our social constructs encourages leaders to allow inequality to persist.

Yale University published an article which depicted the widening of the racial and economic pollution exposure gap. Even when the air meets federal health standards, the researchers found that people belonging to minority groups and those with low socioeconomic status and low education levels are at greater risk to experience pollution-induced health consequences.¹⁹ Boyle Heights, in East Los Angeles, is an example of an area with high pollution and a large minority population. More than 90% of the population of Boyle Heights is Hispanic and it is one of the most economically deprived areas of the city. It is also surrounded by freeways which ship large quantities of commercial goods, four major rail yards, body shops and chrome-platers.²⁰ The Yale study analyzed 14 different components of particulates common in pollution and the levels of each of these components in different racial and socioeconomic level neighborhoods. Significant increases in exposure in persons of minority groups and low socioeconomic backgrounds were found.²¹

Los Angeles is known as a driving city. While driving may be convenient for those of higher socioeconomic statuses, highways contribute to air pollution and suburban sprawl. At the

¹⁵ Jennings B, Kahn J, Matrioanni A, Parker LS. 2003. Ethics and Public Health Model Curriculum. *Association of Schools of Public Health*. Web. 07 Dec 2015. p. 160.

¹⁶ Corburn, 2015, p. 49.

¹⁷ Loewen JW. 2007. *Lies My Teacher Told Me: Everything your American History Textbook Got Wrong*. New York: Simon & Schuster. p. 204.

¹⁸ *ibid*, p. 205.

¹⁹ Bell M and Ebisu K. 2012. Environmental Inequality in Exposures to Airborne Particulate Matter Components in the United States. *Environ Health Perspect*. 120 (12): 1699-1703.

²⁰ Katz C. 2012. Minorities, Poor Breathe Worse Air Pollution, Study Finds. *New America Media*. 04 Nov. 2012. Web. 10 Oct. 2015.

²¹ Bell M and Ebisu K, 2012, p. 1699-1703.

same time, inadequate or inaccessible transportation for the urban poor in LA decreases access to employment opportunities and healthcare/promotion services. The suburban sprawl that results from the construction of highways increases residential segregation. Corburn and other researchers argue that spatial segregation is the driving factor of health outcomes in cities.²² Residential segregation enhances discrimination against racial and ethnic groups and suppresses diversity. They have also claimed that people living in segregated communities may have “. . . .disproportionate exposure, susceptibility,²³ and response to economic and social deprivation, toxic substances, and hazardous communities.”²³

The study of “environmental injustice” began when an American sociologist showed that from 1920 to 1970, Houston placed the majority of its landfills in predominantly African American neighborhoods. Houston’s demographics were 28% African American, yet 15 out of the 17 landfills and 6 out of 8 of the incinerators in Houston were placed in their neighborhoods.²⁴ In 2003, the Association of Schools of Public Health showed similar trends of environmental injustice that were taking place in Los Angeles. At that time, the most polluted U.S. zip code in the United States was in Los Angeles and contained industries that released five times more pollution than the second most polluted zip code. A majority of the population was composed of people of low socioeconomic status and was 59% African American.²⁵

The disproportionate siting of pollution-inducing facilities in minority communities is considered environmental racism.²⁶ When the siting of many toxic sites is placed in a predominantly Hispanic community, such as Boyle Heights, environmental racism is brought into question. When the most polluted zip code in America has a large minority population, environmental racism is also brought into question. It can be easy to see injustice while looking at single communities, but it is much easier to see environmental racism when looking at the United States as a whole. The consistent placement of hazardous sites in communities of minorities and the poor, shows that environmental racism is real and does exist in this nation. Environmental racism is deeply rooted in the political, social, and economic structures that currently exist.²⁷

Every year, more pollution-laden industries move into East Los Angeles. More than 33 million pounds of chemicals are released into the East LA air and water each year. The health consequences mentioned above are rampant. Companies are able to continue moving into neighborhoods with little political power. Two residents of the neighborhood, Juana Gutierrez and Aurora Castillo, outraged about the injustices their home faced, founded Mothers of East Los Angeles, or MELA, in 1986. The group originally was founded to fight against a prison that was proposed to be built in the neighborhood. When a toxic-waste incinerator that would release a large amount of particulate matter into the air was proposed for East LA, MELA stepped in. After 6 years of fighting the incinerator, including 4 lawsuits, 16 hearings, and 6 mile protests, the construction of the incinerator was cancelled.²⁸ When no one else stepped in to fight against the environmental injustice in East LA, the community stepped up and prevailed.

²² Corburn, 2015, p. 49-50.

²³ *ibid*, p. 50.

²⁴ Jennings, 2003, p. 170.

²⁵ *ibid*, p. 170.

²⁶ Checker M. 2005. *Polluted Promises*. New York: NYU Press. p. 14.

²⁷ *ibid*, p. 14.

²⁸ Shrader-Frechette K. 2007. *Taking Action, Saving Lives: Our Duties to Protect Environmental and Public Health*. Oxford Scholarship Online. “Where We Go From Here.” p. 2.

Environmental injustice issues are widespread and provide an important example of the devastating consequences of structural violence. Structural violence is violence that is not caused by an individual's actions, but by society as a whole. It is the accumulation of negative effects imposed by society on people of a social group, in which the people cannot run or fight. It is the everyday violence that often goes unnoticed by many and therefore is less likely to stop. As Nancy Scheper-Hughes defines it, structural violence is "violence that is permissible, even encouraged. It refers to the invisible social machinery of inequality that reproduces social relations of exclusion and marginalization via ideologies, stigmas, and dangerous discourses attendant to race, class, sex, and other individual distinctions."²⁹

There are devastating consequences for anyone exposed to particulate matter. If particulate matter exposure was equally distributed to all people living in the larger metropolitan Los Angeles region, it would be devastating, but at least fair. Because the particulate matter exposure is more closely linked to those who live at the margins of society, structural violence is at play. Structural violence cannot hold one individual accountable, but rather a whole community is held accountable for the degradation of a few, while promoting the lifestyle, values, and beliefs of the majority. Paul Farmer describes it as, "acts of violence [that] are perpetuated usually by the strong against the weak."³⁰

The targeting of minority and underprivileged neighborhoods for landfills and other pollution-expelling industries seems to be planned and purposeful. It is easier to place such sites in neighborhoods filled with individuals that have little political and economic power, because they are less capable of resistance than higher-powered individuals. When the release of environmental pollutants is not protested, profits and wealth increases for the business and stockholders. Many of the polluting businesses are often found to be monetary donors to the political leaders that should be addressing environmental concerns. After looking at the large array of other societal factors that put the people in these populations at a disadvantage, it is not surprising that they are also exposed to unhealthy environments. In *Lies My Teacher Told Me*, Loewen suggests that in addition to minorities and the poor living in poisoned environments, they also face decreased prenatal healthcare, less time and interaction with parents, lower quality day care, and underachieving school systems.³¹ The combination of these factors results in higher school dropout rates. It seems that the compounding effect of these variables in children's lives greatly increases the likelihood that the cycle of poverty will continue.

V. Perpetuation of disparities by healthcare systems

In his article, Coburn argues that where people live and how that place is governed determines if and when people get sick and how that disease defines or kills them.³² Although it is inspiring to see disadvantaged populations take the injustice they face into their own hands to make a difference in their community, there is much more environmental health injustice occurring than one group can possibly fix. The current healthcare system may also be analyzed to determine if these issues of are perpetuated in the healthcare setting.

There is a clear link between socioeconomic status, increased risk of toxic environmental exposures, and poor health status. This poses a challenge for physicians. Even by 2008, most

²⁹ Scheper-Hughes N. 2004. Dangerous and Endangered Youth: Social Structures and Determinants of Violence. *Analys of the New York Academy of Sciences*. 10(36): 13.

³⁰ Farmer P. 2005. *Pathologies of Power: Health, Human Rights, and the New War on the Poor*. Berkeley: U of California. p. 8.

³¹ Loewen, 2007, p. 207.

³² Coburn, 2015, p. 48.

medical schools did not adequately prepare students to address these issues. The University of Michigan designed a “Poverty in Healthcare” curriculum to promote the competency of their students in this area. The hope of this curriculum is that physicians will better know how to handle such clinical situations if they are studied beforehand.³³ Physicians can have a compounding effect on health disparities when they are not adequately trained. Not only do the urban poor face physical disadvantages based on their geographical residence, but also by the poorly equipped medical staff to handle and understand the root causes of their conditions. This understanding is needed for adequate treatment. Although this may be out of the physician’s hands, through the acknowledgement of the possible social causes of an illness, more creative healthcare solutions may be found.

One creative solution is Davenport’s example in a large West Coast city, where medical students and physicians initiated the “Campaign on Homelessness.” This campaign included operating medical clinics throughout the city and educating the university community about homelessness. The students were taught to practice “witnessing” which is the consideration of the whole person while looking at the patient. This witnessing practice allows the students to be “active agents, pushing back against and transforming the structure, even as they operate within its constraints.”³⁴ When physicians are aware of the larger structures which frame their work, they are more likely to initiate change in a patient’s life.

Another creative solution for physicians to better the public health of disadvantaged populations was designed by Jason Corburn, at the University of California— Berkeley. Corburn presented a passionate proposal that suggested city planning could be a tool used in preventative medicine. This proposal called for the collaboration of physicians, public health professionals, and city planners. Currently, many physicians focus on patient poverty on a case-by-case basis in the clinic. This results in impoverished patients often returning to the same living and working conditions that initially provoked their need for medical services. Often, when a patient comes into a doctor’s office with hypertension, physicians focus on the medical interventions that may be used to treat the condition. Their treatment often ignores the whole person, by simply not addressing the “root causes” of the illness.³⁵ The environmental exposures faced by many impoverished and minority patients are ignored in the physician-patient interaction. If cities can be planned in a way that the low members of society are not unequally exposed to environmental pollution, lower quality food, lower quality housing, and constant threats of violence, the health of these communities could substantially increase.

VI. Conclusion

This paper has two main goals: to depict the adverse health effects of environmental pollution and to show how those who are less fortunate in society are more likely to experience this exposure. Racism is a “hot” topic in the media today, although many like to believe that racism no longer exists. However, the data I presented shows that there is a real distinction in the air quality and subsequent health between whites and non-whites. As United States history has proven, decisions of where to place toxic industries and how much toxic pollution can be released from those industries cannot be left up to business executives alone. In order to change the structural

³³ Doran KM, Kirley K, Barnosky AR, Williams JC and Cheng JE.. 2008 Developing a Novel Poverty in Healthcare Curriculum for Medical Students at the University of Michigan Medical School. *Academic Medicine*. 83(1): 5-13.

³⁴ Davenport BA. 2000. Witnessing and the Medical Gaze: How Medical Students Learn to See at a Free Clinic for the Homeless. *Medical Anthropology Quarterly*. 14(3): 324.

³⁵ Corburn, 2015, p. 50.

violence of which these populations are victims, changes in governmental policy and regulations are necessary. United States policy changes could greatly improve conditions for those at the margins of society receiving unequal distributions of particulate matter exposure. By implementing policies that will significantly decrease our nation's current release of particulate matter and by refraining from building new pollution-releasing industries in underprivileged geographic areas, the burden of pollution on minorities and the poor could be greatly lessened. Industries would be more willing to lessen their damage to the environment and health of others if those who profit from the industry also lived within its area of damage.

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