LOCAL ENVIRONMENT
https://doi.org/10.1080/13549839.2020.1754776

Routledge
Taylor & Francis Group

Pollution, place, and premature death: evidence from a mid-sized city

John Hans Gilderbloom[a,b], Wesley L. Meares[c] and Gregory D. Squires[d]

[a]Neighborhood Associates Corporation, Washington D.C.; [b]Urban and Public Affairs, University of Louisville, Louisville; [c]Political Science and Public Administration, Augusta University, Augusta; [d]Sociology and Public Policy and Public Administration, George Washington University, Washington

ABSTRACT

Neighborhood life expectancy varies by as much as 10 years across the City of Louisville. In 2013, the Greater Louisville Project funded by local government, businesses, and foundations, argued these differences had little to do with environmental factors. The Greater Louisville Project (2013) study argued that these neighborhood differences could be attributed 40% to socio-economic factors (with a major emphasis on education), 10% to physical environment, 30% to health behaviors, and 20% to access to medical care. To test these claims, we construct our own model of neighborhood variation in years of potential life lost (YPLL) by adding two variables testing environmental degradation. We operationalise two separate measures of environmental contamination: proximity to EPA designated brownfield sites and proximity to chemical factories in an industrial park in the neighborhood known as "Rubbertown". We conduct several regression analyses, which show a relationship between proximity to environmental contaminants and an increase in neighborhood YPLL. Our beta weights challenge the claims made by the Greater Louisville Project, which minimize the impact nearness to environmental contaminants has on reductions in life expectancy in Louisville neighborhoods.

ARTICLE HISTORY
Received 17 April 2019
Accepted 12 March 2020

KEYWORDS
Environmental justice; lifespan; Inequality

Social critic Paul Goodman (1960) wrote in *Growing Up Absurd*, "A man has only one life and if during it he has no great environment, no community, he has been irreparably robbed of a human right" (17). A person's neighborhood has a significant influence on an individual's life expectancy. Residing adjacent to environmental contaminants has the ability of robbing a person of the right Goodman reflected on in 1960. While we know from studies done outside the United States that premature death is a major problem for neighborhoods close to environmental contaminants, this issue has not gotten the attention it deserves in the US. There have been few studies in the US that systematically study pollution at the neighborhood level and its impact on health by linking place to lifespan. While Flint, MI has received a fair amount of attention in recent years, the question arises as to whether Flint is the exception or the rule in the US.

Worldwide, air pollution was responsible for 7 million premature deaths in 2010 according to a study published in *Journal of The American Medical Association* and sponsored by the World Health Organization (Kuehn 2014). By 2050, according to the Organization for Economic Co-operation and Development (OECD 2012), polluted air will be the number one cause of premature death rates—rising ahead of sanitation and lack of access to clean water, which are currently the

CONTACT John Hans Gilderbloom jigild01@louisville.edu Neighborhood Associates Corporation, Washington D.C. Urban and Public Affairs, University of Louisville, 426 West Bloom Street, Louisville, KY 40208

primary causes. A recent study published in the British medical journal The Lancet (2013) estimates that 1.2 million premature deaths occur annually in Chinese cities due to polluted air (Wong 2013).

Research in the United States

Systematic research on environmental justice issues has long established that hazardous sites—including waste and sources of air pollution—are disproportionately located in minority neighborhoods (Appelbaum et al. 1976; Been 1995; Bullard 1990, 2000; Frederick, Hammersmith, and Gilderbloom 2019; Gilderbloom 2016a; Gilderbloom 2016b; Gilderbloom et al. 2017; Pahl 1975; Pastor, Sadd, and Hipp 2001). Although there has been some debate as to whether hazardous sites have been located in or relocated to minority neighborhoods, or whether minority population "move-in" occurred subsequent to the location of those sites (Bullard 2000; Pastor, Sadd, and Hipp 2001). Recent studies indicate that the sites are located in minority neighborhoods, not that minorities tend to move to areas where such sites are located (Hipp and Lakon 2010; Smith 2009; Swanston 2012). This can be due to the neighborhood's lack of political power or a weak real estate market (Banzhaf 2012; Hamilton 1995). Consistent evidence supporting the disproportionate impact of environmental contaminants on racial and ethnic minority neighborhoods should raise the level of concern about the possible link to shortened lifespans. Recent studies indicate that residing in neighborhoods with high levels of pollution is correlated with a shorter life span ranging from 4 to 13 years (Gilderbloom, Riggs, and Meares 2015; Gilderbloom, Meares, and Riggs 2014; Kuehn 2014; Lancet 2013, Wong 2013). Chetty et al. (2016) dismissed environmental pollution in explaining why Louisville had five year reduction in life span compared to West Coast cities.

Countering the claims that place causes premature death: the case of Louisville

City officials in Louisville have funded studies arguing that environmental degradation has little impact on lifespan. Our research into the relationship between proximity to environmental hazards and premature death rates in neighborhoods is a case study of Louisville, Kentucky which challenges the studies funded by the city. The neighborhood difference of life expectancy in Louisville ranges from 10 to 13 years (Smith et al. 2011; Greater Louisville Project 2013). These Louisville-based studies argue that environmental contaminants are not the cause of premature death rates but rather premature death is mostly related to lifestyle choices, which are tied to socio-economic status. Very few studies have attempted to study the relationship between environmental factors and premature neighborhood death, let alone health, in Louisville—the few that exist suffer from methodological or statistical problems.

There is a consensus that those who work in Rubbertown chemical factories (an area in the far western corner of Louisville located on a large strip of land with 11 plants) can face both dangerous and deadly environments. Accidents and mishaps in Rubbertown have been severe and have resulted in numerous worker deaths throughout the years. Several historic events highlight the tragedies of Rubbertown. In 1961, around 1,000 residents were evacuated from a nearby neighborhood as a cloud of acrid gas formed from the former Stauffer Chemical Company (Barnett 2011). In 1985, a tank explosion killed three workers at Borden Chemicals and, most recently in 2001, an explosion at Carbide industries killed two workers (Barnett 2011). In 1965, the largest accident occurred when 12 workers died from explosions and fires rolling through the DuPont plant (Barnett 2011). Twenty-six former B.F. Goodrich workers have died from liver cancer (Barnett 2011). Bill Moyers' PBS documentary *Trade Secrets* (2001) on the chemical industry brought national attention to workers in Louisville chemical plants who were dying prematurely. These workers had disintegrating bones in their hands and up to 60 non-naturally occurring chemicals in their bodies.

The history of Rubbertown is tainted with industrial accidents and unfortunate environmental devastation affecting workers in the area. However, what about residents who may not work in Rubbertown but who live nearby?

Richardson (1998) argues that it is the workplace—not the place of residence—that causes premature deaths. He found that environmental conditions of "place" had no impact on premature deaths in medium-size cities such as Louisville. He argued that the lack of correlation between place and early death is the result of several factors, most notably the fact that residents are highly mobile and they do not stay long enough in one place for it to impact health.

But Richardson committed several methodological missteps: (1) the number of cases examined was reduced to just West Louisville residents instead of the metro area, providing no comparison; (2) the regression results did not sufficiently take into account the range of other variables considered by this present study and others such as Frank, Engelke, and Schmidt (2003), Dannenberg, Frumkin, and Jackson (2011), and Massey (2004); and (3) the number of census tracts studied were small, making a finding of significance difficult.

The *Louisville Metro Health Equity Report: The Social Determinants of Health in Louisville Metro Neighborhoods* (2013) found that residents living in the poorest neighborhoods adjacent to the chemical industry park have lower life expectancies—in certain cases over 10 years shorter than the average Louisville life expectancy (Smith et al. 2011). Smith et al. (2011) analyzed cancer rates by zip code in Louisville. They found common cancers are significantly higher in the Rubbertown zip codes. They also found that people living in these zip codes have a 45% higher chance of contracting lung cancer and a 31% higher chance of getting colorectal cancer (Ibid, 14). The problem with this study is that zip codes are inexact and cover too much acreage as opposed to the more focused and smaller census tracts. Nevertheless, this study was an important first step in showing how the proximity of environmental contaminants to a neighborhood can have a negative impact on neighborhood premature death levels. Although not noted in the text, the report's maps clearly show that where pollution densities are highest, premature death rates are also higher.

The most recent study was the highly publicised report by the Greater Louisville Project (2013) which estimated years of projected life lost and found wide variation in the length of lifespan by neighborhoods. The purpose of the Greater Louisville Project is to make Louisville a more competitive city compared to 14 "peer cities", mostly located in the South. The larger goal is growth and prosperity, which hinges in part on providing residents in the city with a longer life span. The Greater Louisville Project, funded by the Robert Johnson Foundation along with a consortium of local foundations, businesses, and government agencies, put together an eclectic group of 18 drawing on doctors, Ph.D.'s, public health professionals, and non-professional degree holders representing central business district (CBD) hospitals, medical insurance groups, school district administrators and other stakeholders.

The Greater Louisville Project (2013) found a 13 year difference in life expectancy existed between the mostly black West and mostly white East Louisville. The report states, "This report identifies our most challenging health factors: low educational attainment, unemployment, high rates of smoking, and obesity, moderate access to primary care and poor air quality" (Greater Louisville Project 2013:1). The study argued that years of projected life lost were due to social and economic factors (40%); physical environment (10%); health behaviors (30%) and access to medical treatment (20%).

Additionally, the report claimed that "poor air quality" explains just one-tenth of reduced life expectancy (Greater Louisville Project 2013: 12). However, in the report "poor air quality" is mostly defined as smoking. The report does not address environmental contamination, especially the environmental hazards existing in Rubbertown neighborhoods and the 25 EPA designated brownfields. Rubbertown neighborhoods and brownfields contribute to unhealthy air, water and soil all of which are factors leading to premature death in West Louisville. Consequently, by ignoring environmental contamination, policy recommendations directed towards environmental remediation are not offered, despite environmental degradation being systematically linked to poor health and premature death. The report argued that the primary factors contributing to years of projected life loss, were life style choices, not environmental circumstances. The report emphasized a policy response of addressing personal health choices by encouraging people to not smoke or stop smoking, eat healthy foods, exercise, and improve graduation rates. The major takeaway offered by the report was that "low educational attainment" was a major source of shortened lives in these neighborhoods (Greater Louisville Project 2013:1).

While education as a variable is correlated with premature deaths, it does not mean that the lack of education is the "cause" of premature deaths. It should be noted the impact of education is important. Education has the ability to improve an individual's social mobility and their ability to access neighborhoods of better quality. Neighborhood context is an important factor and education is an avenue for individuals to improve their opportunities (including their choice of neighborhood) and conditions in which they live. But education alone does not determine physical health or directly immunize people from environmental hazards. Only a problem definition that includes the environmental issues and solutions that address the environment will improve YPLL. Without addressing the environmental degradation, the city will continue to see the health of residents erode in neighborhoods with environment contamination.

Research methodology: environmental toxins impacts on health in Louisville

Our research replicates, with modified methodology, previous studies that have established connections between environmental pollutants and reduced life expectancy. While the authors of the majority of these studies chose to study the country, state, region, or city level, we instead adopt an intra-city approach (Appelbaum 1978; Appelbaum et al. 1976; Gilderbloom and Appelbaum 1988). We analyse 170 neighborhoods in Louisville by constructing statistical models to explain why Louisville's neighborhoods differ by as much as 10 years of life expectancy. Our focus, demonstrated through two key independent variables, is on whether environmental toxins have a net impact on neighborhood life expectancy once the effects of other neighborhood factors are removed. This section describes the community under study, the dependent and key independent variables, and the model construction.

We chose to carry out our neighborhood-level analysis in Louisville, Kentucky, a mid-sized U.S. city that, in many ways, is representative of hundreds of other mid-sized cities (Gilderbloom 2008; Gilderbloom and Appelbaum 1988; McMeekin 1946). At about 600,000 people, the consolidated Louisville Metro (the old City of Louisville plus surrounding Jefferson County) ranks 27th in population nationally and, together with surrounding counties in Kentucky and Indiana, 44th as a Metropolitan Statistical Area (U.S. Census Bureau 2012). It is one of approximately 146 cities in the nation with a population greater than 50,000 which is not located within 20 miles of another neighboring city of more than 50,000 (Appelbaum 1978; Appelbaum et al. 1976; Frederick and Gilderbloom 2018; Gilderbloom 2008; Gilderbloom and Appelbaum 1988). Louisville's relatively monocentric urban landscape, with surrounding suburban rings of decentralised development, is characteristic of older industrial cities grappling with the effects of deindustrialisation and suburbanisation. Like many U.S. cities, especially in the South, Louisville is segregated by race and socio-economic status. The minority populations, mostly African-American, constitute about one-third of the inner core and about one-fifth of Louisville Metro. The medium size, geographic isolation, and urban structure of Louisville produces a better estimate of the environmental impact on health for a larger share of the U.S.'s urban and metropolitan population than would a case study of a megacity like New York or Los Angeles (Appelbaum 1978; Appelbaum et al. 1976; Frederick and Gilderbloom 2018; Gilderbloom 2008).

Dependent variable: premature death

The dependent variable measuring premature death at the neighborhood level is the years of potential life lost (YPLL), per 100,000 residents, between 2000 and 2010. The residential population used to create this measure was based on the population reported by the most recent (2010) Census. The years of projected life lost measure is based on data collected by the Louisville Metro Department of Health and Wellness that gives the year of death, age at death, and last known address of all deceased persons in Jefferson County between the years 2000 and 2010. The process used to convert this data into the YPLL variable uses the following equation:

$$YPLL = S(E-A)/P,$$

where E is the standardised expected age of death (=75), A is the age at death, and P is the 2010 population of each tract divided by 100,000.

Total years of potential life lost are summed by tract and divided by each tract's population, divided by 100,000, to control for the differences in population across tracts. Higher numbers denote increases in YPLL—or in other words, decreases in life expectancy. While this present project does not consider specific causes of death, the YPLL dependent variable, as constructed, is appropriate for this study. The age-specific population of each unit of analysis standardises deaths. Thus, the variable highlights clusters of premature death. The University of Louisville Institutional Review Board (IRB) oversaw the creation of this variable to protect the identity of the individuals in the sample. Figure 1 maps the YPLL variable across Louisville's neighborhoods.

Test variable #1: proximity to brownfields

This study examines the impact of environmental conditions on years of projected life lost by using two key test variables measuring contaminants: Environmental Protection Agency-designated (EPA) brownfield sites, scattered throughout Louisville, and chemical factories (concentrated in the Rubbertown area) located in West Louisville along the Ohio River. Louisville has 25 brownfield sites (EPA 2012) and one Superfund site on the National Priority List (NPL) (EPA 2013). In Louisville, contaminated soil is a problem as 25% of downtown Louisville is classified as a brownfield (Barnett 2011). The high numbers of industrial, chemical, and manufacturing plants in the county contribute to poor environmental quality (Smith et al. 2011). The accuracy of the Louisville data is the result of a pilot programme funded by the state, which uses aerial photography to identify potential brownfield areas. Once an area of potential concern is identified through aerial photography, the state launches a ground investigation to confirm if there is contamination. Congress established the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980, in response to growing concerns over the health and environmental risks posed by hazardous waste sites (EPA 2011). CERCLA is informally called the "Brownfield Law" to describe the programme administered by the United

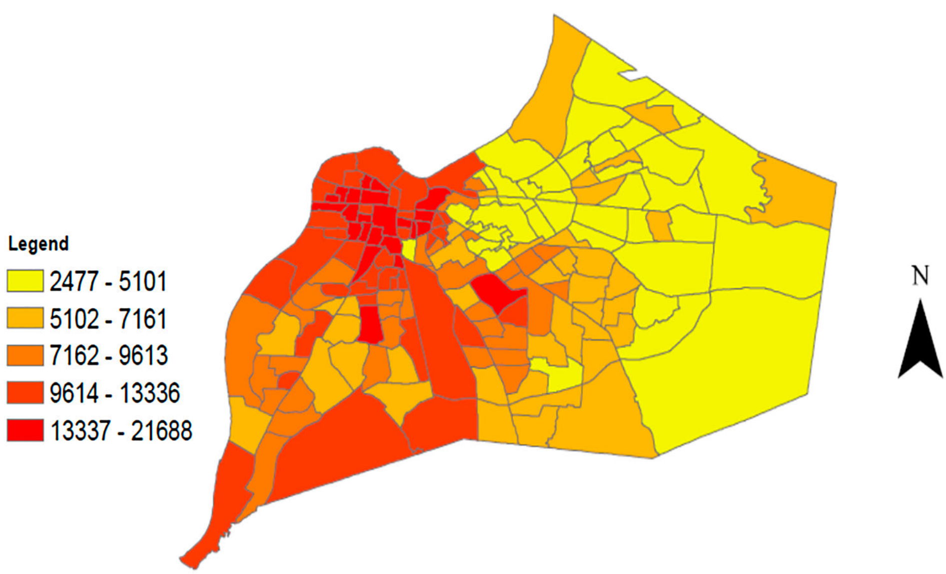

Figure 1. Years of Potential Life by Census Tract in Louisville, KY.

States EPA in cooperation with state and tribal governments, allowing them to clean up hazardous waste sites and hold responsible parties accountable to perform cleanups (EPA 2011). Our maps are pulled from EPA Superfund sites, which list both Superfunds and brownfields that lack the federal funds for cleanup.

For this study, we operationalised proximity to brownfields by constructing a dichotomous variable that codes neighborhoods within a 1.5-mile radius of any brownfield site as “1.” All other neighborhoods are coded “0.” This was done by geo-referencing the centroid, or geographic center, of each brownfield site, and creating a 1.5 mile buffer. If any portion of a census tract fell within this buffer, the tract itself was coded as “1.” Figure 2 presents these sites with their buffers over a map of all Census tracts.

Test variable #2: proximity to Rubbertown

To develop the Rubbertown variable, we used geo-coding techniques to map proximity to the Rubber Town Industrial Zone, identifying all tracts within 10,000 feet north, south, or east of Rubbertown where wind currents can blow (west is the Ohio River area that borders Indiana). Rubbertown was measured by coding all census tracts with any part within 10,000 feet of any part of the Rubbertown factories as “1” and all other tracts as “0.” Figure 3 shows where the Rubbertown factories are located in the western part of the city. Figure 4 shows the names of the industries in the Rubbertown industries. Many of these industries have foreign ownership. The intent of this dummy variable is to gauge whether residence in this sub-region of the city near the Rubbertown factories has a net

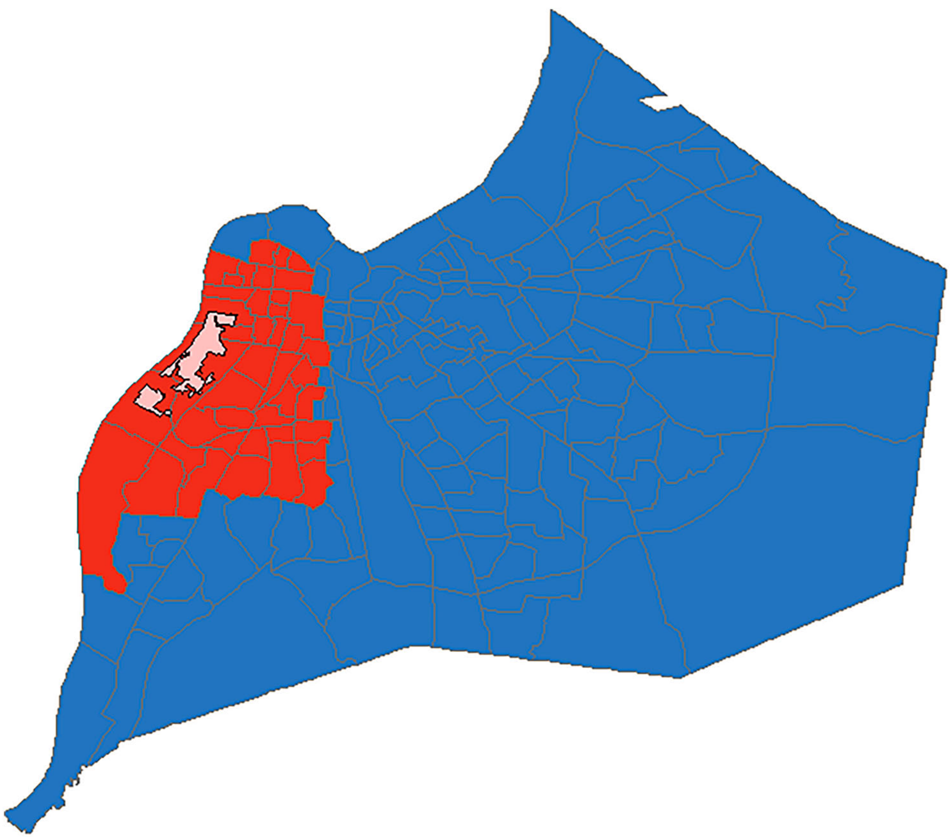

Figure 2. Rubbertown Chemical Locations by Census Tracts.

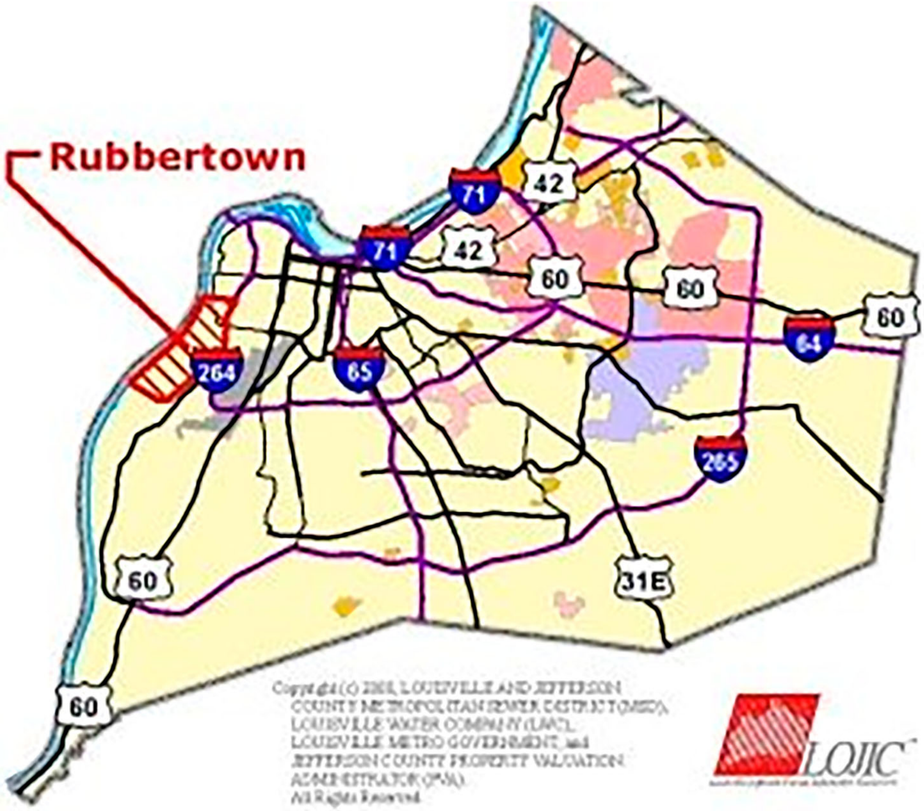

Figure 3. Rubbertown Location. Source: Louisville/Jefferson County Information Consortium. https://www.lojic.org/lojic-online

impact on years of projected life lost while controlling for other neighborhood factors. Table 1 compares Rubbertown (N=42) and non-Rubbertown (N=128) census tracts along with averages for all of the variables in this study. YPLL are significantly higher in Rubbertown neighborhoods.

Similar to Rubbertown plants, a large concentration of the most dangerous brownfields sites according to the former Mayor's office are also located in western Louisville. Toxic sites are not randomly distributed throughout Louisville but are clustered in the northwestern section of the county where a majority of minority and low-income neighborhoods are located. No matter how we created the measurement, using a buffer or, alternatively, distance to the nearest site, our findings were consistent.

Control variables: other neighborhood factors

Most of these variables are traditional predictors with a theoretical basis from the body of literature concerning neighborhood health differentials reviewed earlier (Agyeman 2013; Gilderbloom 2009; Smith et al. 2011). Racial composition, crime rate, income and housing age are all variables that affect the lifespan of residents of a neighborhood (Frederick and Gilderbloom 2018; Frederick, Hammersmith, and Gilderbloom 2019).

Control variables are other, non-environmental factors that affect YPLL. The inclusion of these in our modeling ensures that the effect of brownfields and Superfund sites is not capturing some socio-demographic effect. See Table 1 for a concise description of these variables' (along with others we use in additional specifications found in Table 3) sources, years, measures, means, standard deviations, and ranges.

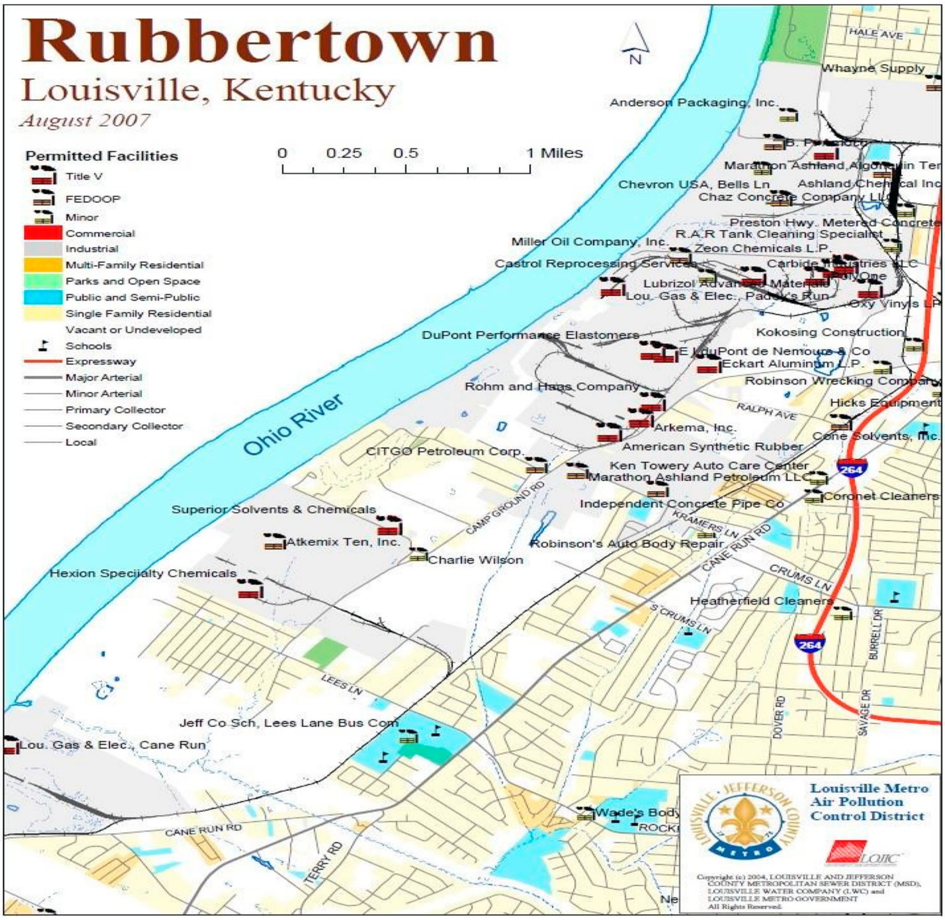

Figure 4. Location of Chemical Plants in Rubbertown Next to Residential Areas. Source: Louisville Metro Air Pollution Control District.

Statistical model

We use OLS regression to predict neighborhood years of projected life lost with the two above-mentioned key test variables and other control variables. The full regression equation is as follows:

$$YPLL = \beta0 + \beta1 * Nonwhitepercent + \beta2 * Housingage + \beta3 * Income + \beta4 * Crimerate + \beta5 * Brownfields + \beta6 * Rubbertown + \varepsilon,$$

where β1 through β6 are the coefficients to be estimated and ε is the error term.

Since the focus of this paper is on how to explain neighborhood variation in lifespan, we use OLS regression to examine net effects of key variables that measure characteristics of each census tract.

For purposes of validity and reliability five separate models were run with the brownfield and Rubbertown variables rotated in and out—alone (Equation 1–3) and then all together (see in Equation 5). All models shown were tested for multi-collinearity by calculating tolerance scores and examining zero-order correlation coefficients (Beck-Lewis 1980; Beck-Lewis 1993–1994; Gilderbloom, Meares, and Riggs 2014). All tolerance scores for variables used in the equation exceed 0.30. Using multiple equation specifications allows us to examine the impact of proximity to environmental contaminants separately and together. A reduced form equation that runs only those variables that are significant and theoretically reasonable provides for possibly a more accurate estimate of the coefficient and could impact the statistical significance and weight of the coefficients. For the purpose of scientific integrity and standard regression protocols, we choose to show the results of all five specifications (Beck-Lewis 1993–1994; Beck-Lewis 1980; Gilderbloom et al. 2012). For good measure, we also provide regression runs of variables that were not shown to fit our original theoretical model.

Findings

Many of the control variables showed significance in the predicted direction. As noted above, the independent variables used are taken from previous studies and have been shown to be significant in measuring neighborhood effects (Smith et al. 2011). For the most part, the control variables operate as expected and raise no concerns. High crime neighborhoods reduce life expectancy. Low-income neighborhoods reduce life expectancy, perhaps due in part to poor access to well-paying jobs, medical care, healthy food choices, and opportunities for exercise.

Equation 1, 2 and 3 found that our proxy measure for average age of housing showed no impact at the .05 level but hovered around .11. In later equations (4 and 5), we removed average age of housing stock because it was not significant at the .05 level and in doing so we obtained a more precise estimate of environmental degradation. This also suggests that older housing, which used lead paint, was not a significant cause of reduced life expectancy.

Our focus here is to control for variables that make both theoretical sense and show statistical significance so we can tease out the net effect of environmental degradation on neighborhood premature death rates. Our models all have high-adjusted R-square statistics showing that these variables collectively explain about three-fourths of the variation in YPLL. Table 2 presents five different specifications of our model rotating out proximity to Rubbertown and brownfields along with key control variables, a process, which allows for estimates that are more accurate.

We found that one of the major causes of premature deaths was proximity to Rubbertown's toxic contaminants, an effect that, according to beta values, ranked fourth after race, income, and crime. We felt it was important to parcel out the impact of brownfields located outside of Rubbertown. Brownfields also had an independent effect on neighborhood life expectancy, although ranking below proximity to Rubbertown. We found these effects of our environmental measures (Rubbertown and brownfields) when run together in Equation 5; the two beta coefficients added together measuring environmental degradation were nearly as powerful as both race and income in shaping neighborhood lifespan. Equation 5 was robust with all control and test variables predicting neighborhood lifespan explaining three-fourths of the variation among neighborhoods. Our odds that Rubbertown is not a contributing factor to premature neighborhood death rates are at least one out of a thousand (brownfields would be one out of hundred).

Additional regression equations—education and medical access

The argument made by Greater Louisville Project that lack of access to medical care is a cause of premature deaths was not supported in Table 3 equation 1. The argument made is that if residents had better access to quality medical care that was close by, life expectancy would be increased. However, access to medical care does not appear to prevent early deaths in neighborhoods, as Rubbertown neighborhoods are closer to the largest highest quality medical complex in the region than are other neighborhoods. Moreover, the locations of brownfields outside of Rubbertown are sometimes even closer to medical facilities. Medical access is not a true cause of how lives are cut short but a response to environmental degradation. This would be like saying large medical centers cause people to get sick instead of well—it might be a correlation but not a cause.

We have acknowledged previously that education is highly correlated with premature death rates. Therefore, we included education as a variable in our analysis. With education in the equation, the effects of income, brownfields and Rubbertown are eliminated as factors influencing reduced life expectancy. As expected, we found education to be highly correlated with several other control

Table 1. Descriptive Statistics.

Measure	Source	Years	Measure	All Neighborhoods in Louisville			Rubbertown Neighborhoods			Non Rubbertown Neighborhoods		
				Mean	Std. Dev.	Range	Mean	Std. Dev.	Range	Mean	Std. Dev.	Range
Distance to the central business district tract (49) in miles	GIS	2000	Miles	7	4	18.6	4.7	2.2	9.6	7.8	4.2	18.6
Percent of nonwhite residents	Census	2000	Ratio* 100	25.4	29.5	98.1	52.6	37.8	92.9	16.4	19.3	94.4
Number of housing units	Census	2000	Count	1296.4	605	3348	1260.1	590.5	3174	1308.3	611.5	2708
Median housing age	Census	2000	Years	38.7	15.1	58	45.6	11.1	58	36.5	15.5	56
Total crimes per 100,000 residents	LMPD	2007	Rate per 100,000	6500.3	5432.8	51022.9	7840.3	4109	16518.5	6060.7	5747.7	50987.9
Median household income	Census	2000	Dollars	40524.5	19527.8	104386	26915.6	8798.3	40118	44989	20027.8	103729
Years of Potential Life Lost (YPLL) rate per 100,000	LMHD	?	Rate per 100,000	8455.6	3883.7	19210.6	11992.4	3274.5	12995.2	7295.2	3334	19210.6
Percent with a high school diploma	Census	2000	Ratio* 100	79.7	12.5	55.9	68.6	9.6	40.6	83.4	11.1	42.9
Population, 2000	Census	2000	Count	4080	1670.6	8912	3643.9	1513.8	7917	4223.1	1700.1	8632

Table 2. The Impact of Rubbertown (Dichotomous Measure) on Neighborhood Years of Potential.

Life Lost

Specification	Model 1: Rubbertown		Model 2: Superfund		Model 3: Superfund + Rubbertown		Model 4		Model 5	
	Unst.	Beta	Unst.	Beta	Unst.	Beta	Unst.	Beta	Unst.	Beta
(Constant)	6614.96***	-	6661.11***	-	6242.83***	-	7325.8***		7250.86***	
Standard error	965.66***	-	967.56***	-	961.13***	-	757.26***		43.53***	
Percent of nonwhite residents, 2000 (ratio*100)	45.7***	.35***	50.8 ***	.386***	45.24***	.34***	48.93***	.372***	43.54***	.331***
Median housing age 2000	20.71	0.08	22.23	.086	20.84	.081	-	-	-	-
Median household income, 1999 (2000 Census)	−0.06***	−.3***	−.061***	−.31***	−.057***	−.29***	−.07***	−.335***	−.07***	−.325***
Total crimes per 1,000 residents 2007	334.5***	.277***	294.23***	.244***	300.63***	.25***	323.6***	.268***	324.18***	.269***
Near Rubbertown (1/0)	1042.53**	.116**	-	-	1701.87**	.19**	-	-	1761.52***	.196***
Brownfield Site (1/0)	-	-	806.06*	.103*	-	-	1029.79**	.131**	-	-
Brownfield Sites (1/0) (Excluding those in Rubbertown Sites)	-	-	-	-	881.38**	.12**	-	-	879.1**	.119**
F	99.08		98.54		86.4		123.9		102	
R Square	0.751		.75		.76		0.75		0.75	
Adjusted R Square	0.74		.743		.75		0.74		0.75	
N	169		169		169		169		169	

Table 3. The Impact of Rubbertown (Dichotomous Measure) on Neighborhood Years of Potential Life Lost.

Specification	Model 6		Model 7	
	Unst.	Beta	Unst.	Beta
(Constant)	8918.9***	-	18667.14***	-
Standard error	732.34***	-	1542.63***	-
Percent of nonwhite residents, 2000 (ratio*100)	40.6***	.308***	41.5***	.32***
Distance to the CBD Hospitals (in miles)	−16.3	−.17	-	-
Median household income, 1999 (2000 Census)	−.07***	−.38***	−.017	−.086
Total crimes per 1,000 residents 2007	.114**	.159**	191.226***	.159***
Near Rubbertown (1/0)	1148.65*	.128*	458.7	.051
Brownfield Site (1/0)	1111.6**	.141**	-	-
Brownfield Sites (1/0) (Excluding those in Rubbertown Sites)			374.9	.051
Percent of individuals 18 and older with a High school diploma/equivalent or higher	-	-	−150.2***	−.484***
F	73.5		129.7	
R Square	.73		.83	
Adjusted R Square	.72		.82	
N	169		169	

*.05

variables including income and race. Education and environmental exposure contain potential interactions, which may make it difficult to differentiate the independent effects of each factor. Education being correlated positively with income, demonstrates the upward mobility of education, thus demonstrating its ability to allow individuals to access neighborhoods with better quality. Additionally, education levels tend to be higher in more affluent neighborhoods that have less exposure to environmental degradation. This raises multi-collinearity issues. The amount of explained variation is slightly higher, but it masks the net impacts of income and environmental degradation.

While education is a key to enabling someone to move to a cleaner community, it does nothing to address the problem of environmental degradation. In a sense, this might constitute preventing problems that arguably cannot be cured at least for those with the education that enables them to move. However, a practical reality is that we cannot simply empty out neighborhoods with populations totalling 100,000 persons. Place based remediation of environmental degradation gets to the cause of these problems and constitutes a more practical approach to preventing premature deaths.

Other statistical tests

Since the data used in this research was nested in a spatial relationship, there is a potential for it to be biased due to spatial dependence. Considering this, we tested the model for spatial autocorrelation. In doing so, the LaGrange Multiplier indicated that the model did suffer from spatial lag and in running both a spatial lag model (SLM) and a spatial error model (SEM), we found the SLM was a better fit for the data and had higher levels of significance. However, both models' likelihood ratio test indicated that spatial dependence is still present. The results of the model revealed no significant changes in the test variable's (Rubbertown) statistically significant impact on neighborhood disparities in years of projected life lost. Therefore, being within the Rubbertown boundary presented here or within a one and a half mile radius of a brownfield site still has a significantly correlated relationship with years of potential life lost. We also found that the education variable washes out in terms of statistical significance on the lifespan measure, further demonstrating the theoretical challenges to education as a causal factor.

Additionally, in order to better understand the power of each coefficient of the control and test variables to explain years of potential life lost, we transformed scale (non-dummy) variables, including our dependent variable, into z scores and reran the regressions.[1] The interpretation of the standardised coefficients from these models provide a more accurate interpretation of the substantive magnitude of each variable. The weight of the coefficient is calculated by measuring for every one standard deviation change in the dependent variable the change in the standard deviation for the independent variables. After conducting this specification, we discovered that our Rubbertown variable exceeds the impact of the crime variable, but the variables controlling for race and income remain the most powerful in the model.

We have used several statistical methods to test whether proximity to Rubbertown explains neighborhood disparities in premature death rates. We found, in each test, the same results:

1. Cluster analysis—Rubbertown was statistically significant.
2. Discriminant analysis–Rubbertown was statistically significant.
3. Regression runs—all five specifications of the model proved that Rubbertown was consistently statistically significant.
4. Z score conversion runs of the independent variables showed statistical significance and moreover, the coefficient weight became stronger over crime variable.
5. Spatial autocorrelation analysis showed that key test variable Rubbertown remained significant while education dropped out.

Policy implications and conclusions

The Greater Louisville Project (2013), argues that education, or more specifically the lack of education, is associated with higher levels of premature deaths in Louisville neighborhoods while environmental conditions have little effect. We stated concerns with that report and offered another examination of years of potential life lost in Louisville. We do note that education is important when it comes to improving one's social mobility and life opportunities; people have more opportunities to leverage education to move to better neighborhoods. Providing educational opportunities may be one part of the solution. However, problem definitions and solutions concerning life expectancy that focus on socio-economic characteristics of residents while ignoring the physical space in which people reside leaves environmental degradation and its effects unchecked. This can lead to greater inequalities in the health of neighborhood residents within the city. Louisville is not alone in these kinds of issues. In another paper, we rank cities and show these challenges show up in a number of midsize cities (Gilderbloom et al. 2020).

Lower-income communities and racial and ethnic minority populations have historically been the target of disproportionate amounts of pollution. To provide more insight into these problems, our study builds on previously published regression models. This kind of modeling allows us to better understand the impacts of neighborhood environmental toxins on health. In doing so, we advance the notion that neighborhoods located on or near sites of concern shorten lives. The data shows that people live longer, up to 10 years longer, in neighborhoods that are located away from environmental hazards. Inequalities are generated within and among cities that contribute to varying life chances, including the length of life itself. Everyone who lives, works, attends school or spends substantial time near these sites pay a price.

Instead of responding with more pills, radiation, implants, cutting and gadgets, why not address the causes of these premature death rates? Why not remove the toxins in what we drink, breathe, and plant in our neighborhoods? We are spending billions of dollars to find a cure for diseases that kill while ignoring the causes of these problems.

These realities require more proactive rather than reactive policies. As the Physicians for Social Responsibility (n/d) point out, the focus should be on "preventing what we cannot cure". One such preventive measure is ensuring that communities, including poor inner-city neighborhoods, enjoy a clean environment. A cleaner environment also addresses the challenge of climate change (Gilderbloom 2019). Whether through remediating older or abandoned industrial sites or reducing emission from existing sites, more needs to be done to reduce hazardous materials in the environment in order to address inequities on a range of quality of life measures including life expectancy. Furthermore, we urge proponents of environmental protection to shift the focus from life expectancy to healthy life expectancy. This expands the problem definition beyond individual choice and creates encompassing solutions that include addressing environmental degradation. At least part of the remedy for many cities is in the air, water, soil, streets and trees.

Notes

1. Due to length restrictions, the authors did not include these tables. However, they are available upon request to the corresponding author.

Acknowledgements

We would like to thanks to our colleagues, Stella Capek and Joshua Ambrosius who worked with us on this paper and gave us valuable suggestions to improve the manuscript. We also want to thank Sait Sarr for providing assisting us with editing and locating some of the figures. We would also like to thank Leah Callahan, Carla Snyder, Shahbaz Altaf, Chad Frederick, Russ Barnett, James Mains, Jeremy Chesler, Lilly Rose, and the Kentucky Institute for Environment and Sustainability (which is now disbanded) for their support and suggestions.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

Agyeman, J. 2013. *Introducing Just Sustainabilities: Policy, Planning, and Practice*. London: Zed Books.

Appelbaum, R. 1978. *Size, Growth, and U.S. Cities*. New York: Praeger Publishing.

Appelbaum, R. P., J. Bigelow, H. Krammer, H. Molotch, and P. Relis. 1976. *The Effects of Urban Growth: A Population Impact Analysis*. New York: Praeger.

Banzhaf, S. 2012. *Superfund Taint and Market*. Palo Alto: Stanford University Press.

Barnett, R. 2011. *Environmental Issues: Louisville, KY*. Louisville, KY: Kentucky Institute for the Environment and Sustainable Development.

Beck-Lewis, M. S. 1980. *Applied Regression*. Newbury Park, CA: Sage.

Beck-Lewis, M. S. 1993–1994. *International Handbooks of Quantitative Applications in the Social Sciences (6volumes)*. Thousand Oaks, CA: Sage.

Been, V. 1995. "Analyzing Evidence of Environmental Justice." *Journal of Environmental Land Use and Environmental Law* 11: 1–37.

Bullard, R. D. 1990. *Dumping in Dixie: Race, Class, and Environmental Quality (Vol. 3)*. Boulder, CO: Westview Press.

Bullard, R. D. 2000. *Dumping in Dixie: Race, Class, and Environmental Quality*. Boulder, CO: Westview Press.

Chetty, R. M., S. Stepner, S. Abraham, B. Lin, N. Scuderi, A. Turner, D. Bergeron, and D. Cutler. 2016. "The Association Between Income and Life Expectancy in the United States, 2001-2014." *Journal of the American Medical Association* 315 (16): 1750–1766.

Dannenberg, A. L., H. Frumkin, and Richard J. Jackson. 2011. *Marking Healthy Places: Designing and Building for Health, Well-Being and Sustainability*. Washington D.C.: Island Press.

Environmental Protection Agency. 2011. *This is Superfund: A community guide to EPA's Superfund program*. http://www.epa.gov/superfund/community/today/pdfs/TIS%20FINAL%209.13.11.pdf.

Environmental Protection Agency. 2012. Facility *registry system state CSV download file descriptions*. Retrieved from: http://www.epa.gov/envirofw/html/frs_demo/geospatial_data/geo_data_state_combined.html.

Environmental Protection Agency. 2013. *Superfund sites* Region 4. Retrieved from http://www.epa.gov/region4/superfund/sites/sites.html#KY.

Frank, L. D., P. Engelke, and T. L. Schmidt. 2003. *Health Community Design: The Impact of the Built Environment on Physical Activity*. Washington D.C.: Island Press.

Frederick, C., and J. Gilderbloom. 2018. "Commute Mode Diversity and Income Inequality: an Inter-Urban Analysis of 148 Midsize US Cities." *Local Environment: The International Journal of Justice and Sustainability* 23 (1): 54–76. doi:10.1080/13549839.2017.1385001.

Frederick, C., A. Hammersmith, and J. I. Gilderbloom. 2019. "Putting "Place" in its Place: Comparing Place-Based Factors in Interurban Analyses of Life Expectancy in the United States." *Social Science and Medicine* 232: 148–155.

Gilderbloom, J. I. 2008. *Invisible City: Housing, Poverty and New Urbanism*. Austin, TX: University of Texas Press Winter.

Gilderbloom, J. I. 2009. "Amsterdam: Planning and Policy for the Ideal City?" *Local Environment* 14 (5): 473–494.

Gilderbloom, J. I. 2016a. "Ten Commandments of Urban Regeneration: Creating Healthy, Safe, Affordable, Sustainable, and Just Neighborhoods." *Local Environment: The International Journal of Justice and Sustainability* 21 (5): 653–660. doi: 10.1080/13549839.2015.1005467.

Gilderbloom, J. I. 2016b. "The Causes of Shorter Life Expectancies in America." New York Times. April 11. A-19 letter Opinion Section.

Gilderbloom, J. I. 2019. "The Future of Cities: The End of Marxism and the Promise of Green Urbanism." *Journal of Urban History* 110. doi:10.1177/0096144218764406.

Gilderbloom, J. I., and R. Appelbaum. 1988. *Rethinking Rental Housing*. Philadelphia: Temple Univ. Press.

Gilderbloom, John, Chris Bird, Karrie Quenichet, Chris Manella, Calvin Dwenger, Lilly Rose, Sait Sarr Altaf, Shahbaz Altaf, and Chad Frederick. 2020. What Cities are the Most Dangerous to Your Health? Ranking the Most Polluted Mid-Size Cities in the United States Lancet Pre Publication. https://ssrn.com/abstract=3506217.

Gilderbloom, J. I., W. L. Meares, and W. Riggs. 2014. "How Brownfield Sites in Neighborhoods Kill Places and People: an Examination of Neighborhood Housing Values, Foreclosures, Crime and Lifespan." *Journal of Urbanism: International Research on Placemaking and Urban Sustainability* 9 (1): 1–18.

Gilderbloom, J., W. Riggs, and W. L. Meares. 2015. "Does Walkability Matter? An Examination of Walkability's Impact on Housing, Values, Foreclosures and Crime." *Cities* 42: 13–24.

Gilderbloom, J. I., A. G. Squires, M. Hanka, and Z. Kenitzer. 2012. "Investors: the Missing Piece In the Foreclosure Racial gap Debate." *Journal of Urban Affairs* 5 (December): 559–582.

Gilderbloom, J. I., G. D. Squires, W. Riggs, and S. Čapek. 2017. "Think Globally, act Locally: Neighborhood Pollution and the Future of the Earth." *Local Environment: The International Journal of Justice and Sustainability* 22 (7): 894–899. doi:10.1080/13549839.2017.1278751.

Goodman, P. 1960. *Growing up Absurd*. New York, NY: Vintage Books.

Greater Louisville Project. 2013. *Building a Healthier Louisville*. Louisville, KY: Community Foundation of Louisville.

Hamilton, J. 1995. "Testing for Environmental Racism: Prejudice, Profits, Political Power?" *Journal of Policy Analysis and Management* 14 (1): 107–132.

Hipp, J. R., and C. M. Lakon. 2010. "Social Disparities in Health: Disproportionate Toxicity Proximity in Minority Communities Over a Decade." *Health and Place* 16 (4): 674–683. doi:10.1016/j.healthplace.2010.02.005.

Kuehn, B. M. 2014. "WHO: More Than 7 Million air Pollution Deaths Each Year." *Journal of the American Medical Association* 311 (15): 1486. doi:10.1001/jama.2014.4031.

Lancet. 2013, September 21. " Action on Ambient air Pollution." *The Lancet*. [Editorial] 382 (9897): 1000. doi:10.1016/S0140-6736(13)61960-1.

Massey, D. S. 2004. "Segregation and Stratification: a Biosocial Perspective." *Du Bois Review: Social Science Research on Race* 1 (01): 7–25.

McMeekin, I. M. 1946. *Louisville: The Gateway City*. New York: Julian Messner.

Moyer, B. 2001. *Trade Secrets: A Moyers Report*. New York: PBS.

Organization for Economic Co-operation and Development. 2012. *Environmental Outlook to 2050: The Consequences of Inaction*. Washington, DC: OECD Publishing.

Pahl, R. E. 1975. *Whose City?* London, England: Penguin.

Pastor, M., J. Sadd, and J. Hipp. 2001. "Which Came First? Toxic Facilities, Minority Move-in, and Environmental Justice." *Journal of Urban Affairs* 23 (1): 1–21.

Physicians for Social Responsibility. n/d. *Website Slogan*. http://www.psr.org.

Richardson, T. 1998. The Effects of Race on Public Health Planning: An analysis of Premature Mortality in an Urban Environment. Doctoral Dissertation. Louisville, KY: University of Louisville.

Smith, C. L. 2009. "Economic Deprivation and Racial Segregation: Comparing Superfund Sites in Portland, Oregon and Detroit, Michigan." *Social Science Research* 38 (3): 681–692.

Smith, P., M. Pennington, L. Crabtree, and R. Illback. 2011. *Louisville Metro Health Equity Report: The Social Determinants of Health in Louisville Metro Neighborhoods*. Louisville, KY: REACH of Louisville, Inc.

Swanston, S. F. 2012. "An Environmental Justice Perspective on Superfund Reauthorization." *Journal of Civil Rights and Economic Development* 9 (2): 18.

United States Census Bureau. 2012. *American Community Survey*. http://www.census.gov/acs/www.

Wong, E. 2013, April 2. Early deaths linked to China's air pollution totaled 1.2 million in 2010, Data Shows. New York Times, A9.