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UMASS

PROXIMITY TO INDUSTRIAL RELEASES OF TOXINS AND CHILDHOOD RESPIRATORY, DEVELOPMENTAL, AND NEUROLOGICAL DISEASES: ENVIRONMENTAL ASCRIPTION IN EAST BATON ROUGE PARISH*

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ABSTRACT: Recent research by Legot et al. (2010a, 2010b) has identified East Baton Rouge Parish (EBR) as a locus of particularly high volumes of emissions of developmental neurotoxins, i.e., those toxins that put children's health and, especially, learning abilities at greatest risk. Many developmental neurotoxins are also classified as respiratory toxins, which are also linked to the sorts of childhood diseases (e.g., asthma) that impact school performance. This case study specifies the degree to which proximity to the main sources of these toxins in EBR is associated with high rates of neurodevelopmental diseases and childhood asthma. We also examine the relationship between proximity to toxins and race and class. We find very strong patterns: disease rates are significantly higher in zip codes close to pollution "hot spots" than in more distant zip codes, as are percent minority and percent poverty. This is evidence of "environmental ascription", the existence of multiple, overlapping ascriptions based on race, class, and "place". Vulnerable populations are disproportionately exposed to the sorts of toxins that limit their life chances.

Key Words: environmental ascription; developmental neurotoxins; respiratory toxins; childhood diseases; vulnerable populations

JEL Codes: Q53; I19; J15

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INTRODUCTION

Many environmental inequality (EI) studies have shown that sources of toxic pollution are often located near communities inhabited by a disproportionate number of minorities and the poor (Ash and Fetter, 2004; Bullard et al., 2007; Downey at al. 2008; Downey, 2006a,b; Fitzgerald et al. 2009; Mohai and Saha, 2006; Mohai and Bryant, 1992; Stretesky and Lynch, 2002). These studies often begin with a focus on a specific geographic region or category (e.g., metropolitan areas) and rely on residential *proximity* to a pollution source as an indicator of exposure, often finding evidence of environmental inequality. The extent and *causes* of such unequal exposures have been extensively documented. However, one of the core (albeit usually implicit) assumptions of EI proximity studies is that living close to pollution sources has *consequences*. More research that documents or specifies the health, educational, and life-chance consequences of exposure to toxins is clearly warranted.

Some recent research on these issues combines the focus of traditional environmental inequality studies with a novel focus on yet another vulnerable subset of the population: children (Pastor et al., 2004, 2002). Children are especially susceptible to suffering the harms of exposure to environmental toxins (Morrison and Heath 2008; Grandjean and Landrigan 2006; Landrigan 2002; Kaplan and Morris 2000). Therefore, the study of environmental inequality among children necessitates an increased focus on the consequences of disproportionate exposures. According to Pastor et al. (2004), who were among the first researchers to explicitly examine this problem, “In some communities, parents have complained of diminished school performance among their children because of health effects associated with outdoor and other pollution… The

growing sense is that there may be a link between disparate levels of air pollution and differences in human-capital formation and realization" (Pastor et al. 275). More recently, a study by Legot, London and Shandra (2010a) (see also Legot et al. 2010b) focusing specifically on high volume polluters (HVPs) of developmental neurotoxins found that these HVPs were often located near large numbers of schools and children, and that these numbers were positively and significantly correlated with measures of race and class. Considering these exploratory findings, the authors point to the potential existence of "environmental ascription"—in other words, that in addition to the socially-constructed ascriptive factors of race and class, scholars should also consider the *place* where a child lives and attends school as another, often interrelated and overlapping ascriptive force. In contrast to earlier environmental inequality studies (which focus on proximity to *general* sources of pollution such as superfund sites), Legot, London and Shandra's study began with a focus on those *specific toxins* that have the greatest potential to harm a child's learning/cognitive abilities. Hence, the results can be considered "hypothesis-generating" in the sense that it is crucial for future research to establish a connection between the *potential* for children facing multiple, overlapping ascriptions, and the *reality* of whether or not communities actually experience elevated levels of certain health problems that can be detrimental to human capital.

One way to do this is through a case-study approach looking at those communities that have been labeled by previous national research on environmental inequality as "hot spots," or, the "worst of the worst" in terms of HVPs being located in close proximity to large, primarily minority and poor populations and high numbers of schools and children. This is precisely what the present study begins to do. One such "hot spot" discovered in the Legot et al. research is East Baton Rouge (EBR) Parish, Louisiana. Among other large industries, EBR Parish is home

to two large ExxonMobil facilities (one refinery and one chemical plant), sited within a mile of each other and in close proximity to a large minority and poor population and a number of schools. A large Honeywell Chemical facility is also located within two miles of the Exxon facilities (see below for more detail). These facilities are among the top emitters of developmental neurotoxins in the United States (see Legot et al., 2010b). Previous research, from both locally-based activist groups such as the Louisiana Bucket Brigade (LABB) and the Louisiana Environmental Action Network (LEAN), as well as from nationally-focused organizations such as the Political Economy Research Institute (PERI) at the University of Massachusetts, has also highlighted the ExxonMobil facilities in particular as especially damaging in terms of overall emissions and their disproportionate impact on vulnerable populations. In this regard, the most recent version of PERI's "Toxic 100" indicates that 75.4% of the total risk from the Exxon Mobil refinery is borne by minorities, while 33.3% of that risk is borne by the poor. The corresponding rates for the Exxon Mobil chemical plant are 68.5% and 27%. To place these figures in context, we note that the overall percent minority in EBR is 44.4%, while that of the state of Louisiana is 32.1%. Therefore, the percent of risk from Exxon Mobil pollution borne by minorities is clearly disproportionate relative to the parish and state minority populations. The same is true regarding poverty. The parish and state overall percent poverty (17.2% and 17.6%, respectively) is much lower than the risk of pollution from Exxon Mobil facilities borne by the poor.

ExxonMobil was ranked second on PERI's "Toxic 100," which lists the worst corporate air polluters in the U.S., taking "into account not only the quantity of releases, but also the toxicity of chemicals, transport factors such as prevailing winds and height of smokestacks, and the number of people exposed" (http://www.peri.umass.edu/toxic_press/). Among the

company's many U.S. facilities, the Baton Rouge refinery and chemical plant were considered (respectively) to be the two worst facilities in terms of their toxic scores (quantity x exposure x toxicity x population). Similarly, LABB's "Common Ground" report notes that within a 2-mile radius of the ExxonMobil refinery, the second-largest oil refinery in the U.S. and the refinery with the highest level of accidental emissions in the state, there is a much higher percentage of minority (86.7% versus 39.6%) and poor (34.1% versus 17.8%) residents when compared with the rest of EBR Parish ("Common Ground" 7). The report also quotes numerous residents that lament the unusual number of health afflictions faced by friends, neighbors, even their own children. Through many such anecdotal accounts, locally-based activist reports often allude to, but do not empirically evaluate, the implicit claims that those living proximate HVPs such as the two ExxonMobil facilities face a higher incidence of a broad range of health problems, many of which can, in turn, act as a detriment to individual life chances or community-level human capital.

Although few studies in the social sciences have focused on the connections between "environmental inequality, health and human capital," (Pastor et al., 273) there has been a considerable amount of epidemiological and toxicological research that guides the methodology in the present study. For instance, using hospital inpatient discharge data by zip code of residence, several studies by Carpenter and colleagues (Baibergenova et al., 2003; Carpenter et al., 2003; Huang et al., 2006; Kouznetsova et al., 2007; Kudyakov 2004; Shcherbatykh et al., 2005) have examined the prevalence of various diseases linked to environmental contaminants in New York State by comparing rates of health problems such as low birth weight (Baibergenova et al., 2003), respiratory disease (Kudyakov et al., 2004), and infectious disease in children (Carpenter et al., 2003), in zip codes containing or adjacent to hazardous facilities with rates in

other “clean” zip codes. The authors note that using zip code of residence is a “very crude measure” of individual exposure, but it is often the best data available because personal identifiers contained in hospitalization and illness records are confidential. However, this limitation does not mean that assessments using zip code proximity to hazards as an indicator of exposure are not useful; in a study focusing on rates of diabetes and proximity to hazardous waste sites, the authors suggest that “[d]espite the limitations, one might argue that if we find such clear elevations of rates of diabetes when our exposure assessment is so crude, the real relationship between disease and exposure is likely much stronger” (Kouznetsova et al., 2007:78-79). Similarly, a study (DeSoto 2009) finding a relationship between residence in a school district proximate to an EPA Superfund site and rates of autism in children relied on school districts as the unit of analysis. Acknowledging the possibility that some families had relocated, the author still reasons that “if exposure to toxins (prenatally or in early childhood) is playing any causal role in the increase in diagnosis… then proximity to a NPL Superfund location should serve to increase the observed prevalence” (DeSoto 2009:4).

Taken together, these considerations inform the present study. We will attempt to determine whether or not proximity to the already identified high volume releases of developmental neurotoxins in EBR has a demonstrable impact on precisely those childhood diseases that are likely to be caused by exposure to these toxins: childhood asthma and neurodevelopmental diseases (see below). Do places with high levels of developmental neurotoxin releases also have high levels of the specified childhood diseases? At this juncture, it is important to note that many recognized and/or suspected developmental toxins and neurotoxins are also classified as “suspected respiratory toxins” (www.scorecard.org). It is common for chemicals to be associated with multiple health effects. For example, a number of

the specific developmental neurotoxins released by the previously-identified HVPs in EBR are also suspected respiratory toxins. The following highly toxic chemicals are released by Exxon Mobil and/or Honeywell (www.scorecard.org): benzene, lead, chloromethane, mercury, and carbon tetrachloride. All of these are associated with all three health effects. Consequently, it is possible that some of the same toxins that are causally linked to neurodevelopmental diseases are also causes of childhood asthma.

Note that this extremely useful classification scheme is the only source that permits researchers to focus, as we do, on *specific* categories of toxins (see above). It (a) lists chemicals by type of health impact (i.e., developmental, neurological, respiratory, and others), and (b) specifies industrial sources of these categories by volume using data from EPA's Toxic Release Inventory (TRI) for the year 2002. It is available only on www.scorecard.org/health-effects/ , a website created by Environmental Defense, and currently maintained by Green Media Toolshed. Using information from scholarly, scientific research and regulatory agencies, Scorecard provides lists of chemicals that lead to several types of health impacts. "Chemicals whose health hazards are widely recognized by authoritative scientific organizations are separated from chemicals whose health hazards are suspected on the basis of more limited data." Lists are available for a dozen different adverse health effects, including those presently under consideration. "Developmental toxicants are agents that cause adverse effects on the developing child…(such as) psychological or behavioral deficits that become manifest as the child grows". Scorecard's list of these toxicants was compiled from several references. The primary, most authoritative source is California's Proposition 65 (www.oehha.ca.gov/prop65), but this list is augmented from a number of EPA sources and scholarly publications. The lists of (a) suspected neurotoxicants (substances that can cause adverse effects to the nervous system, including

confusion, fatigue, and other behavioral changes), and (b) suspected respiratory toxicants (substances that can impair respiratory function) are compiled from several EPA offices, committees, and centers; as well as from the CDC's Agency for Toxic Substances and Disease Registry (ATSDR), the California EPA, and a host of other sources.

Emerging toxicology research on pollution's unique, and often magnified, effects on children suggests that many possible health problems can emerge from environmental exposures to a range of contaminants (Landrigan et al., 2002). One of the most definitive links in the research thus far is between exposure to a range of air pollutants and the acquisition or aggravation of respiratory problems. Previous research linking pollution exposure and human capital attainment has also adopted this focus, suggesting that elevated exposure to air pollutants can result in increased school absences—both through actual occurrences of illness and through 'avoidance behavior' on the part of parents— (Currie et al. 2009; Neidell 2004; Crain 2000). The direct effects of living with a chronic respiratory illness such as asthma, as well as the implications of higher absenteeism associated with asthma, can consequently result in lower academic performance (Pastor et al., 2004; 2002). While most such studies have been conducted on a case-study basis in specific regions or cities, the problems associated with childhood respiratory problems are of national concern; according to the CDC, "[a]sthma is the third-most common cause of childhood hospitalization, resulting in $3.2 billion in treatment costs and 14 million school days lost annually" (GAO 2008).

Although the empirical data on environmental contaminants' effects on development and neurological functioning is far more limited than the data on respiratory illness (Morrison and Heath 2008; Wright et al., 2006; Landrigan et al., 2002; Crain 2000), these illnesses have an

especially high potential to exert a direct negative impact on academic achievement. Thus, we also include the prevalence of various neurodevelopmental disorders (see below) in our case study of EBR, allowing for a more complete picture of the range of potential effects that childhood residence in this "hot spot" exerts over human capital.

DATA AND METHODS

Our primary goal is to test the general hypothesis that children living in close proximity to toxic air pollution are more likely to have respiratory and developmental or neurological diseases than children living further away. In other words, as distance from spatial concentrations of developmental neurotoxins and respiratory toxins increases, rates of specified illnesses will decrease.

Testing this hypothesis requires that we (a) specify the existence and location of high concentrations of general toxins and developmental, respiratory, and neurotoxin releases, and (b) obtain data on specific illness rates by location. We approach the first goal by using TRI-based data from www.scorecard.org to specify the spatial distribution/concentration of toxic pollution in East Baton Rouge Parish in 2002. There are several important limitations to consider when using TRI data, especially when it is used in relation to potential health (and human capital) outcomes that may result from exposure. First, TRI data report total chemical releases with no information on the toxicity or the fate of these chemicals once they enter the environment (EPA). Thus, considering TRI releases is not the same as considering actual human exposure to those releases (EPA). Also, not all sources of emissions for a given pollutant (e.g., mobile sources, or non-industrial sources) are required to report to the EPA because of minimum reporting requirements. Further, TRI emissions data are self-reported by those facilities that meet a

certain emissions threshold, and these figures are often estimated by the facilities, so there is the possibility of variation in methodology for estimating and measuring emissions among various facilities (EPA). A final limitation noted by Downey (2008), is that the latitude-longitude coordinates provided to the EPA sometimes do not accurately reflect the exact physical location of the reporting facility. Recent research such as that by Crowder and Downey (2010) suggests that despite various concerns with the use of TRI data, these data "are still the most comprehensive and detailed publicly available national record for industrial facility activity available to researchers" (1120). Despite the drawbacks, the use of TRI data is essential for our current purposes because, as explained above, scorecard.org is the only resource for viewing a ranking of the top emitters of specific categories of toxins based on potential health effects (e.g., the top one hundred polluters of suspected neurotoxins); and, this resource is TRI-based. A central contribution of our study is the focus on proximity to those specific toxins that have the greatest potential to contribute to diminished academic performance among children, and hence to degrade a community's future reserve of human capital. Thus, the benefits of the use of TRI data outweigh the potential limitations because our assessment would not be possible without Scorecard's classification scheme.

As noted above, recent research by Legot et al. (2010 a, b) identified EBR as a toxic "hot spot" because several of the nation's highest-volume polluters of developmental neurotoxins are located there. Additional information on pollution in EBR and Louisiana is readily available. Table 1 shows pollution rankings (www.scoredard.org/ranking) for both EBR Parish and the state of Louisiana in 2002 for (a) several types of toxic releases, and (b) all criteria air pollutants. (While our focus is on toxins, we include data on CAPs here simply for added detail). It is clear that, in national terms, Louisiana is a highly polluted state, ranking in the top half of states on all

observations but one. Moreover, rankings are especially high for toxic releases. Roberts and Toffolon-Weiss (2001:vii) describe Louisiana as "a state that has been called a "pollution haven": a place where companies come to exploit natural resources, cheap energy, nonunion labor, tax breaks, and lax environmental enforcement". And, EBR is one of the most highly polluted parishes in the state, never ranking lower than seventh (of 64) in Table 1, while ranking between first and third on 11 of 14 observations. Roberts and Toffolon-Weiss (2001:6-7) describe the view from the interstate of "the huge Exxon refinery looming just behind" the state capital. "The construction of that refinery in 1909 anchored the development of the petrochemical pole here…"

> "In driving just ninety minutes (from east New Orleans to Baton Rouge), a motorist on I-10 has passed 156 facilities, which are the sources of 129.3 million pounds of toxic releases each year, as reported by the petrochemical firms themselves. This equals over one-sixteenth of the entire emissions in the United States of America. How did this "Chemical Corridor" (as the industry calls it) or "Cancer Alley" (as environmental justice advocates call it) get to be this way? One explanation is that the proximity to rich gas and oilfields and the ability of the river to handle ocean-going tankers made industry keenly interested in the area. Another is that, due to their poverty and lack of political power, the poor rural communities along this Delta floodplain have had to welcome any firm…Some observers point out that people simply didn't know what was coming into their communities, and, when they did come, they were simply unaware or misinformed of the potential health effects. Another common explanation is that a majority of Louisiana politicians, like those in most places dependent on oil, have always been more attentive to the needs of industry than those of average residents and corrupted by the concentrated wealth oil brings".

Taken together, all of these historical, numerical, and descriptive observations suggest that we are studying within-parish patterns for a highly polluted parish in a highly polluted region of a highly polluted state.

Table 2, part (a) lists all facilities that reported toxic releases to the EPA in EBR in 2002 (n=24), and the volume (in pounds) of total releases for each facility. Note that data were not available on the volume released by CMC Steel. Eight of these facilities were in zip code 70805,

while ten were in contiguous zip code 70807. Moreover, the highest volume polluters (Exxon Mobil Chemical, Exxon Mobil Refinery, and Honeywell) are all located in zip code 70805, within a short distance of each other. In fact, these three facilities form a "toxic triangle", with the Exxon Mobil Refinery located less than a mile south of Exxon Mobil Chemical, and the Honeywell facility located less than two miles to the southwest of the chemical plant. These data indicate that there is, in fact, a very high spatial concentration of toxic pollution releases in EBR.

Table 2, part (b) presents similar information for suspected respiratory toxins and the three categories of developmental neurotoxins. Sixteen facilities report releases of developmental neurotoxins, with seven in zip code 70805 (including very high volumes from the Exxon Mobil and Honeywell facilities noted above) and six in zip code 70807. Nine facilities report releases of respiratory toxins, with six in zip code 70805 (again, including very high volumes from Exxon Mobil and Honeywell) and two in zip code 70807. So, developmental neurotoxin pollution and respiratory toxin pollution are also concentrated in the same zip codes, with 70805 showing a particularly high volume of releases. While most polluters and pollution by volume are located in these two zip codes, there are also reporting facilities in zip codes 70810, 70814, 70815, and 70791. Only one facility is found in each of the first three of these zips codes. Moreover, emission levels tend to be low and/or not in the categories under consideration. Zip code 70791, however, the city of Zachary, has three TRI facilities that release about a million pounds of toxins, including substantial volumes of developmental, neurological and respiratory toxins. Zachary's disease rates are above average, but lower than the means for the targeted toxic zip codes. On the other hand, Zachary's percent minority and poverty are well below the means for the highly polluted zip codes. So, this community (which is about 12 miles from our toxic "hot spot") with its high level of toxic releases, coupled with above average

disease rates, but low poverty and minority populations, may merit further consideration at a later date.

Finally, there is one additional way to empirically describe patterns of pollution by facility in EBR. The EPA's Risk Screening Environmental Indicators (RSEI) program (www.epa.gov/oppt/rsei/pubs/get_rsei.html) weights every TRI facility's volume of releases by measures of the toxicity of each chemical released, yielding a hazard ranking for each facility. Facilities may release equal volumes of chemicals, but if the chemicals released by one facility are more toxic than those released by another facility, then the former facility will have a higher hazard ranking. For each chemical released by a facility, RSEI calculates "hazard" as "pounds released" times "toxicity weight", using the inhalation toxicity weight for air releases and the oral toxicity weight for surface water releases. The hazards are then added up over all of the chemicals from a facility to yield a single facility hazard score. In other words, the hazard rankings are more precise indicators of toxic risk than are the simple measures of volume of releases. Table 3 presents RSEI hazard rankings for all facilities reporting to the Toxic Release Inventory in East Baton Rouge Parish in 2002, ranked in descending order by hazard scores based on total on-site releases of toxins to air and water. Also presented are hazard rankings based on air releases only, and information on the pounds of both air and total releases from each facility. The list of facilities in Table 3 (n=22) is almost identical to that in Table 2 (n=24). RSEI omits CMC Steel (which did not have information on total releases available) and the Novolyte facility in Zachary. Note, too, that the "All Pounds" column in Table 3 is almost identical to the "Total on-site releases" column in Table 2. ExxonMobil Refining and Chemical are ranked first and second in both tables, but some of the other rankings change modestly from Table 2 to Table 3. Honeywell for example, was ranked third in terms of volume of releases, but

drops to sixth when ranked by toxicity. DSM (Lion) Copolymer and Formosa, on the other hand, are ranked higher in Table 3, based on toxicity, than in Table 2, based on volume. DSM rises from sixth to fourth, while Formosa rises from eighth to third. Overall, it is clear from Table 3 that zip codes 70805 and 70807 are the most polluted in the parish (as was specified in Table 2), however, 70805's extremely high hazard risk/toxicity level is accentuated in Table 3: five of the top six facilities ranked in terms of hazard are in 70805, as are six of the top ten. Zip code 70807, on the other hand, dominates the middle and lower portions of the rankings.

Taken together, all of these results suggest several measures of "proximity" to be employed in this study. First, we will simply compare mean illness rates in zip codes 70805 and 70807 with those in all other zip codes in EBR. Note that there are 20 residential zip codes in the Parish. Are mean illness rates in proximate (i.e., the two most highly polluted) zip codes substantially different from (i.e., higher than) those in more distant zip codes?

Second, we incorporate more precise measures of proximity or distance by (a) specifying the midpoint between the two Exxon Mobil HVPs in zip code 70805 (a very high release "hot spot")(www.ig.utexas.edu/outreach/googleearth/latlong.html), and (b) measuring linear distance from the centroid of each zip code in the parish to this midpoint (centroid data may be found at http://louisiana.hometownlocator.com). Examination of these distance measures reveals that six contiguous zip codes have centroids that are less than or equal to four miles from the hotspot (70802, 70805, 70806, 70807, 70811, and 70812). Centroids for all other zip codes are between 6 and 13.6 miles away. (In analyses not presented here, we also specify the midpoint between the Exxon Mobil Chemical Plant and the Honeywell facility. This midpoint is .6 miles from the midpoint of the two Exxon Mobil facilities. So, measuring distance from centroids to this second

midpoint produces no meaningful difference in our results). This suggests a final, alternative measure of proximity. Specifically, we will compare mean illness rates in the six proximate zip codes with those in all other zip codes.

As noted above, we also need data on specific illness rates by location to test our hypothesis. Our first step was to develop a list of those specific childhood respiratory, developmental, and neurological diseases that are most likely to be caused by exposure to toxic air in general and developmental neurotoxins in particular. Following the epidemiological studies cited above, we scanned the International Classification of Disease data set (see http://icd9cm.chrisendres.com) to generate the following list of relevant diseases (with their codes): childhood asthma (493), autistic disorder (299.0), delayed development (783.40), specific delays in development (315), attention deficit disorder (314), and cerebral degeneration usually manifested in childhood (330). We asked the Bureau of Policy Research and Health Systems Analysis of the Louisiana Department of Health and Hospitals to provide us with hospital inpatient discharge data by zip code of residence for all of the above ICD codes, for persons under the age of 20, for the years 2002-2006. Cells with fewer than 30 cases must be suppressed to maintain confidentiality. Given this restriction, LDHH was able to provide us with the following: (a) counts of childhood asthma inpatients under the age of 20 discharged between 2002 and 2006, by EBR zip code of residence, and (b) counts of discharged inpatients under the age of 20 for all of the diagnosis codes combined, for the years 2002-2005, by zip code of residence. So, we are able to do analyses for childhood asthma alone, and for all childhood respiratory, development, and neurological diagnoses combined. Note that counts for each zip code are converted to rates by dividing the count by the number of people under the age of 20 (1000's) in each zip code (see www.census.gov). Note, too, that childhood asthma counts were

suppressed for zip codes 70819 and 70770, while counts for all diseases combined were suppressed for zip codes 70819, 70770, and 70818. These low-illness zip codes all have below average minority and poverty populations, and are between 8.1 and 13.6 miles from the Exxon Mobil facilities.

These data are limited in a number of ways. First, data on neurodevelopmental diseases cannot be presented separately because counts are too low. Combining them with childhood asthma data does, however, enable us to do separate analyses for asthma on the one hand, and "all" childhood diseases linked to toxic pollution on the other. This attempt to examine two different indicators of childhood illness by zip code also necessitates that we use data for two different time periods (2002-06 for asthma vs. 2002-05 for combined diseases). If we had been given data on both indicators for the same years, a simple process of subtraction would reveal suppressed data. Of course, the use of hospital discharge data for identification of subjects does not account for patients with these diseases who received treatment solely as outpatients, yielding an undercount of the total population subjected to these diseases. Although most of the neurological dysfunctions we studied are fairly common, they are treated primarily in the outpatient setting (Dr. James Makol, personal communication). This helps to explain why zip code counts are so low. It may well be the case, however, that those people who did require hospitalization were experiencing the most severe cases of the diseases. If this is the case, then our analysis focuses on the relationship between proximity to toxic releases and rates of the most serious related illnesses.

Nonetheless, the fact that we are restricted to the use of inpatient discharge data in our attempt to study illnesses (neurological dysfunctions) that are treated primarily on an outpatient

basis represents a substantial weakness in our analysis. Fortunately, data are available that may serve as a proxy for our measure of neurodevelopmental disease rates. The Louisiana Department of Education presents data on the number of students with disabilities attending each school in the Parish in its school accountability report cards (www.doe.state.la.us/lde/pair/1794.asp). Aggregating these data by zip code of school yields a measure of the total number of students with disabilities attending school in each zip code. Dividing these counts by the total number of school-aged children (ages 5-19) residing in each zip code[1] yields a measure of students with disabilities per 1000 students. This measure may be used as a proxy for the rate of neurodevelopmental disorders only if a substantial proportion of the disabilities included in the original, overall counts are neurological and/or developmental. More specifically, neurological dysfunctions or disabilities are linked to brain and/or central nervous system abnormalities. In some cases, these abnormalities may be considered injuries or deficits, some of which are caused by exposure to toxins. The overall count of students with disabilities includes the following (selected) categories (the percent of students in each category in EBR Parish in 2002 is noted in parentheses): autism (2.3%); deaf-blindness (0%); developmental delay (9.6%); emotional disturbance (2.7%); hearing impairment (1.1%); mental disabilities (7.8%), other health impairment (6.4%); specific learning disability (38.4%); speech-language impairment (28.2%); traumatic brain injury (0.4%); and visual impairment (0.5%) (source: State Special Education Data Profile, 2003. www.doe.state.la.us/lde/uploads/3792.pdf). Of these categories, autism, developmental delay, and specific learning disability are clearly neurodevelopmental disorders. They comprise 50.3% of the total students with disabilities in the Parish. Moreover, a number of other categories may well include a high proportion of neurological/brain dysfunctions. Mental disability, for example, is a category reflecting deficits

in higher brain function, which could, in some cases, be caused by exposure to toxins. Speech and language are also high level brain functions. Some cases of speech/language impairment could be caused by toxins. A similar point can be made regarding emotional disturbances. Behavior abnormalities can accompany brain injury, and this category could include some of the central nervous system effects of mild or even more severe injury from toxins (Dr. James Makol, personal communication). In sum, then, many of the students with disabilities attending school in the parish may well have neurological dysfunctions. Therefore, we will include the disability rate by zip code as a third illness measure in our analysis, treating it specifically as a proxy for neurodevelopmental disorder rates.

Finally, questions arise regarding the etiology of all diseases under consideration. In some cases, exposure may be prenatal; in others it could be postnatal. It is also the case that these diseases may be caused by any number of things other than breathing toxic air, including genetic factors, diet, and exposure to second-hand smoke and criteria air pollutants. Migration histories also present complications. It is possible that discharged patients currently living in a given zip code were exposed to the disease someplace else, or that children exposed to the disease in a given zip code moved after exposure to a nearby district and contribute inaccurately to that place's illness rate. While all of these caveats are important, a simple fact remains: if exposure to toxins is playing any causal role in disease and disability rates, then proximity (at home and/or in school) to high-level toxic releases should increase the observed prevalence (Desoto 2009).

As is incumbent upon any researcher studying environmental inequality, we also gather census data on race (% minority in each zip code) and class (% poverty in each zip code). Table 4, panel (a) compares means for zip codes 70805 and 70807 with all other zip codes in EBR in

2002 on all three of our disease indicators, as well as our measures of race and class. Panel (b) replicates this analysis using a different definition of "proximity": means for the six zip codes closest to the "hotspot" identified above are compared with means for all other more-distant zip codes. Panel (c) presents data for disease rates, race, and poverty for all zip codes. Finally, Table 5 presents a bivariate correlation matrix that includes all indicators of disease, our indicators of race and class, and the measure of linear distance from the centroid of each zip code to the "hot spot" (noted above).

FINDINGS

Overall, we find that mean rates of illness (asthma; asthma, neurodevelopmental disorders combined; and students with disabilities) are significantly higher in those zip codes with the highest level of Toxic Release Inventory emissions (see below for details). We also find that minority and poverty levels are significantly greater in the same high risk zip codes.

Table 2 summarizes the 2002 TRI releases for all facilities in East Baton Rouge. ExxonMobil Refinery released the greatest amount of total toxins (over 2.6 million pounds), followed by ExxonMobil Chemical and Honeywell. ExxonMobil Refinery was also the top emitter of recognized developmental toxins, suspected neurotoxins and suspected respiratory toxins. ExxonMobil Chemical was the highest volume polluter of suspected developmental toxins (over 935,000 pounds). In all categories of toxins, ExxonMobil Refinery, ExxonMobil Chemical and Honeywell were the top three polluters, accounting for: 71.3% of total releases; 89.3% of developmental toxin releases; 78.3% of suspected developmental toxin releases; 67.7% of suspected neurotoxin releases; and, 68.1% of suspected respiratory toxin releases. Table 1 shows that all three of these High Volume Polluters—along with several others— are sited in zip

code 70805, clearly indicating that this can be considered a “hot spot” in terms of these toxic releases. Note also that a considerable number of other HVPs are located in 70807, with the remaining HVPs dispersed among various zip codes. This descriptive representation of pollution in EBR justifies our focus on these two zip codes, as well as our focus on the midpoint of ExxonMobil Refinery and ExxonMobil Chemical, as a frame of reference from which to compare illness prevalence with the rest of the Parish.

Table 4 presents the results of a difference of means analysis comparing the average prevalence of asthma, and all of the neurodevelopmental illness listed above plus asthma, and students with disabilities, for (a) zip codes 70805 and 70807 versus all other zip codes in EBR; and (b) the six zip codes closest to the midpoint of the ExxonMobil facilities versus all others in EBR . In every case, the mean prevalence of illness was significantly higher in the “hot spot” zip codes than in the surrounding area. Table 4 also shows the difference between the mean for proximate zip codes and that for all other zip codes, as well as the ratio of these two values, for all variables in the table. Zip codes 70805 and 70807 have, on average, 11.81 more childhood asthma cases per 1,000 children, 9.57 more “all diseases” per 1,000 children, and 21.15 more students with disabilities per 1000, than do all other zip codes combined. In other words, the asthma rate and the “all disease” rate are both 1.6 times greater in zip codes 70805 and 70807 than in all others, and the disability rate is 1.39 times higher. We see comparable difference and ratio figures in panel (b), which compares means for the six most highly impacted zip codes with all others. Table 4 also illustrates that % minority and % below poverty are, in every case, significantly higher in the most highly polluted zip codes, with ratios ranging from 2.5 to 3.8. Also, given that we are working with a small data set, it makes sense to also show all of the data. Panel (c) of Table 4 presents data on all key variables by zip codes. The zip codes are grouped

by “impact”: the two highly polluted zip codes, the four zip codes within four miles of them, and all other zip codes. These impact patterns may also be presented graphically, in the form of (a) stripplots (see Figure 1. Health and Social Indicators by Zip Code Group), and (b) a map (see Figure 2: East Baton Rouge Major Source Neurological Risk). This map uses census tract data on level of neurological risk from facility pollution, derived from the 2002 National Air Toxics Assessment, to clearly depict the concentration of risk in proximity to our “hot spot”.

Finally, Table 5 is a correlation matrix that shows the relationships between distance from the midpoint of the ExxonMobil facilities, rates of illness/disability, and race and class measures. The correlations between these measures are very strong and in the expected direction. We find that distance from the midpoint and rates of childhood asthma, asthma plus neurodevelopmental illness, and disabilities are negatively correlated (r=-0.63, r=-0.65, and r=-0.68, respectively), meaning that as distance from the midpoint increases, prevalence of these illness decreases. The same relationship is found for our measures of race (r=-0.85) and class (r=-0.81), suggesting that concentrations of minorities and the poor are higher as distance from the midpoint decreases. Additionally, we find strong positive relationships between measures of illness/disability and race (r=0.78, r=0.73, r=0.51), as well as measures of illness/disability and social class (r=0.7, r=0.71, r=0.59).

CONCLUSIONS

Our findings speak to the ascriptive power of place. They reveal a heightened prevalence of certain illnesses in those zip codes most proximate to a pollution “hot spot” area in East Baton Rouge Parish. It is noteworthy that we find such striking within-parish differences in a highly polluted parish in a highly polluted region in a highly polluted state. Exposure to the emissions

from these spatially-concentrated HVPs is likely to place a disproportionate burden on young children by contributing to learning disabilities and respiratory problems, both of which can be detrimental to academic performance. Academic performance is often considered a key indicator of life-chances, or of community level human capital (Pastor 2004; 2002). Studies of ascription typically emphasize the structural disadvantages faced by populations born into marginalized social categories (e.g., minority status, or low socioeconomic status), and how these disadvantages systematically contribute to diminished life chances for these populations. The perpetuation of this systematic disadvantage occurs through the inherited lack of those transformative resources (e.g., cultural capital, social capital, and access to a quality learning environment) that could increase the potential for academic success (and implicitly, the potential for social mobility) within these groups. Our data suggest that there are also marginalized spatial categories, which can also exercise a limiting force over future academic success by physically degrading learning potential. Physical proximity to emitters of high thresholds of developmental neurotoxins during the most formative period of mental development (i.e., childhood) can be considered ascriptive in the sense that some places are more likely than others to contribute in this way to diminished potential for success in school. And although it is not as clearly determined as one's race, class or gender, the place where a child lives and attends school is often not a matter of choice either. As Legot et al. (2010:285) put it, "if children are regularly being exposed…to the sorts of toxins that impair their ability to learn and develop, both their individual life chances and society's aggregate reserve of human capital are in jeopardy".

Further, the concept of environmental ascription encompasses more than this relationship between place and life chances. Our analysis also reveals that the highly polluted zip codes contain more minority and poor residents than other, less proximate zip codes in EBR Parish and

that these measures of race and class are also linked to our measures of illness. Hence, these case study findings suggest that certain populations are facing multiple, overlapping ascriptions of social class, race, and place. As suggested by Legot et al. (2010), "those children born into racially and economically marginalized groups are already disadvantaged in terms of potential educational outcomes, and this additional dimension of environmental ascription overlaps with those other socially constructed ascriptive forces. As groups, minorities, the poor, and those who live in polluted places are at increased risk for reduced life chances even when considered separately; and… the populations comprising these groups are likely to intersect. Thus, specifying the concept of environmental ascription involves studying the relationship between polluted places, race and class and how they converge to produce multiple ascriptions (emphasis added)."

These "overlaps" or "convergences" merit additional consideration. It is often the case, especially in regard to asthma, that conditions associated with poverty (such as an absence of medical coverage) yield increased hospitalizations. The recommended treatment for chronic asthma requires visits to medical facilities, with follow-up visits for monitoring. Poor people without medical coverage tend to access emergency rooms for care rather than repeatedly visiting physicians' offices and fully following complicated treatment protocols. Thus, poverty works against effective treatment, and may lead to chronic symptoms and recurring hospitalizations. Also, physicians practicing in areas where compliance with protocols is limited may alter their approach to address only the acute exacerbations of asthma. This, too, is likely to result in more hospitalizations (Dr. James Makol, personal communication).

It may well be that toxins (and other proximate factors such as mold, second-hand smoke, and criteria air pollutants) "cause" disease, but poverty exacerbates the situation. So, any study of hospitalization rates must consider the interaction of proximity to pollution and poverty. This insight about interaction effects is quite compatible with the concept of environmental ascription (i.e., of multiple overlapping ascriptions). Note that this approach is quite a bit different from the usual approach taken by social science research in this area. Most of the time we try to determine if a potential causal variable is "significant" or "spurious" in the context of a properly specified model. This may be the wrong sort of question to ask. Instead we need to determine whether or not crucial variables of interest interact with each other.

This research has several implications for policy intervention. Executive Order 12898 "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," implemented in 1994 by former President Clinton, has not been completely effective in increasing environmental equity (O'Neil 2007). Our findings provide an impetus for full implementation of Executive Order 12898, where future legislation assesses and oversees the impacts of multiple chemical exposures and their disproportionate impact on all vulnerable populations, including children. Full implementation of Executive Order 12898 may, for example, require safety buffers around facilities that emit respiratory toxins and suspected developmental neurotoxins to reduce impacts on vulnerable populations.

Furthermore, the EPA's Office of Children's Health Protection needs to increase expenditures to coordinate research and legislation that address all chemical-related respiratory and developmental health effects. Little research and monitoring exist that compare nationwide

childhood respiratory and neurological disorders with those on a local level. A nationwide database that keeps track of these efforts can provide more insight into nationwide disease patterns and further push legislation to enact more stringent industrial reporting standards, especially if more "hot spots" are identified. As noted by Legot et al (2010), "there are few local, state or federal programs that encourage research into chemical commerce…and few regulations to compel industries to find substitutes for harmful chemicals." Industries therefore have little reason to make investments in research and development that produces chemicals less detrimental to health and human capital. Funding should be allocated to programs that address chemicals that are especially harmful to children.

Lack of action to regulate and strictly monitor industries and their impact on health disparities is partially due to America's history of favoring corporate interests where, "as a result of sharp economic and political power inequities, the interests of producers are routinely given policy precedence over the public interest, including public health" (Legot et al. 2010). A priority shift needs to occur within the policy sector, where human health takes precedence over the needs of large corporation. Only then will essential measures be enacted that strengthen environmental and health regulations that work to decrease the health disparities among populations with multiple, overlapping ascriptions.

Although our methodology is necessarily simple and not without certain limitations (see above), these findings supplement the nation-wide results reported in Legot et al. (2010) by beginning to empirically examine the presence of environmental ascription in this "hot spot." Further research in this area should include more proximity-based case studies that link likely exposure to those toxins that put children's learning potential (and hence, life chances) into

jeopardy to measurable health outcomes. Additionally, health outcomes should be further linked to human capital impacts by examining the relationship between proximity and academic performance, similar to Pastor et al.'s (2002, 2004) work in the Los Angeles area.

FOOTNOTES

1. Most elementary school students in the Parish attend neighborhood schools that are centered in narrowly-bounded attendance zones, and they go on to attend nearby middle schools that are fed by several elementary schools. Consequently, most students live and attend school in the same zip code. One zip code, however, represents a marked departure from this pattern. The schools in zip code 70770 (Northeast Elementary and Middle-High Schools) serve a geographically-dispersed unincorporated area that covers several zip codes. In fact, these schools enroll more students from zip codes 70714, 70739, and 70811 than from 70770. We account for this anomaly by dividing the number of students with disabilities attending the Northeast schools by the sum of the number of school-aged children residing in all four zip codes (data provided by East Baton Rouge Parish Schools' public information office).

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Table 1. Pollution Rankings for East Baton Rouge Parish (EBR) and State of Louisiana (LA)(2002)

Pollutant:			EBR Volumes
a. Toxic Releases	LA Rank*	EBR Rank **	Pounds
Total Environmental Releases	11	7	8,635,810
Air Releases	12	2	6,389,990
Recognized Developmental Toxins to Air	8	3	506,398
Suspected Developmental Toxins to Air	4	2	2,993,535
Suspected Neurotoxins to Air	3	2	5,403,548
Suspected Respiratory Toxins to Air	12	2	5,940,790
b. Criteria Air Pollutants			Tons
Volatile Organic Compounds	18	3	24,513
Carbon Monoxide	18	2	158,879
Nitrogen Oxide	7	6	36,041
Particulate Matter 2.5	21	1	7,171
Particulate Matter 10	31	1	15,043
Sulphur Dioxide	15	3	45,179
Nitrogen Oxide (ozone season daily average)	7	6	104
VOCs (ozone season daily average)	22	3	66

* Louisiana's national rank among states

** EBR's rank among Louisiana's 64 parishes

Source: www.scorecard.org/rankings

Table 2: Facilities releasing (a) total toxins and (b) developmental neurotoxins and respiratory toxins in EBR Parish in 2002 (pounds).

	Zip Code	Total on-site releases	Recognized developmental	Suspected developmental	Suspected neurotoxins	Suspected respiratory
Exxon Mobil Refining	70805	2,693,922	230,816	523,027	970,030	1,049,414
Exxon Mobil Chem	70805	2,045,712	191,974	935,985	1,394,809	1,792,472
Honeywell	70805	1,500,762	29,142	874,888	1,282,159	1,144,526
Georgia Pacific	70791	955,844		380,408	488,166	581,268
Baton Rouge Plastics	70807	947,071		29,088	914,723	937,921
DSM Copolymer	70805	136,409	14,776	116,376	135,831	135,869
Exide	70807	110,259	4,200		4,200	
Formosa Plastics	70805	93,637		58,584	80,737	93,216
Rhodia	70805	91,520		28,509	31,621	83,887
Deltech	70807	36,327	22,520		36,302	36,222
Exxon Mobil Polyolefins	70807	31,905				
Ferro Corp.	70791	29,528	2,815	4,465	9,717	
Novolyte	70791	29,528				
EDO Specialty Plastics	70810	25,300		25,300	25,300	
Exxon Mobil Resin	70807	10,112	1,091	3,842	7,139	
Albemarle	70805	6,075	5,500	27	6,075	
PPG	70807	3,641	1,589			
Clean Harbors	70807	2,448	1,236			
Gulf Wandes	70815	1,238				
Oxbow Calcining	70807	193				
Stupp	70807	16				
Schering-Plough						
	70814	10				
Driscoll	70807	5				
CMC Steel	70805	NA				
TOTALS		8,751,462	505,659	2,980,499	5,386,809	5,854,795

Table 3. RSEI hazard rankings for all facilities reporting to the Toxic Release Inventory in East Baton Rouge Parish, ranked by "All Hazard" (2002).

Facility Name	Zip Code	Air Pounds*	Air Hazard**	All Pounds***	All Hazard****
ExxonMobil Refining	70805	1,125,218	12,073,394,653	2,693,886	12,091,262,488
ExxonMobil Chemical	70805	1,898,211	7,381,985,643	2,045,712	9,611,259,473
Formosa Plastics	70805	93,338	5,041,771,587	93,637	5,057,349,287
DSM (Lion) Copolymer	70805	135,869	2,939,882,605	136,409	2,951,033,910
Georgia Pacific	70791	581,570	1,156,962,096	772,253	1,185,463,084
Honeywell	70805	1,483,754	770,380,277	1,500,257	773,306,815
Deltech	70807	36,302	289,681,428	36,327	289,962,043
Rhodia	70805	91,520	198,364,602	91,520	198,364,602
Ferro Corp.	70791	9,717	111,042,330	29,528	146,083,140
ExxonMobil Polyolefins	70807	31,695	129,031,188	31,905	129,067,818
Exide	70807	4,200	75,600,000	4,229	80,521,500
Clean Harbors	70807	2,438	37,305,947	2,448	37,605,352
Baton Rouge Plastics	70807	938,401	21,068,346	947,071	24,563,610
ExxonMobil Resin	70807	7,404	19,957,032	10,112	20,015,823
Oxbow Calcining	70807	192	3,465,000	192	3,465,000
Albemarle	70805	6,074	1,155,166	6,075	1,155,167
Stupp	70807	16	1,120,000	16	1,120,000
Schering-Plough	70814	10	96,000	10	96,000
Specialty Plastics	70810	25,300	88,550	25,300	88,550
PPG	70807	3,641	13,939	3,641	13,939
Gulf Wandes	70815	1,238	4,332	1,238	4,332
Driscoll	70807	5	3,098	5	3,098

* stack and fugitive releases in pounds

** toxicity-weighted air releases

*** stack, fugitive, and surface water releases in pounds

**** toxicity-weighted all releases

Table 4. Difference of means between (a) zip codes 70805 and 70807 vs. all others in East Baton Rouge Parish (2002), and (b) the six zip codes close to ExxonMobil facilities vs. all others, for disease rates, race, and poverty. Panel (c) shows all data for disease rates, race, and poverty by zip code. (* t-test significant at p<.05)

	Indicator	Mean for proximate zip codes (N)	Mean all other zip codes (N)	Difference (X-Y)	Ratio (X/Y)
		X	Y		
a)	Childhood asthma	31.35(2)	19.54(16)	11.81*	1.6
	All diseases	25.56(2)	15.99(15)	9.57*	1.6
	Disability	76.02(2)	54.87(16)	21.15*	1.39
	% minority	92.65(2)	36.78(18)	55.87*	2.52
	% poverty	33.8(2)	11.11(18)	22.69*	3.04
b)	Childhood asthma	28.34(6)	17.11(12)	11.23*	1.66
	All diseases	23.21(6)	13.79(11)	9.42*	1.68
	Disability	79.96(6)	45.85(12)	34.11*	1.74
	% minority	80.55(6)	26(14)	54.55*	3.1
	% poverty	28.28(6)	7.38(14)	20.9*	3.83

c)	Zip code(grouped)	Asthma	All diseases	Disability	%poverty	%minority
	70805	34.01	28.54	76.29	31.6	90.1
	70807	28.68	22.57	75.76	36	95.2
	70802	26.65	21.94	88.05	35	84.8
	70806	24.25	19.43	92.8	18	48.1
	70811	32.69	27.53	56.43	19.9	73.6
	70812	23.73	19.24	90.43	29.2	91.9
	70808	8.89	7.26	56.46	4.9	20.5
	70809	19.8	16.18	36.58	4.3	14.7
	70810	15.3	11.51	12.39	6.3	37.9
	70814	20.5	12.92	46.51	6.7	65.2
	70815	19.29	15.09	126.28	10	33.9
	70816	21.7	17	41.06	6.1	24.8
	70817	10.43	8	18.35	1.3	9.5
	70818	9.93		76.37	6	10.1
	70819				6.3	19.4
	70820	14.41	11.66		17.6	37.2
	70714	26.46	21.34	43.52	10.3	47.9
	70791	26.85	21.36	57.67	9.6	33.1
	70739	11.76	9.35	22.76	3.4	6.1
	70770			12.31	5	3.7

Table 5. Correlation Matrix: disease/disability rates, %poverty, %minority, and distance to midpoint.

	1	2	3	4	5	6
1. Childhood asthma	1					
2. All diseases	0.99	1				
3. Disability	0.36	0.45	1			
4. %poverty	0.7	0.71	0.59	1		
5. %minority	0.78	0.73	0.51	0.9	1	
6. Distance	-0.63	-0.65	-0.68	-0.81	-0.85	1

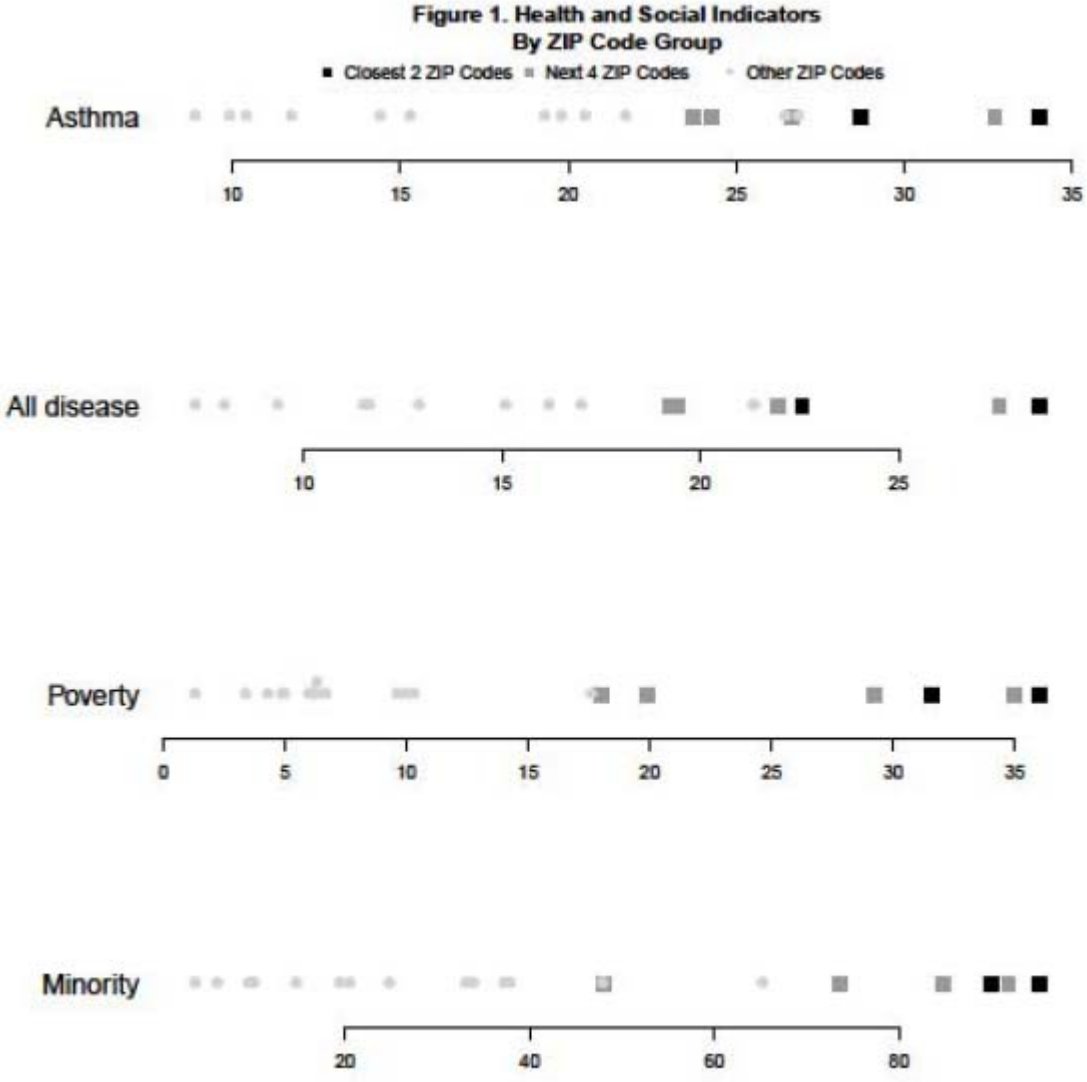
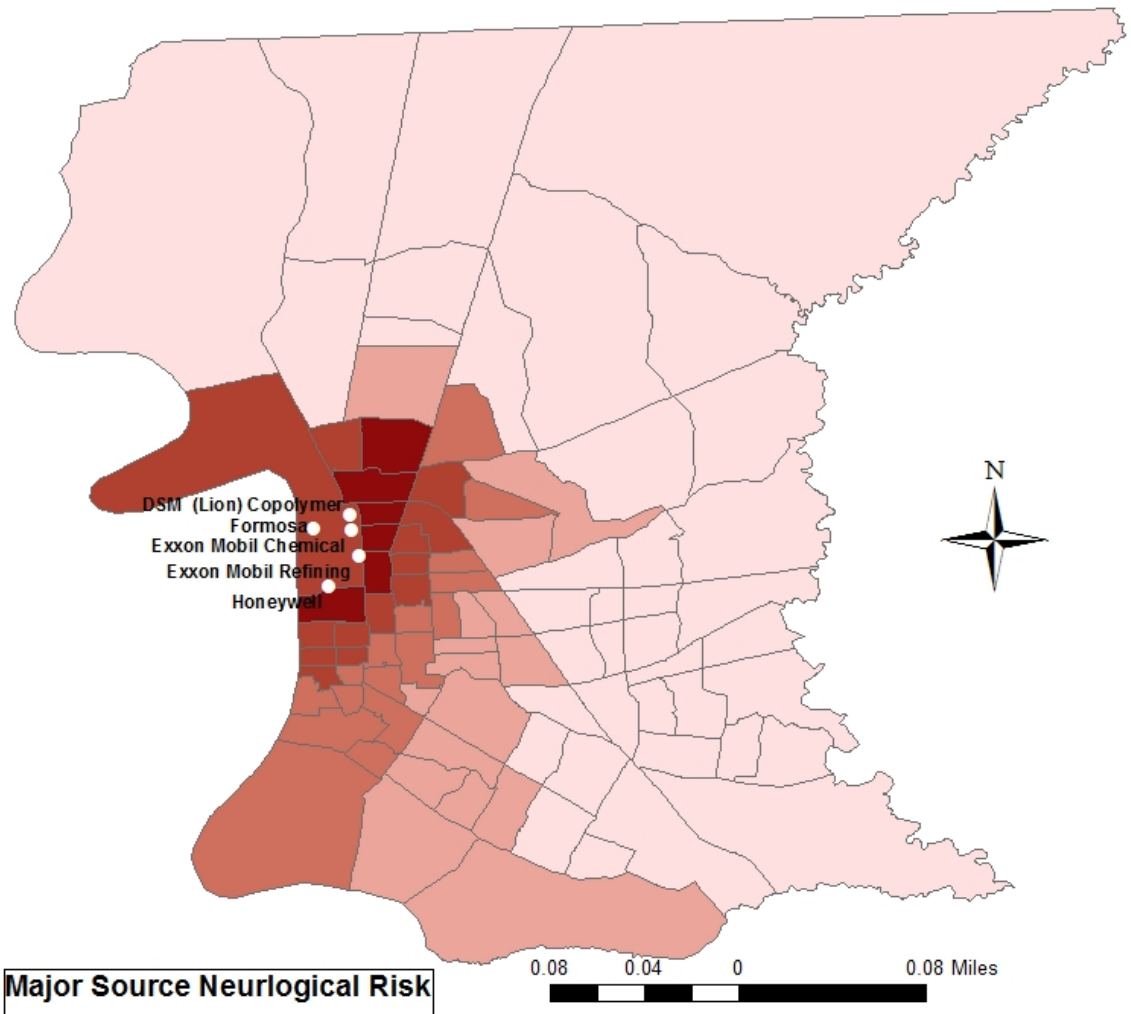


Figure 1. Health and Social Indicators
By ZIP Code Group
Closest 2 ZIP Codes
Next 4 ZIP Codes
Other ZIP Codes
Asthma
10
15
20
25
30
35
All disease
10
15
20
25
Poverty
0
5
10
15
20
25
30
35
Minority
20
40
60
80

Figure 2: East Baton Rouge, LA
Major Source Neurological Risk (U.S. EPA 2002)



Risk measured by Hazard quotient (HQ): the ratio between the concentration to which a person is exposed and the reference concentration .