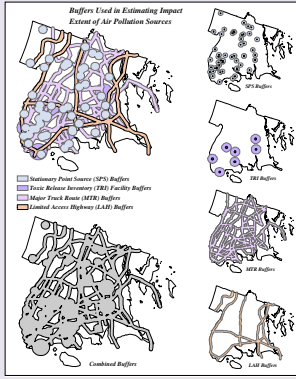


Mapping Asthma Hot Spots: The Geography of Asthma and Air Pollution in the Bronx

Dr. Juliana Maantay¹, Dr. Hal Strelnick², Holly A. Porter Morgan³, Juan Carlos Saborio⁴
Lehman College, City University of New York, Department of Geology and Geography¹;

Montefiore Medical Center/Albert Einstein College of Medicine, Institute for Community and Collaborative Health²; Ph.D. Candidate, CUNY Graduate Center (Biogeography)³; Geography Major, Lehman College⁴



Project Description:

Mapping Asthma Hot Spots: The Geography of Asthma and Air Pollution in the Bronx, New York City, examines the spatial correspondence between the incidence of asthma and the locations of environmentally-burdensome land uses and activities. We propose that there is a spatial correspondence between areas having high rates of asthma hospitalizations and areas in close proximity to sources of air pollution. To test this hypothesis, we are using Geographic Information Systems (GIS) to map and model the major mobile and stationary sources of air pollutants in the Bronx, New York City. Environmental Systems Research Institute's "ArcView" mapping and spatial analysis software is being used, as well as specialized data sets, orthophotos, and geostatistical programs.

Recent studies¹⁻³ have linked high concentrations of known air pollutants to respiratory disease, demonstrating that increased air pollution is a serious public health and environmental concern. Reduced air quality and respiratory health problems, particularly asthma, have been associated with a number of sources, including toxic air emissions from industrial processes, particulate matter and increased levels of NO_x and SO_x from truck traffic, and increased pollution from other noxious land uses (e.g. waste-related facilities, medical institutions, power plants).

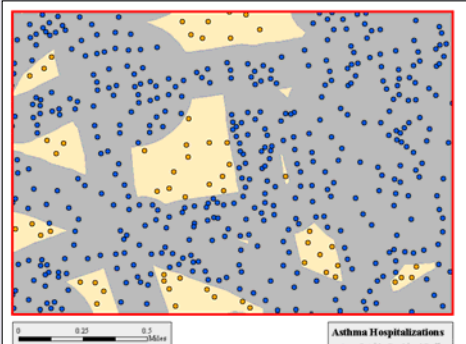
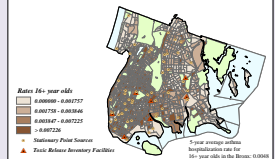
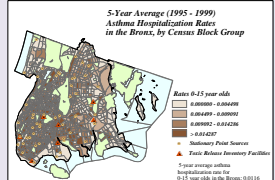
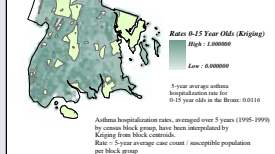
These issues are of particular interest to the Bronx community, because residents of the Bronx, specifically children under the age of 14, suffer from one of the highest rates of asthma hospitalization in the country^{4,5}. In addition, the Bronx has a disproportionate number of Stationary Point Sources and TRI facilities⁶, and these are mainly concentrated in the South Bronx, where the asthma rate is relatively high. The South Bronx also has the highest volume of vehicular traffic in the nation, which greatly lowers air quality⁷. There has been no major geographic studies of New York City that have addressed the potential connection between noxious land uses and asthma. Therefore, we are investigating the possible correlations that may exist between high rates of asthma and multiple sources of air pollution in the Bronx.

We are addressing the following questions using the methods discussed below:

- 1) What are the major sources of air pollution in the Bronx? For each source, what are the quantities and characteristics of pollutants emitted?
- 2) What is the geographic extent of pollutant dispersion (impact zone)?
- 3) What are the characteristics (age, socio-economic, and racial/ethnic) of populations potentially most affected by these pollution sources?
- 4) Is there a spatial correspondence between areas having high asthma hospitalization rates and areas in close proximity to major sources of air pollution?
- 5) Is there a connection between age, income, race/ethnicity, high rates of hospitalization for asthma, and environmental burdens?



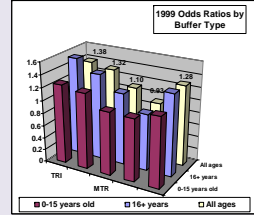
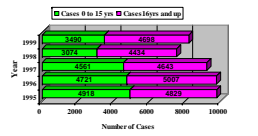
Asthma Hospitalization Rates in the Bronx, Interpolated from Census Block Centroids



Each dot represents the residence of one Bronx person admitted to the hospital for asthma in 1999. Some dots represent multiple admissions of the same person, or multiple people admitted from the same address. The multiple cases are not shown as individual dots on the map, but have been included in statistical calculations. There were 1180 hospital admissions for asthma in 1999, 5.3% of them from within the area of the combined buffers, and 2,312 of them from the area outside the buffers. Overall in 1999, a Bronx resident was 2% in one likely to be admitted to the hospital for asthma if living within a buffer area than if living outside a buffer area.

Important Note: The patient address locations shown on this map are derived from hypothetical data, and do not represent actual addresses. Due to patient confidentiality requirements, the actual address locations could not be shown in a document for public dissemination, and this map is intended only to be illustrative of the methods used in the analysis. The actual address locations were, however, used by the researchers in the spatial analyses to derive the in- and out-of-buffer rates, odds ratios, and other statistical tests. The researchers were only permitted to show aggregate data (as opposed to record level data) in any maps available to the public.

Asthma Hospitalization Cases in Bronx County



5-Year Average Rates

| Age Cohorts | Rates |
|---------------------|--------|
| 0 to 15 years old | 0.0116 |
| 16 years old and up | 0.0048 |

Methods:

- Located and mapped major sources of air pollution in the Bronx: facilities that emit, or store toxic substances (TRI); facilities that emit criteria pollutants (SPS); limited access highways (LAH); and major truck traffic routes (MTR).
- Created buffers around the above listed major sources of air pollution. Each buffer represents an approximation of the areal extent of potential air pollution impact. Buffer sizes are as follows: 150m buffers around the limited access highways and major truck routes, 0.5 miles buffers around TRI facilities, and 0.25 mile buffers around SPS facilities. These buffer distances are based on standards used in environmental assessment, reflecting the distances that air pollutants typical for each source are expected to travel. All four buffer types were joined in order to create the "Combined Buffer" layer.

- Using Census Bureau information at the block-group level, we mapped the potentially impacted population by socio-economic and demographic indicators, such as race and ethnicity, and poverty status.

- Mapped the asthma hospitalization cases, using the latitude and longitude of patient addresses. The cases were mapped by individual years, months and seasons within each year, and by age cohort (0-15 years old and 16 years and older).

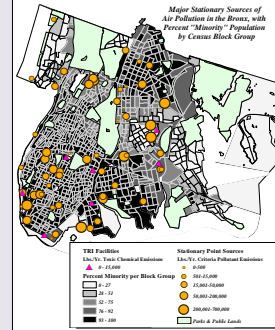
- Summarized asthma hospitalization case counts for each block group. Then, calculated rates based on overall population of the block group and the population of each age cohort. This analysis was conducted separately for each of the five years, as well as for the 5-year average of asthma hospitalization counts, and by age cohort.

- Conducted a geospatial operation called "Clipping" in order to select the portions of the block groups and asthma hospitalization cases that lie within the buffers. This was done for each separate buffer type and for the combined buffer, using case data for each separate year.

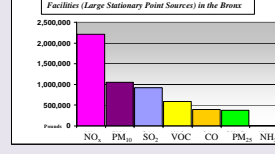
- Summarized data for the number of cases in each resulting portion of the block group (in and out of buffers). To estimate how much of each block group's population lives in and outside of each portion of buffer, we had to calculate what proportion of each block group's area lies within the buffer. Population counts inside the buffers were therefore assigned based on areal weighting ratios of block groups. Rates were developed based on these population estimates and case counts.

- Conducted statistical analyses on the difference of case counts and rates between areas within the buffers and areas outside the buffers. The odds ratios comparing the risk of being hospitalized for asthma based on proximity to air pollution source (living inside or outside the buffers) were calculated for each year, by age cohort, and each buffer type, including the combined buffers.

Overall Bronx rates and odds ratios were also calculated. In addition, we calculated Chi-Square values to determine if there is a significant association between residence location and asthma hospitalization rates.



Annual Emissions of Criteria Pollutants From SPS Facilities (Large Stationary Point Sources) in the Bronx



Conclusions:

The odds ratios for children (age 0-15 years) and adults (16 years and older) for asthma hospitalizations for each year from 1995-1999 were calculated, comparing those who lived in buffer areas surrounding Toxic Release Inventory (TRI) facilities, Stationary Point Sources (SPS), along Major Truck Routes (MTR), and/or Limited Access Highways (LAH), and compared to other Bronx residents living outside these buffer zones. Patterns of increased risk were consistent from year to year.

For adults living near TRI facilities, the increased risk for asthma hospitalization ranged from 29-60%, for SPS sites from 26-66%, along MTRs from 7-17%, and in all buffer zones from 28-30%. The increased risk for children living near SPS sites ranged from 14-30%, for TRI facilities 16-31%, and for combined buffer zones 11-17%. No increased risk was found along LAHs and none for children living along MTRs. The increased risk for the total population living in all buffer zones was 25-29%.

Odds Ratio Ranges for the Five Year Study Period

* Indicated results are statistically significant at p<0.01

| Buffer Type | Adults | Children | Total Population |
|-------------|------------|------------|------------------|
| Combined | *1.28-1.30 | *1.11-1.17 | *1.25-1.29 |
| TRI | *1.29-1.60 | *1.14-1.30 | *1.33-1.49 |
| SPS | *1.24-1.66 | *1.16-1.31 | *1.23-1.32 |
| MTR | *1.07-1.17 | 1.09-1.00 | *1.10-1.15 |
| LAH | 0.90-0.93 | 0.99-0.83 | 0.86-0.93 |

Data Sources:

Geographic Information Systems (GIS) are systems that combine specialized software, hardware, spatial attribute databases, and the knowledge base and analytical capabilities of the GIS analyst. The main functions of a GIS are to perform spatial analyses, computerized mapping, and geostatistical operations. A map is composed of several "themes" or layers of data, which can be combined using Boolean algebra in order to yield procedures to yield additional information. Data layers used in this study are listed below, along with their tabular sources and the processing techniques used to transform them into spatial data:

- Data Layer:** Major Manufacturing Zones.
Source: New York City Department of City Planning, "Citywide Industry Study: Geographical Atlas of Industrial Areas" (1993). (Major "M" Zones digitized and plotted at Lehman GIS lab)
- Data Layer:** Demographic and Socio-Economic Data by Block Group.
Source: U.S. Department of Commerce, Bureau of the Census. "Census of Population and Housing, Summary Tapes File 3a" (2000).
- Data Layer:** Street Segments.
Source: U.S. Department of Commerce, Bureau of the Census (2000). TIGER Files. (Topologically Integrated Geographic Encoding and Referencing) (Linked Access Highway and plotted at Lehman GIS lab)
- Data Layer:** (Shedlines, Water Bodies, Ponds, Census Tract Boundaries and Centroids)
Source: U.S. Department of Commerce, Bureau of the Census (2000)
- Data Layer:** Zoning and Land Use.
Source: Landfile by Space Track (2002); New York City Department of Finance, RPD3 (Real Property Attribute Data) (2002)
- Data Layer:** Asthma Hospitalization Data.
Source: New York State Department of Health SPARCS database (Statewide Planning and Research Cooperative System) (1995-1999)

- Data Layer:** Toxic Release Inventory Facilities (TRI).
Source: U.S. Environmental Protection Agency (2000). (TRI locations geo-coded and plotted at Lehman GIS lab, 2002)
- Data Layer:** Local and Through Truck Route Network.
Source: New York City Department of Transportation/Traffic Rules and Regulations (2002). (Truck routes digitized and plotted at Lehman GIS lab, 2002)
- Data Layer:** National Economic Trends (NET).
Source: U.S. Environmental Protection Agency. (Facility locations geo-coded and plotted at Lehman GIS lab)
- Data Layer:** Digital Orthophotos of New York City.
Source: New York City Department of Environmental Protection, NYCAMP (2000)



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