Spatial and Temporal Evaluation of USEPA NATA Database for Environmental Equity Analysis in Cook County, IL

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Introduction

The U.S. Environmental Protection Agency (USEPA) defines environmental justice as the "fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies." In the last two decades, limited progress has been made in identifying environmental justice (EJ) areas and underlying health and social determinants responsible for environmental inequities at national and global levels[1, 2]. *In order to assess evidence of environmental inequity in terms of air pollution burden and inhalation excess cancer risk (IECR) associated with exposure to air toxics, we performed a spatial and temporal regional analysis using USEPA's National Emissions Inventory (NEI) database for the State of Illinois, USA and the National Air Toxics Assessment (NATA) database*[3] *for Cook County, IL, which has the highest air emissions and highest and the most diverse population in IL* (see Table 1).

Table 1. Demographic Information for Cook County, IL[4]

	Illinois		Cook County	
	2000	**2010**	**2000**	**2010**
White (%)	73.5	71.5	56.3	55.4
African American (%)	15.1	14.5	26.1	24.8
Asian (%)	3.4	4.6	4.8	6.2
Other race (%)	8.0	9.4	12.8	13.6
Hispanic (of any race) (%)	12.3	15.8	19.9	24.0
Total Population	12,419,231	12,830,632	5,376,741	5,194,675

Methods

We employed the following methods:

- The NEI NATA databases for the same years available (i.e., 1999, 2002 and 2005) were downloaded from the EPA's Technology Transfer Network website for the state of Illinois and all counties in the state of Illinois.
- The NEI data at county level and NATA data at the census tract level were spatially and temporally evaluated using Geographic Information System (GIS) techniques to determine spatial and temporal distribution of populations' exposure levels in outdoor air and resultant IECR associated with inhalation exposure to carcinogenic air toxics.
- A more-detailed analysis was performed for benzene, the top contributor to total cancer risk in Cook County (see Table 2).

Results

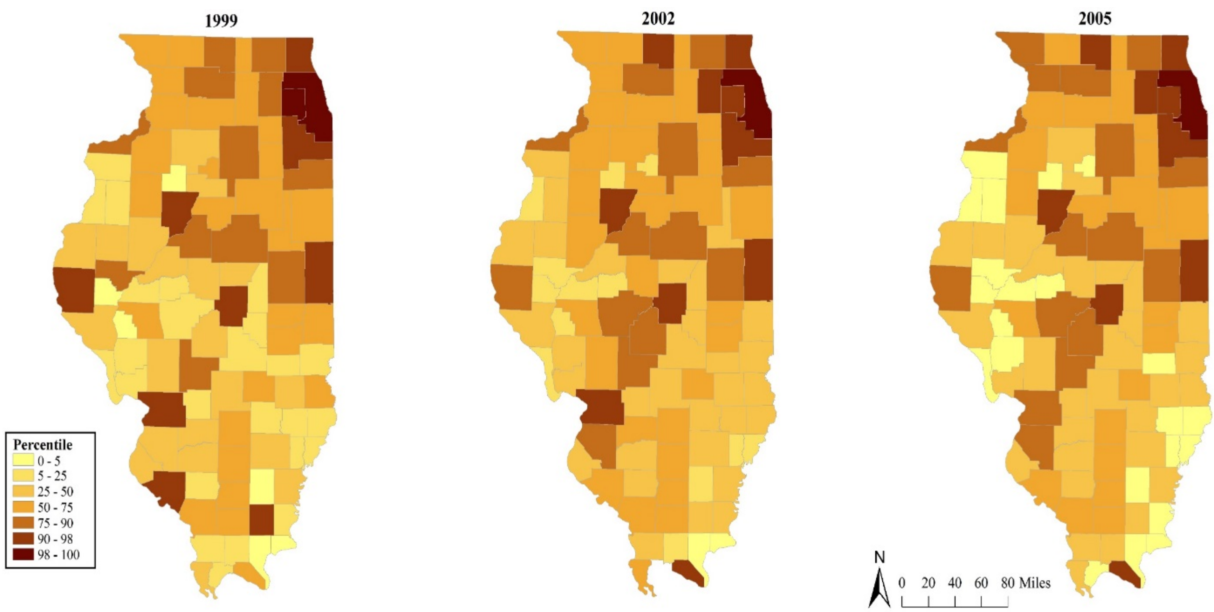

Figure 1. Spatial Distribution of 1999, 2002, and 2005 EPA's NEI Air Emissions in Illinois, USA.

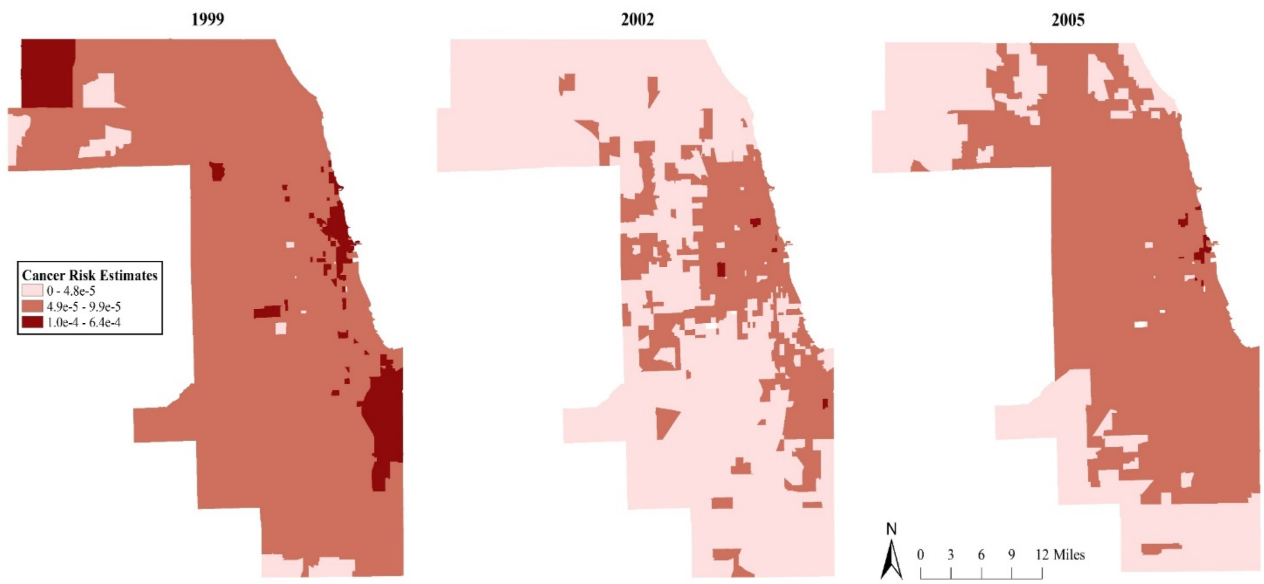

Figure 2. Spatial Distribution of 1999, 2002, and 2005 EPA's NATA Inhalation Total Cancer Risk Estimates for Cook County, IL.

Table 2. Top Twenty Carcinogenic Air Toxics that Contribute to the Total Cancer Risk in Cook County, IL – 1999, 2002, 2005.

	1999		2002		2005	
	Chemical	**Contribution to Total Risk (%)**	**Chemical**	**Contribution to Total Risk (%)**	**Chemical**	**Contribution to Total Risk (%)**
1	Benzene	24.22	Benzene	22.76	Formaldehyde	39.03
2	Ethylene Dibromide	11.56	Carbon Tetrachloride	14.11	Benzene	12.06
3	Butadiene	10.50	Acetaldehyde	9.62	Naphthalene	7.21
4	Acetaldehyde	8.29	Naphthalene	7.82	Acetaldehyde	5.78
5	1,1,2,2-Tetrachloroethane	6.54	1,3-Butadiene	7.81	1,4-Dichlorobenzene	5.75
6	Naphthalene	6.22	1,4-Dichlorobenzene	6.89	Tetrachloroethylene	5.23
7	Carbon Tetrachloride	4.73	Arsenic Compounds (Inorganic Including Arsine)	6.51	1,3-Butadiene	4.81
8	Cadmium Comp	4.21	Tetrachloroethylene	6.31	Carbon Tetrachloride	4.71
9	Chromium VI	3.71	Ethylene Oxide	4.57	Ethylene Oxide	3.35
10	Bis(2-ethylhexyl) phthalate	3.32	Coke Oven Emissions	3.30	Chromium Compounds	2.91
11	Tetrachloroethylene	2.78	Chromium Compounds	3.04	Acrylonitrile	1.52
12	Ethylene Oxide	2.10	Acrylonitrile	1.86	Arsenic Compounds (Inorganic Including Arsine)	1.48
13	Ethylene Dichloride	1.86	PAH POM	1.71	PAH POM	1.13
14	p_ Dichlorobenzene	1.48	Trichloroethylene	0.95	Ethylbenzene	1.06
15	POM_Group_2_nodata	1.29	Cadmium Compounds	0.58	Coke Oven Emissions	0.97
16	Vinyl Chloride	1.08	Ethylene Dibromide	0.40	Trichloroethylene	0.71
17	1,3-Dichloropropene	1.08	Nickel Compounds	0.39	Cadmium Compounds	0.44
18	Trichloroethylene	0.93	1,1,2,2-Tetrachloroethane	0.35	Nickel Compounds	0.40
19	Coke Oven Emissions	0.89	1,3-Dichloropropene	0.32	Ethylene Dibromide	0.34
20	Propylene Dichloride	0.74	Methylene Chloride	0.29	1,1,2,2-Tetrachloroethane	0.28

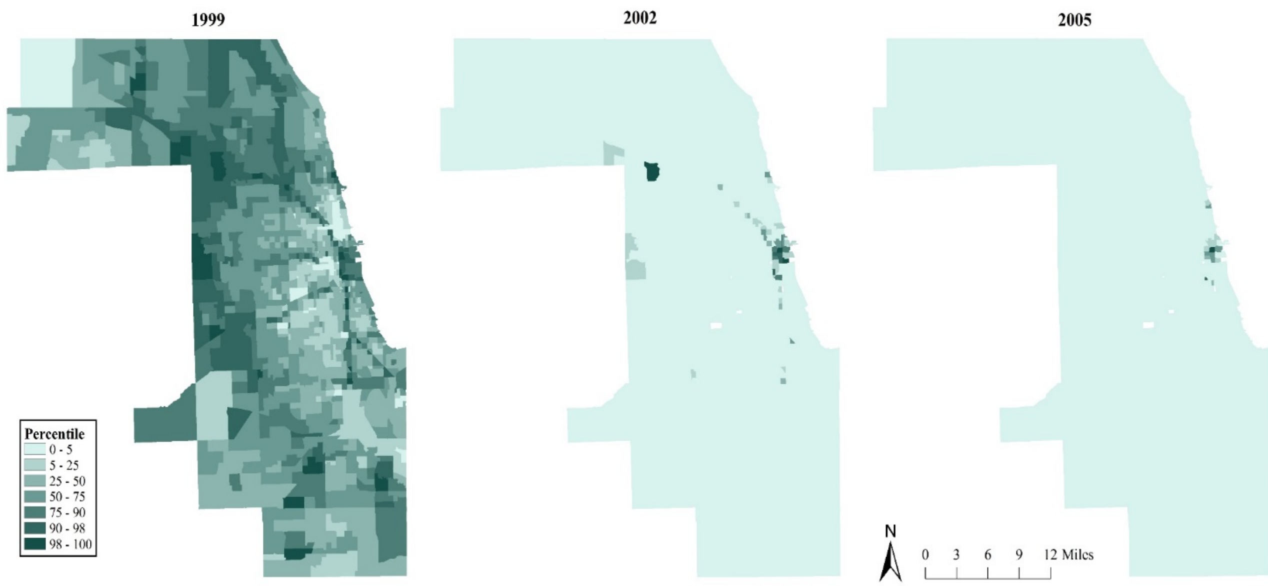

Figure 3. Spatial Distribution of 1999, 2002, and 2005 EPA's NATA Benzene Inhalation Cancer Risk Estimates for Cook County, IL.

Conclusions

- Cook County is the primary contributor to total emissions in IL with 28.5% -24.8% of total emissions in IL originating from sources in Cook County. DuPage, Lake and Will counties have contributed 3.5% to 6.6% of total air emissions in IL in 1999 to 2005 time frame. The contribution of sources in other counties in IL is less than 5% during this time frame. There has not been a substantial reduction in air emissions from 1999 to 2005 for which NATA data are available. Although there has been an effort to reduce emissions from industrial sources (i.e., major sources), emissions from area sources (e.g., gas stations, dry-cleaners, pesticide use, commercial and consumer organic solvent usage) have increased. For example, in Cook County, while contribution of major emissions to total air emissions decreased from 15% in 1999 to 2.4% in 2005; that for area emissions increased from 27.2% to 48.5% during the same time period. For mobile source emissions, which include both on-road and non-road vehicle/source emissions, a more complex trend was observed. While total mobile emissions decreased by 13% from 1999 to 2005 in Cook County, it increased by 14% in DuPage County. Top ten air toxics contributing most to total air emissions carry mobile source (BTEX components and aldehydes) and area source (solvents) signatures. While majority of benzene, ethyl benzene, formaldehyde, and 2, 2,4-Trimethylpentane) emissions have decreased by 40.6%-52.1% from 1999 to 2005, area emissions associated with methanol and methylethylketone increased by about 100% during the same time period (see Figure 1).

- Total inhalation cancer risk estimates ($5.8x10^{-4}$ to 0; mean =$1.2x10^{-5}$) showed high variability across Cook County, IL in 1999 (SD=$3.2x10^{-5}$) than those for 2002 and 2005 (see Figure 2). In 1999, 8.7% of census tracts (n= 218) consisting of 7.2% of total population in Cook County had inhalation total cancer risks equal to or exceeding $1x10^{-4}$, i.e., the policy-based threshold for cancer risk assessment standard. On the other hand, only 0.75% and 1.5% of census tracts consisting of 0.42% and 1% of total population were at the cusp or in exceedance of this threshold in 2002 and 2005, respectively. These high-risk areas were more widespread in 1999 with exceedances observed in industrial areas in the southeast side of Cook County which was the center of steel manufacturing in the world in mid to late 1800s, in areas near O'Hare international airport, urban core and highway/freeway corridors/subareas. In 2002, only 10 census tracts had total cancer risks above the threshold with high risk areas concentrated in urban core, international airport (O'Hare) and freeway corridors. In 2005, the downward trend was reversed with more residents in Cook County experiencing higher level of cancer risk in more census tracts (n=20) as shown in Figure 3. This was partly due to EPA's accounting of secondary formation of air toxics (e.g., formaldehyde) in the atmosphere in air quality modeling, which form the basis of exposure concentrations in cancer risk assessment. Thus, 2005 results should be viewed to be more representative of atmospheric chemistry, resultant air toxic mixture in air and associated inhalation health risks.

- Benzene was consistently the top contributor to total inhalation cancer risks in Cook County across 1999-2005, constituting 23% -39% of total inhalation cancer risks, followed by similar low molecular weight VOCs found in transportation fuel (1,3-butadiene, acetaldehyde, formaldehyde) along with some solvents and industrial chemicals (see Table 2). The highest benzene cancer risk ($4.2x10^{-5)}$ across 1999-2005 was found in 1999 in census tract 17031770700, which is a transportation hub in Rosemont, IL, where a number of major highways (I-190, I-190, I-294) merge. The higher benzene cancer risk areas were more widespread in 1999 in industrial suburban, urban core and highway/freeway corridors and areas. In 2002, higher risk areas for benzene concentrated in urban core, international airport (O'Hare) and freeway corridors. In 2005, further reduction in benzene emissions resulted in more concentration of higher risk areas to urban core specifically (see Figure 3). These results indicate that reduction in benzene air emissions through implementation of MACT standards, voluntary emissions control programs and mobile fleet turn-over over time have resulted in significant improvement in associated benzene cancer risk. However, certain pockets of Cook County with highly diverse population, particularly, urban core of Chicago, still have subareas with higher cancer risks and further efforts towards air emissions control for public health protection is necessary. In addition, despite these reductions in benzene, some air toxic cancer risks (e.g., formaldehyde) have increased over time and requires a further study and evaluation.

Sources

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