

ENVIRONMENTAL EQUITY AND INDUSTRIAL CHEMICAL ACCIDENTS

Theodore S. Glickman, Dominic Golding, and Robert Hersh
Resources for the Future
1616 P Street, NW
Washington, DC 20036

ABSTRACT

Concerns about environmental equity to date have focused almost exclusively on undesirable land uses and chronic health hazards associated with pollution, especially air pollution. In contrast, this analysis deals with the acute hazards associated with storing extremely hazardous substances in industrial facilities. These chemicals have the potential to form toxic vapor clouds when accidentally released. Using EPA's technical guidance for hazard analysis, the degree of spatial vulnerability to such accidents is estimated for various socioeconomic groups in Allegheny County, Pennsylvania. The results show that minorities and the poor are more vulnerable than others, with race being a somewhat more influential factor than income.

INTRODUCTION

This paper examines the issue of environmental equity in the context of industrial hazards in urban areas, a topic that has received considerable attention recently [Mohar and Bryant (1), Napton and Day (2), *National Law Journal* (3)]. The hazard of concern here is the storage of certain chemicals which, if accidentally released, might result in the formation of toxic vapor clouds that would spread to residential communities. The area of interest is Allegheny County, Pennsylvania, where the major industrial city of Pittsburgh is located. The environmental equity issue is whether certain disadvantaged members of the public bear a disproportionate share of the hazard burden. We have chosen to study this issue by comparing, in a spatial sense,

the vulnerability of African American residents and the residents of lower income households with the vulnerability of other residents of the county. Available data on the location and characteristics of the county's facilities and population are analyzed with a geographical information system (GIS). The facility data are the 1992 Section 312 (Tier II) reports that industry submits to comply with the provisions of the 1986 Emergency Planning and Community Right to Know Act (EPCRA), which is also known as SARA Title III. The population data come straight from the 1990 U.S. Census files.

A circular vulnerability zone is derived for each reporting facility, the size of which depends on the toxicity and the quantity of chemicals stored there. The procedure for generating these circles is adapted from EPA's technical guidance on hazard analysis (summarized in the next section) and uses CAMEO software as recommended by the agency. The level of vulnerability is assumed to be uniform throughout each zone and constant from one zone to another. As a measure of the combined vulnerability of any socioeconomic group to accidental releases occurring at any facility in the county (i.e., the group's hazard burden), we introduce the notion of "average vulnerability intensity" (AVI). The AVI value for any such group indicates the degree to which the vulnerability zones overlap the areas where those people reside. The level of equity between any pair of socioeconomic groups of interest is then reflected by the relative difference in their AVI values.

EPA'S TECHNICAL GUIDANCE

According to the EPA technical guidance publication known as the "Green Book" [USEPA (4)], the analysis of vulnerability proceeds in two steps: screening and reevaluation. In the *screening* step, a vulnerability zone based on worst case assumptions is calculated for each of the facilities in the area of concern. The zones, which ideally ought to be shaped in a way that reflects the formation of a plume in the direction of the wind, are drawn instead as circles because the wind direction at the time of release is unpredictable. A risk-based ranking of the facilities is then produced, based on the probability of release for each facility and the population in its zone. During the *reevaluation* step, new vulnerability zones are calculated for the top-priority facilities, using facility-specific data to generate more realistic descriptions of the most probable release scenarios.

The size of a vulnerability zone depends on four major factors: (1) quantity and rate of release, (2) meteorological conditions, (3) surrounding topography, and (4) level of concern (the concentration of a released chemical in the air above which there may be serious irreversible health effects or death as result of a single exposure for a relatively short period of time).

In the screening step, the vulnerability zone's radius is based on the maximum quantity that could be released from the largest vessel in the facility within 10 minutes for a solid or gas, or one minute for a liquid, assuming a wind speed of 1.5 meters per second (3.4 mph) and very stable atmospheric conditions (stability class F). The surrounding topography is assumed to be that of a rural area (i.e., flat, unobstructed terrain) and the level of concern is assumed to be one-tenth of the IDLH concentration.

In determining the vulnerability zones to use in the equity analysis, we followed the technical guidance for the screening step in every respect but one: since we are dealing with a large metropolitan area, we assumed the topography to be urban rather than rural. Then, since the results of the screening step are only considered to be valid when the radius of the zone is between 0.1 mile and 10 miles, inclusive, we ignored the results for all radii below this range and truncated to 10 miles all radii above it. We did not perform the reevaluation step.

VULNERABILITY ZONES

The 1992 Section 312 (Tier II) reports for Allegheny County, obtained from the Pennsylvania Department of Labor & Industry, Bureau of Right to Know, reveal that a total of 867 facilities stored a total of approximately 1750 chemicals. Of these facilities, 176 reported at least one extremely hazardous substance (EHS). EPA considers these chemicals to be the ones most likely to have severe toxic effects on human beings exposed to an accidental release. On closer inspection, we found that some of the chemicals reported by these facilities were incorrectly marked as EHSs. After eliminating them we ended up with only 128 facilities reporting a total of approximately 120 different EHSs.

For each facility we used CAMEO to calculate a vulnerability zone for each EHS stored there and then selected the largest resulting circle. The amount of each of these chemicals that might accidentally be released at each facility was assumed (conservatively) to be the midpoint of the range of the daily average amount reported.

In the first round of CAMEO calculations, almost half the cases entered could not be handled by the program for lack of a "liquid factor" value for incorporating the molecular weight and vapor pressure of a liquid chemical into the release rate equation. CAMEO's chemical database

includes such values for substances that are liquid at ambient temperature and pressure. However, since many of the reporting facilities either store their chemicals at other than ambient conditions or incorporate them in mixtures, substances that are not usually stored as liquids had to be treated as such. In the next round, we calculated the liquid factors for these substances using Appendix G of the Green Book, which gives equations for liquid factors in ambient conditions, at boiling point, and at melting point. The molecular weights, vapor pressures, and boiling temperatures needed for these equations were taken from a table of EHS properties in Appendix C, supplemented by information in Section D of the *Handbook of Chemistry and Physics* [Chemical Rubber Company (5)].

Of the 128 facilities considered, only 62 turned out to have a vulnerability zone radius of at least 0.1 mile. The distribution of these radius lengths is presented in Table 1. Figure 1 shows the locations of the 62 facilities, many of which are located on one of the three major rivers in the county.

Table 1. Radii of vulnerability zones for facilities storing EHSs in Allegheny County

<u>Radius (miles)</u>	<u>No. of Facilities</u>
0.10 - 0.99	12
1.00 - 1.99	16
2.00 - 2.99	8
3.00 - 6.99	0
7.00 - 7.99	4
8.00 - 8.99	1
9.00 - 9.99	0
10.00	21

THE GIS ANALYSIS

In the context of the acute hazards considered here, environmental equity relates to how the spatial vulnerability of minorities com-

pare to that of non-minorities and how the spatial vulnerability of low-income groups compares to that of higher-income groups. To obtain the numbers required to make such comparisons, we used Atlas GIS software to superimpose the vulnerability zones on each of the block groups in the county and to examine the socioeconomic attributes of the population in the intersecting areas. Block groups are spatial divisions defined by the U.S. Census Bureau; in Allegheny County, their average size is about 0.5 square miles. Three types of data files were needed for the GIS analysis: (1) geographic files for mapping the areas of interest, (2) a datapoint file for locating the facilities of concern, and (3) attribute files for associating sociodemographic data with the intersecting areas.

The geographic files, including the TIGER file, were obtained from the U.S. Census Bureau. The datapoint file was constructed from the Section 312 reports, except when the latitude-longitude coordinates were not provided, in which case the street address was "address-matched" to a pair of coordinates using a function built into the software. Any addresses that were not recognized were assigned locations based on telephone calls to the facilities. A circle representing the vulnerability zone was then plotted around each facility. The attribute files were constructed using 1990 Census data on race and income (STF1A and STF3A). Block groups were selected as the unit of spatial analysis because smaller units (blocks) would have required more computational without adding much meaningful precision, while larger units (census tracts) might have blurred important spatial distinctions.

The first step in the analysis was to generate an indicator of the total vulnerability of each block group by finding the area it has in common with each of the 62 vulnerability zones and summing up those areas. This is an appropriate indicator, assuming that being exposed to n

equal hazards is n times worse than being exposed to any one of the hazards alone. To put these resulting areas in relative terms, we then introduced another notion, the *vulnerability intensity* (VI) of a block group, which is the ratio of this area to the total area of the block group. The corresponding formula for this calculation is

$$VI_i = (\sum_j a_{ij}) / A_i$$

where a_{ij} is the area that block group i has in common with the vulnerability zone of facility j , and A_i is the total area of that block group.

The *average vulnerability intensity* (AVI) for any given racial or income group depends on the number of individuals or households of that type in each block group and on the corresponding values of VI_i . It is calculated for the county as follows:

$$AVI_k = \sum_i [(N_{ik} / \sum_i N_{ik}) \times VI_i]$$

where N_{ik} denotes the number of individuals or households of type k in block group i . The AVI may be thought of as an indicator of "individual" vulnerability, since it is simply the average number of vulnerability zones in which each individual resides.

The equity issue thus reduces to comparisons between (a) the AVI value for the racial or income group of concern and (b) the AVI value of the corresponding reference group. For example, if equity with respect to race is the issue and the group of concern is African Americans, then the reference group could be whites. Or if equity with respect to income level is the issue, then the group of concern is individuals with family incomes below the poverty line or below the median income for the county, and the reference group could be individuals with incomes above the poverty line or above the median income for the county.

RESULTS OF CALCULATIONS

The results of the AVI calculations appear in Table 2. An AVI value is given for Allegheny County as a whole, for African Americans alone, and for whites alone. AVI values are also given for the individuals within each of these groups who live below the poverty line (\$12,674 in annual income for a family of four in 1989) or above it. The poverty-related figures in the table do not account for anyone who is not in the "poverty sample," i.e., anyone who is institutionalized or lives in a military barracks or a college dorm. Taken as a whole, the county has an AVI value of 12.5. That is, the average resident lives within 12.5 of the vulnerability zones calculated for the Section 312 facilities which store EHSs. If this seems high, it is because EPA's technical guidance for screening analysis, which was developed for emergency planning purposes, generally results in a conservatively large value for the size of a vulnerability zone.

The AVI values in the table show that, on average, poor people are more vulnerable than other people (14.4 vs. 12.2) and African Americans are more vulnerable than whites (15.8 vs. 12.0). The worst-off group is African Americans living below the poverty line (16.2). Thus, poor African Americans tend to be more vulnerable than other African Americans (15.6). Similarly, poor whites (13.4) tend to be more vulnerable than other whites (11.9). However, race is a more dominant factor than income level, as evidenced by the fact that, on average, even African Americans above the poverty line are more vulnerable than poor whites (15.6 vs. 13.4).

Table 3 shows in percentage terms the relative differences in these AVI values, depending on whether the comparisons are made by race or income level. The first comparison shows the greatest disparity: a relative difference of 31% between the average vulnerability

Table 2. AVI values in Allegheny County by race and income level

	Number of persons	AVI
Total population	1,336,449	12.5
Above the poverty line	1,154,460	12.2
Below the poverty line	150,713	14.4
White population	1,169,452	12.0
Above the poverty line	1,049,914	11.9
Below the poverty line	95,317	13.4
African American population	149,550	15.8
Above the poverty line	92,544	15.6
Below the poverty line	51,712	16.2
Total households		
Median household income at or above the county median		11.6
Median household income below the county median		14.4

Table 3. Relative differences in AVI values

Comparison by race: African Americans vs. whites

For all county residents	31%
For county residents living below the poverty line	21%

Comparison by income level: living below the poverty line vs. living above it

For all county residents in the poverty sample	19%
For all whites in the poverty sample	12%
For all African Americans in the poverty sample	4%

of African Americans and whites in the county. With a value of 21%, the second comparison shows that the relative difference between poor African Americans and poor whites is somewhat less. When the comparisons are based instead on whether the income level is below or above the poverty line, we find that the average vulnerability of all the poor county residents is 19% higher than it is for other county residents, which is less than the relative difference based on race.

Since the poverty line only separates the very poor from the rest of the population, we also examined differential vulnerability according to income level using median household income as the dividing line instead. Allegheny County had a median household income of \$28,136 in 1989. We calculated two additional AVI values: one for all block groups with a median household income below that level, and another for the remaining block groups in the county. They turned out to be 14.4 and 11.6, respectively, for which the relative difference is 24%. This is larger than the relative difference of 19% associated with the poverty line, indicating that the class difference is even greater between the lower half and the upper half of the economic ladder than it is between the poor and the "not poor." In other words, for the acute hazard of concern, inequity as a function of income level is not limited to the very poorest residents.

Finally, since the oldest and youngest members of the public are generally considered to be more sensitive than others to the hazard of toxic inhalation and less capable of self-protection in the event of a release accident, we calculated AVI values for these groups, too. The resulting values, which were only slightly different from the overall value of 12.5 that applies to all county residents, turned out to be 12.3 for ages five and younger (100,509 people) and 12.9 for ages 65 and older (231,911 people).

For mapping purposes, we also calculated AVI values by block group, regardless of racial composition and income levels. The results, as seen in Figure 2, lead to an interesting pattern in which the vulnerability tends to be highest near the center of the county and declines in bull's-eye fashion as one moves away from the center in any direction. To some degree, this is due to a higher density of facilities near the center, but for the most part it is attributable to the fact that more of the larger-radius vulnerability zones overlap near the center of the county than further from its center. For comparison, Figure 3 shows by block group what percentage of the population is African American. Figure 4 does the same for the percentage of the population that lives below the poverty line in each block group.

REFERENCES

1. P. Mohar and B. Bryant, eds. *Race and Incidence of Environmental Hazards: A Time for Discourse*, Westview Press, Boulder, 1992.
2. L. Napton and F. Day, "Polluted Neighborhoods in Texas: Who Lives There?" *Environment and Behavior* 24(4), 1992, 508-526.
3. *National Law Journal*, "Unequal Protection: The Racial Divide in Environmental Law," September, 1992, 51-511.
4. U. S. Environmental Protection Agency (USEPA), *Technical Guidance for Hazards Analysis: Emergency Planning for Extremely Hazardous Substances*, December, 1987.
5. Chemical Rubber Company, R.C. Weast, ed., *Handbook of Chemistry and Physics*, 1969.

Figure 1. Facilities storing EHSs in Allegheny County

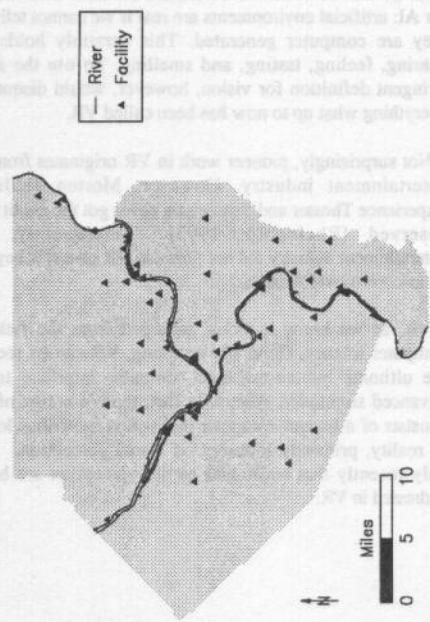


Figure 2. Average vulnerability intensity in Allegheny County block groups

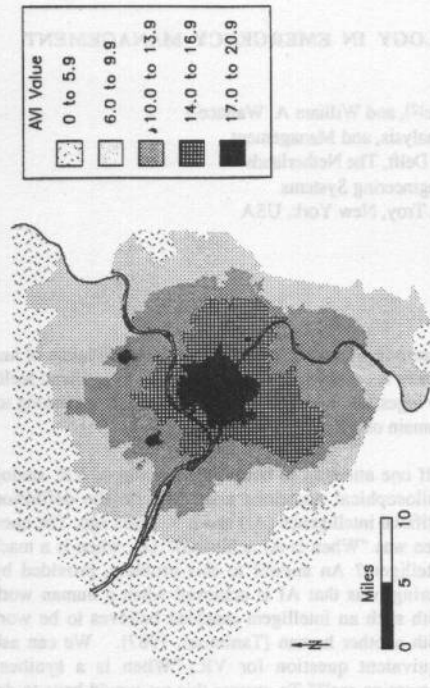


Figure 3. Percent African Americans in Allegheny County block groups

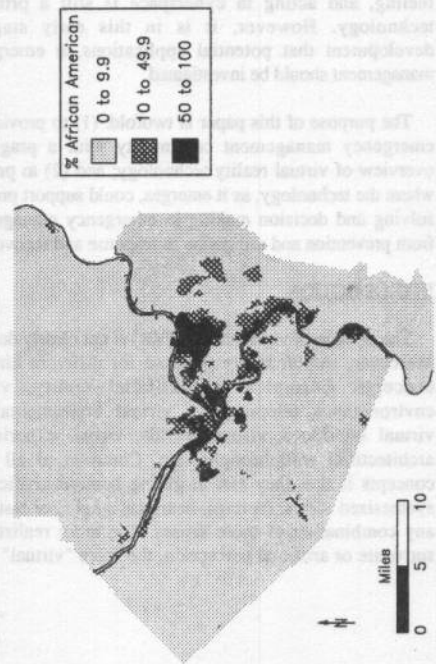


Figure 4. Percent of population below the poverty line in Allegheny County block groups

