Toxics Release Inventory Discharges and Population Health Outcomes in Rural and Urban Areas of the United States

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EXECUTIVE SUMMARY

Purpose of the Report: The current study examined whether chemical releases from facilities monitored through the Toxics Release Inventory (TRI) program were associated with population mortality rates for both rural and urban populations.

Methods: We used the TRI database, Centers for Disease Control and Prevention age-adjusted mortality data, and additional county level covariate data to conduct a national study at the county level of the association between amounts of on-site TRI air and water releases for the years 1988-2006 and population mortality rates for the years 1999-2006 for cancer, respiratory, cardiovascular, and total causes. Rural counties are defined based on rural-urban continuum codes from the USDA: urban counties are metropolitan (codes 1-3) and rural counties are non-metropolitan (codes 4-9).

Findings: There were significantly higher adjusted total mortality rates associated with greater air and water releases in both rural and urban counties. Effects were found in rural areas for total, cardiovascular, and (marginally) cancer mortality outcomes. We also found that counties with higher percentages of African American populations had more non-zero releases, but did not find this for populations characterized by greater Native American populations, lower income levels or higher poverty.

Conclusions: The results support the use of the TRI as a public reporting tool and demonstrate that greater amounts of air and water TRI releases are related to mortality outcomes for both rural and urban populations.

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BACKGROUND

Research on environmental health hazards for rural populations has focused primarily on agricultural studies.[1-3] One potential source of hazardous environmental exposure is from facilities that manufacture, process or use chemicals monitored through the Toxics Release Inventory (TRI) program.[4] Previous research on TRI sites and population health outcomes is limited, but includes findings suggesting that such sites pose health risks, especially with regard to air releases.[5-7]

In this study, we investigate the association between air and water chemical releases and age-adjusted mortality rates nationally at the county level. We test the hypothesis that greater release amounts into air and water will be associated with poor health outcomes across all measures in both rural and urban counties, after controlling statistically for the effects of other risk variables.

METHODS

TRI database

The TRI database includes chemical discharges from manufacturing facilities that have 10 or more full-time employees and manufacture or process over 25,000 pounds annually or otherwise use more than 10,000 pounds of any chemical specified on the TRI list.[8] For the current study we limited releases to on-site planned or unplanned releases to air or surface water for the years 1988-1998 (the years prior to the mortality period). We calculated the release at the county level measured in log-transformed pounds summed over the combined years.

CDC mortality database

The Centers for Disease Control and Prevention (CDC) Wonder database contains age-adjusted county-level mortality data for the years 1999-2006 based on ICD-10 classifications.[9] For this study, mean mortality rates were found combined across years and age-adjusted using the standard 2000 US Census population. Mortality from all internal causes was included (mortality from accident or intentional injuries was excluded.) We also analyzed mortality rates for all types of cancer, and for non-acute forms of cardiovascular and respiratory disease.

Covariates and rural-urban classification

County data from the 2005 Area Resource File were used to assess potential confounders, including race/ethnicity percentages, percent male population, high school and college education rates, percent below the federal poverty level, and the number of active, non-federal primary care doctors per 1,000 population. Prevalence of smoking for each county was obtained from Behavioral Risk Factor Surveillance System (BRFSS) data. Obesity rates for each county were taken from the US Department of Agriculture (USDA) Food Atlas.[10] Rural-urban continuum codes in effect in 2003 from the USDA were used to categorize counties into metropolitan (codes 1-3) or non-metropolitan (codes 4-9) areas.

Statistical analysis

A descriptive summary of study variables was calculated. Univariate and multivariate ordinary least squares linear regression analyses were used to determine the association of age-adjusted mortality rates with amounts of TRI on-site air and water releases.

We used linear models to test whether the percent of minority populations (percent African American, Native American, and Hispanic) were higher in counties with higher levels of TRI discharges.

FINDINGS

The distribution of air and water releases across rural and urban areas is shown in the national maps in Figures 1 and 2.

Figure 1: TRI Air Releases 1988-1998

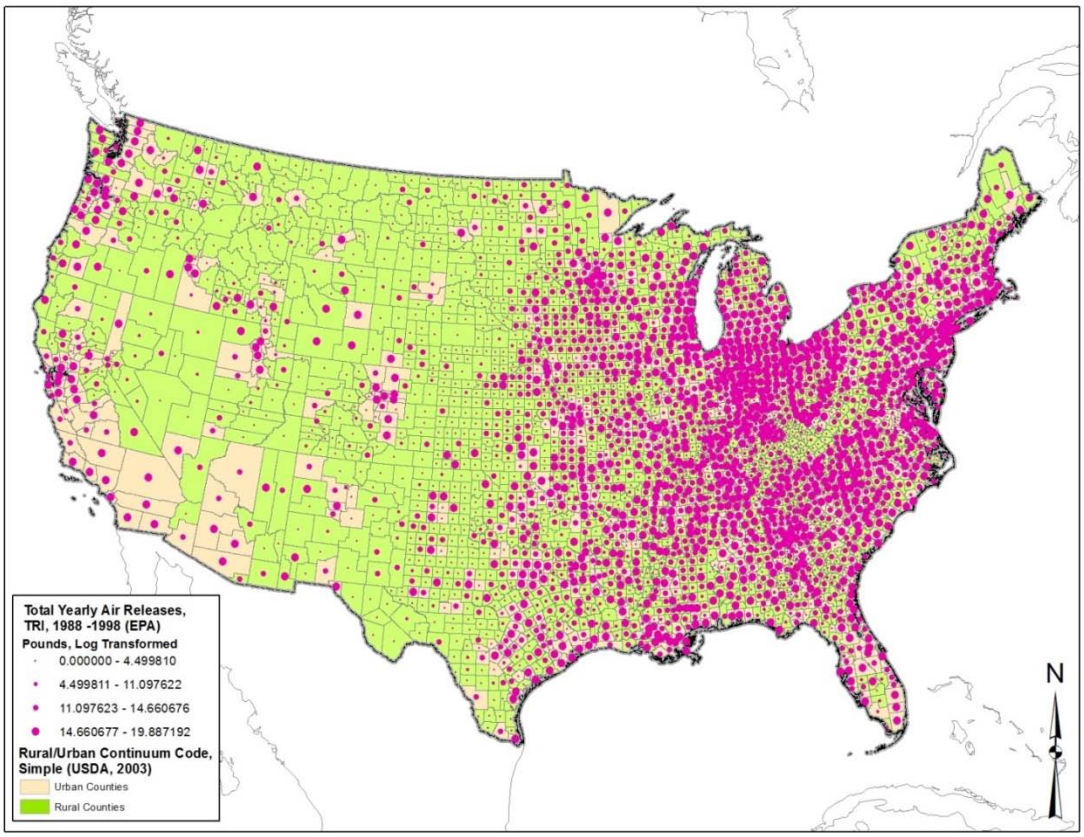
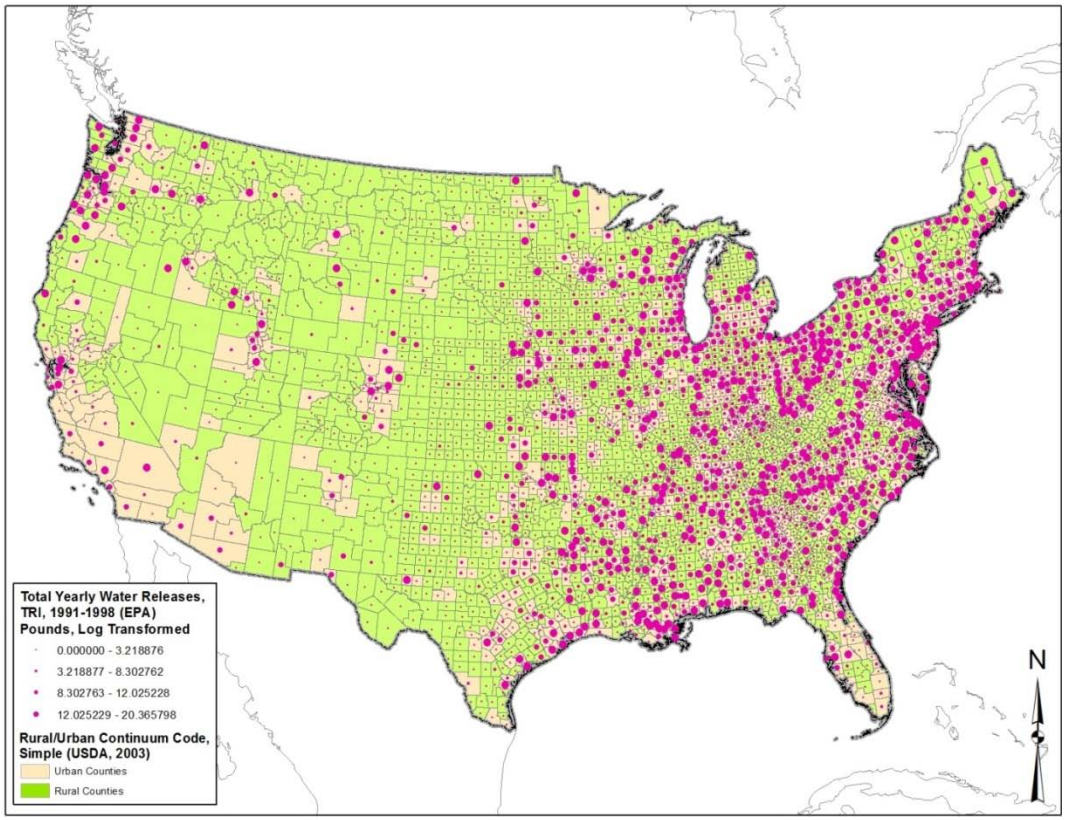


Figure 2: TRI Water Releases 1988-1998.



Model results for urban and rural areas.

Linear regression results for total mortality are presented in Table 1. A higher quantity of both water and air discharges was significantly related to higher total age-adjusted mortality rates in both rural and urban settings, and in the combined rural-urban analysis.

Table 1: Results of multiple linear regression analyses on total internal-cause age-adjusted mortality rates 1999-2006 for rural, urban, and combined counties.

Variable	Rural [1]	Urban [1]	Combined [1]
Adjusted R-square	.47	.60	.50
Smoking rate	3.88 (0.64) [5]	3.02 (0.54) [5]	3.76 (0.45) [5]
Obesity rate	3.85 (0.92) [5]	5.11 (0.89) [5]	4.38 (0.68) [5]
Percent male population	-1.36 (1.12)	3.42 (1.52) [2]	-0.13 (0.90)
Active primary care doctors per 1,000	7.02 (2.63) [3]	0.56 (1.57)	3.10 (1.52) [2]
Poverty rate	3.84 (0.66) [5]	4.58 (0.78) [5]	3.69 (0.51) [5]
Percent African American	1.06 (0.22) [5]	1.44 (0.20) [5]	1.17 (0.16) [5]
Percent Native American	1.08 (0.27) [5]	-1.20 (1.00)	0.95 (0.24) [5]
Percent Hispanic	-1.39 (0.21) [5]	-2.42 (0.24) [5]	-1.71 (0.16) [5]
Percent Asian American	1.49 (1.37)	-0.78 (0.81)	-0.30 (0.79)
Percent without high school education	4.54 (0.48) [5]	3.16 (0.54) [5]	4.38 (0.36) [5]
Percent with college education or higher	-1.64 (0.59) [3]	-0.87 (0.45)	-1.11 (0.38) [3]
Metropolitan county (yes/no)	--	--	30.53 (3.93) [5]
Log of air releases 1991-1998 in pounds	1.95 (0.43) [5]	1.14 (0.53) [2]	1.68 (0.33) [5]
Log of water releases 1991-1998 in pounds	1.21 (0.54) [2]	1.28 (0.47) [3]	1.23 (0.38) [3]

1) Cell values are unstandardized regression coefficients with standard errors in parentheses.
2) p<.05; 3) p<.01; 4) p<.001; 5) p<.0001

For cancer, the only significant effect was for water discharges in urban counties. However, the effects of air discharges in rural areas was marginally significant (p<.09). For respiratory mortality outcomes, we found no significant effects. For cardiovascular outcomes, greater TRI air discharges were significantly associated with higher mortality rates in rural areas and in the combined analysis; in urban areas the effect of greater air discharges was marginally significant (p<.07). The effect for greater water discharges in rural areas was also marginally significant (p<.09).

TRI discharges by race

We found that both rural and urban areas with higher percentages of African American populations had greater TRI discharges per county.

CONCLUSIONS

In rural areas, population all-cause mortality rates were positively associated with greater amounts of chemical discharges through both on-site air and water release routes. A previous analysis that counted only TRI sites per square mile[11] did not find a significant relationship between this measure and mortality outcomes, suggesting that the quantities of chemicals released is important over and above potential geographic or population confounds associated with the location of TRI facilities.

Counties with higher percentages of African American populations had significantly higher TRI discharge amounts, in both rural and urban counties. The association between African American populations and TRI discharges may be a result of sub-county residential proximity to more localized industrial facilities, or may be the result of higher exposure to releases in occupational settings among African Americans, although our data cannot answer this question. This possibility is supported by prior research showing that sources of pollution are often located in or near poor working-class communities and disadvantaged groups.[12-15]

The results support the use of the TRI as a public reporting tool and demonstrate that release quantities from the TRI sites are related to mortality outcomes for both rural and urban populations. Potential implications include policies that:

- Encourage discovery and use of alternative chemicals with less toxic properties
- Support industrial waste recycling and reuse to reduce emissions
- Support research to better understand individual exposures and health consequences
- Improve zoning practices that reduce exposures for vulnerable populations
- Educate rural providers on potential environmental exposures faced by their patients

REFERENCES

1. Mills PK, Dodge J, Yang R. Cancer in migrant and seasonal hired farm workers. *Journal of Agromedicine.* 2009;14:185-191.
2. Greger M, Koneswaran G. The public health impacts of concentrated animal feeding operations on local communities. *Family and Community Health.* 2010;33:11-20.
3. Wing S, Cole D, Grant G. Environmental injustice in North Carolina's hog industry. *Environmental Health Perspectives.* 2000;108:225-231.
4. EPA. Toxics Release Inventory (TRI) Program. 2010; http://www.epa.gov/tri/index.htm. Accessed 06-08-10.
5. Agarwal N, Banternghansa C, Bui LTM. Toxic exposure in America: estimating fetal and infant health outcomes from 14 years of TRI reporting. *Journal of Health Economics.* 2010:in press.
6. Suarez L, Brender JD, Langlois PH, Zhan FB, Moody K. Maternal exposures to hazardous waste sites and industrial facilities and risk of neural tube defects in offspring. *Annals of Epidemiology.* 2007;17:772-777.
7. Boeglin ML, Wessels D, Henshel D. An investigation of the relationship between air emissions of volatile organic compounds and the incidence of cancer in Indiana counties. *Environmental Research.* 2006;100:242-254.
8. EPA. TRI current data. 2010; http://www.epa.gov/tri/tridata/current_data/index.html. Accessed 05-15-10.
9. CDC. Compressed Mortality File. 2008; http://wonder.cdc.gov/mortSQL.html. Accessed 05-10-10.
10. USDA. Your food environment atlas. 2010; http://www.ers.usda.gov/foodatlas/. Accessed 06-08-10.
11. Hendryx M, Fedorko E, Halverson JA. Pollution sources and mortality rates across rural-urban areas in the United States. *Journal of Rural Health.* 2010, 26, 383-391.
12. Perlin SA, Setzer RW, Creason J, Sexton K. Distribution of industrial air emissions by income and race in the United-States - an approach using the Toxic Release Inventory. *Environmental Science & Technology.* 1995;29:69-80.
13. Daniels G, Friedman S. Spatial inequality and the distribution of industrial toxic releases: Evidence from the 1990 TRI. *Social Science Quarterly*. 1999;80:244-262.
14. Kogevinas M, Pearce N, Susser E, Boffetta P. *Social Inequalities in Cancer*. 1997, International Agency for Research on Cancer: Lyon.
15. Stuart AL, Mudhasakul S, Sriwatanapongse W. The social distribution of neighborhood-scale air pollution and monitoring protection. *Journal of the Air & Waste Management Association*. 2009;59:591-602.

Additional Information

See the Full Report that corresponds to this Brief for more detailed methods and findings from this study at: http://wvrhrc.hsc.wvu.edu/projects/2010/hendryx/