Disproportionate Environmental Risks: An Analysis of Chemical Facilities and Accidents in the U.S.

Dennis Guignet, Robin R. Jenkins, Ian Berry, and Margaret Sugg

Working Paper 24-08
October, 2024

U.S. Environmental Protection Agency
National Center for Environmental Economics
https://www.epa.gov/environmental-economics

NATIONAL CENTER FOR ENVIRONMENTAL ECONOMICS

Disproportionate Environmental Risks: An Analysis of Chemical Facilities and Accidents in the U.S.

Dennis Guignet[1], Robin R. Jenkins[2], Ian Berry[3], and Margaret Sugg[3]

Last Revised: October 2, 2024

1. Corresponding Author: Department of Economics, Appalachian State University, 416 Howard Street, ASU Box 32051, Boone, NC, 28608-2051. Ph: 828-363-2117. guignetdb@appstate.edu.

2. National Center for Environmental Economics, US Environmental Protection Agency.

3. Department of Geography and Planning, Appalachian State University.

Disproportionate Environmental Risks:
An Analysis of Chemical Facilities and Accidents in the U.S.

Dennis Guignet, Robin R. Jenkins, Ian Berry, and Margaret Sugg

Abstract:

A key objective of the environmental justice movement in the United States is to identify and resolve situations where environmental risks and harms are shouldered disproportionately by historically underserved populations (based on race, ethnicity, and low-income status). This study examines a unique dataset of chemical facilities that use extremely hazardous substances, and subsequent chemical accidents involving fires, explosions and/or toxic vapors. Using nationwide data on the U.S. Environmental Protection Agency's Risk Management Plan (RMP) program, we examine the proportions of underserved populations living near these facilities and accidents, compared to populations elsewhere across the broader contiguous U.S. We find that the proportions of residents who are Black, Hispanic, Asian, and living in poverty are greater in communities near these facilities. We find even larger percentages of underserved groups living near facilities where chemical accidents occur. Similar disparities are found when examining the spatial clustering of facilities and accidents. Finally, we find that some of these disparities are greater in communities where the state governments are in control, rather than where the federal government oversees the RMP program. These findings can inform policies to address disparate environmental risks and harms.

JEL Classification: D63; Q53; Q56

Keywords: accident, chemical, environmental justice, equity, toxic, Risk Management Plan, RMP

Acknowledgements: We thank the Office of Student Research at Appalachian State University for support in conducting this research. The first author's work on this research was supported by the Dean's Club Summer Research Grant from the Walker College of Business at Appalachian State University. We thank Jim Belke and Kevin Daniel for sharing RMP program information and data,and thank Peiley Lau and participants at the Northeastern Agricultural and Resource Economics Association's 2024 annual conference for helpful comments. The views expressed in this paper are those of the authors and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency.

I. INTRODUCTION

Communities living near facilities that use hazardous substances in their production processes face risks from potential accidental releases. Such releases can result in fires, explosions, and drifting clouds of toxic vapors. The United States Environmental Protection Agency's (EPA) Risk Management Plan (RMP) program is in place to protect the public from accidental releases at facilities using extremely hazardous substances. The RMP program was authorized by Section 112(r) of the 1990 Clean Air Act Amendments, which established a "general duty" for owners and operators of "stationary sources" holding extremely hazardous substances to identify potential hazards, take steps to prevent releases, and minimize the consequences of accidental releases that do occur.[1] Despite the sheer number and ubiquity of RMP facilities across the United States (U.S.), there are few studies examining the surrounding communities. The RMP program currently regulates almost 12,000 facilities, and there are multiple RMP facilities located in every U.S. state, putting close to 150 million people in communities located within 3 miles (about 4.8 km) of these regulated facilities (U.S. EPA 2023).

Using nationwide data on facilities regulated by the U.S. EPA's RMP program, and on accidents that occurred at those facilities from 2004 to 2019, we compare demographic characteristics of communities located near RMP facilities and chemical accidents to those of communities not near such facilities. We spatially link the RMP data to Census tract-level demographic data from the U.S. Census Bureau's 2010 American Community Survey. We use multivariate regression models to statistically examine (i) whether industrial facilities regulated under the RMP program are more likely to be located near communities where a greater proportion of residents are Black, American Indian, Asian, Hispanic, and/or living below the poverty line; (ii) whether facilities near such communities are more likely to have experienced chemical accidents at these facilities; and (iii) whether those accidents tend to be more severe. In addition, we investigate the distributional implications resulting from the clustering of multiple RMP facilities and accidents, and examine heterogeneity based on whether the U.S. EPA versus the state administers the program.

The results suggest that facilities are more often located near communities where a greater proportion of people are Black, Asian, Hispanic, and living in poverty. Greater proportions of these demographics in a neighborhood are also associated with an increased occurrence of chemical accidents. These positive associations are generally stronger in areas with multiple RMP facilities and accidents, and are robust to alternative model variants, such as the inclusion of state fixed effects, or the use of alternative distance bins to define proximity to a facility (i.e., five, three, and one kilometer(s)). Finally, among the nine states that are delegated authority to implement all or part of the RMP program themselves, we find an even stronger positive association between proximity to RMP facilities and accidents, and the proportion of the population that is Black, Asian, or living in poverty; though we find a weaker association with the proportion of the population that is Hispanic, suggesting mixed results regarding potential inequities in these states.

Overall, this nationwide analysis provides objective information to aid discussions with government, industry, and community stakeholders as part of the regulatory development process.

[1] 42 U.S.C. § 7412(r)(1).

Information on the demographic characteristics of communities facing risks of chemical accidents will improve understanding of the RMP program's distributional impacts and of other policies aimed at reducing the risk of exposure to chemical accidents and toxic releases from chemical facilities. Multiple Executive Orders, including President Biden's 2023 *E.O. 14096: Revitalizing Our Nation's Commitment to Environmental Justice for All,* call for Federal agencies to consider environmental justice (EJ) issues. Special consideration to such concerns is given, for example, in the EPA's recently finalized "Safer Communities by Chemical Accident Prevention" rule, which includes provisions to further reduce the probability and magnitude of future chemical accidents at RMP facilities (U.S. EPA 2023).

The remainder of this paper provides additional background on the RMP program and related literature. The empirical data and methodology are then discussed, followed by the results. We conclude by discussing the implications and importance of our findings.

II. BACKGROUND AND LITERATURE

The original RMP regulation promulgated by the U.S. EPA in 1996 requires that any stationary source that uses, stores, manufactures, or handles, more than a threshold quantity of one or more of 140 listed substances must undertake accident prevention steps and submit a ''risk management plan'' to various local, state, and federal planning entities.[2] The purpose of the RMP program is to protect the public and the environment from accidental chemical releases that can result in escaped toxic clouds, fires, and explosions. While onsite worker safety is regulated by the U.S. Occupational Safety and Health Administration , the U.S. EPA's RMP program is specifically meant to reduce risks to populations living in the surrounding communities.

The RMP program covers a wide range of industry categories, from large multi-process manufacturing plants such as petroleum refineries and chemical manufacturers, to smaller facilities, such as agricultural chemical distributors, water and wastewater treatment systems, and cold storage facilities. In-between there are a variety of other manufacturers, energy production facilities, chemical storage terminals and warehouses, natural gas processing plants, and food manufacturers, among others, regulated under the RMP program.

When a chemical accident occurs, an RMP facility must report it to regulators within 6 months if the accident resulted in death, injury, property damage, evacuations or sheltering-in-place of people, and/or environmental damage (e.g., fish or animal kills, water contamination, tree defoliation). In most cases any reportable accident impacts are onsite, meaning that the extent of harm is limited to what occurred at the regulated facility and on its property. In recent years, 27% of those reportable accidents involved *offsite* impacts such as deaths, injuries, property damage, evacuations, sheltering-in-place, and/or environmental damage to the surrounding communities (U.S. EPA 2023).

The spatial distribution of RMP facilities and reportable chemical accidents could be considered inequitable if they tend to be located near communities where a greater share of the population is

[2]CAA section 112(r) (3)–(5) and (7)(B).

a historically underserved racial or ethnic group, or living in poverty. If there are no inequities, then proximity to RMP facilities and accidents should be uncorrelated with the surrounding population demographics. To our knowledge, there are only three prior studies that have examined potential inequities around facilities and chemical accidents regulated under the RMP program. Elliott et al. (2004) studied facility data reported by an initial set of approximately 15,000 facilities regulated at the beginning of the RMP program, covering accidents from 1994 to 2000. Looking only at counties with RMP facilities, they examined correlations between county-level demographic information and measures of the riskiness of RMP facilities, including the frequency of chemical accidents. Elliott et al. found that larger and more chemical-intensive facilities are in counties with larger Black populations, and although these counties had higher median incomes, they also had greater levels of income inequality. Using data for the same set of facilities and time period as Elliot et al., Kleindorfer et al. (2004) examined the relationship between RMP facilities' propensities for accidents and their financial conditions, capital structures, regulatory environments, and demographic characteristics of the county where the facility is located. They found that counties with larger Black populations are more likely to have RMP facilities with higher quantities of chemicals (and other measures of riskiness); and that the risk of accidents, and of accidents with more severe outcomes (including injuries and property damage), is greater in counties with larger proportions of Black residents. More recently, Guignet et al. (2023a) used census tract-level data to examine population demographics near RMP facilities in Michigan (MI), Ohio (OH), and Pennsylvania (PA). They found that RMP facilities and accidents are more often located near neighborhoods where a greater proportion of the population is Black, Hispanic, and living in poverty.

Our current study includes populations near RMP facilities nationwide, and examines a wider set of racial groups (including American Indian and Asian). This study also investigates whether the presence of multiple RMP facilities and accidents is associated with greater shares of historically underserved populations, and assesses whether any disparities are greater among states that manage their own RMP programs directly, as opposed to implementation by the federal government. Such states must set standards at least as strict as those set by the federal program (42 U.S. Code 7412(I)). For example, such states may have increased frequency of facility inspections or lower chemical quantity thresholds for triggering program participation. Data on differences in RMP facility requirements between federal EPA and delegated states is sparse. The U.S. Government Accountability Office (2022) offers one useful comparison. In 2019, EPA inspected approximately 2% of RMP facilities nationwide, whereas in the delegated state of Florida, the Division of Emergency Management inspects an average of 12% of RMP facilities each year. Other examples of greater stringency include lower threshold quantities on many chemicals in Delaware and additional planning, auditing, and notification obligations in New Jersey (JJ Keller Compliance Network, 2024). At the same time, there is less federal oversight and state regulators may have closer relationships with regulated entities, which could lead to more relaxed enforcement.

Although not exclusively focused on EJ, studies by Guignet et al. (2023a; 2023b) examined how RMP facilities and accidents affect residential property values. They find that the value of homes near RMP facilities in general are lower, all else constant. This is important given that for many families their home is their single most important financial investment.[3] At the same time, Guignet et al. (2023a; 2023b) find that accidents with direct offsite impacts lead to an additional decrease in the value of homes (looking at distances of either 5 or 5.75 km, respectively).

The current study aims to enhance our understanding of the demographic composition of communities near RMP facilities and accidents. Doing so sheds light on which historically underserved populations are most affected by housing value depreciations. More importantly, our study provides insight as to what demographic groups are exposed to the potential health and safety risks; as well as to other negative impacts (such as evacuations and road closures) from living near hazardous chemical facilities, and to the associated increases in adaptation costs to mitigate or avoid those impacts and risks. In doing so, our results also demonstrate who experiences the benefits of RMP program requirements, including provisions like third party inspections and analyses of safer alternative technologies.

Outside of just the RMP program, a wide variety of studies have examined disparate exposures to toxic air emissions, some at the national level and others focused on smaller regions. Data and measures of toxic air exposures that have been examined include the Toxic Release Inventory (TRI), the National Emissions Inventory, the Air Quality System, satellite/remote sensing information, proximity to polluters, and more (Davis, 2011, Mikati et al. 2018, Gillingham and Huang 2021, Currie et al. 2023, Madrigal et al. 2024; Sheriff 2024). There is a long history of related studies that find disproportionate exposures among historically underserved populations near contaminated sites (Bullard et al. 2007, Burda and Harding 2014, Solatyavari et al. 2022, Brodin and Guignet 2024). A recent review by Cain et al. (2024) synthesizes the economics-oriented EJ research that has been published over the past decade and categorizes the primary contribution of each study. Forty percent of the papers reviewed are categorized as primarily "documenting and quantifying" population disparities in exposures to, or damages from, environmental risks. Of the 40 papers falling into this category, some compare differences in exposure and damages faced by Black and White populations. Others include additional racial and ethnic groups, as well as income groups, sometimes using the poverty line as a demarcation. Two main findings from the broader literature are that communities with higher percentages of Blacks, Hispanics, and Asian populations face higher pollution exposures, and that low-income communities face higher pollution burdens (as reflected in impacts on morbidity and mortality, for example). Documenting baseline disparities in exposures and harms from environmental risks is important to help inform policy intended to prioritize and address the largest disparities. Our current paper contributes to this literature by examining disparities associated with proximity to chemical facilities and accidents of different severities. As is often the case, there are no direct measures of risks and exposure available, and so proximity is used as a surrogate (U.S. EPA 2023).

[3] As of Quarter 2, 2024, the overall homeownership rate in the U.S. is 65.6 percent; the rate for Black Alone households is 45.3 percent; for Asian, Native Hawaiian and Pacific Islander Alone is 62.8 percent, and for Hispanic households is 48.5 percent (Federal Reserve Bank of St. Louis 2024).

III. DATA

Information on the location of RMP facilities and chemical accidents were obtained from the U.S. EPA's Office of Emergency Management and used to create variables denoting the presence and count of RMP facilities, and different accident severities. We link these data to community demographics from the U.S. Census Bureau's 2010 American Community Survey (ACS) based on varying proximities of facilities to individual census tracts.

III.A. RMP Facility and Accident Data

RMPs are required to be submitted by regulated facilities every five years. Submissions include information about the facility, its location, the chemical processes used, and emergency response plans. All submissions are required to include a facility's prior five-year history of reportable accidents (those that resulted in deaths, injuries, significant property damage evacuations, shelter-in-place orders, or environmental damage).[4] EPA maintains a national database of all submitted RMPs. As shown in Figure 1, our analysis focuses on the 17,437 facilities in the contiguous U.S. that were regulated under the RMP program for at least a portion of time from 2004 through September 2021. This includes all facilities who submitted at least one RMP to the program during this period, as well as seven facilities who submitted an earlier RMP, but did not deregister from the program until after 2004.[5]

In addition to examining the demographic characteristics of communities surrounding these facilities, we examine the demographics surrounding reportable accidents. Among the 17,437 facilities, there were 2,275 reportable accidents from 2004 through 2019.[6] These reportable accidents occurred at 1,428 different facilities, with most facilities (1,061) experiencing just one accident, 202 facilities experiencing two accidents, 70 experiencing three accidents, and 95 experiencing four or more accidents. The number of reportable accidents fluctuates from year to year, but has been trending downward over time (see Figure A1 in Appendix A). Among the reportable accidents, 789 resulted in offsite impacts to the surrounding community, including an offsite mortality (1 accident), offsite injuries (260 accidents), property damage (89), evacuations (312), and sheltering-in-place (222). During our 16-year study period, accidents with offsite injuries ranged from one to 15,020 people being injured or hospitalized, with an average of 64 injuries. Among the 312 accidents where people in the surrounding community had to evacuate, the average number of people evacuated was 307, with a range from one person to 50,000 people

---

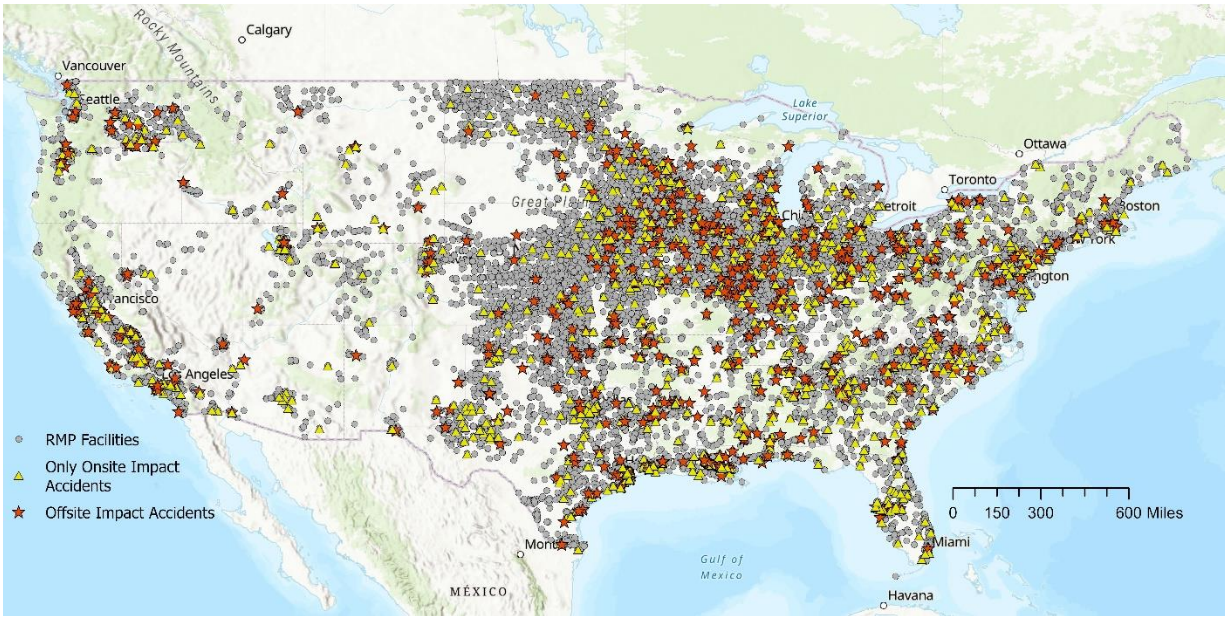
[4] See 40 CFR 68.42.

[5] The RMP dataset started with 20,758 facilities in the contiguous U.S. who submitted an RMP since the program's inception in 1999 through September 2021. We then excluded 3,292 facilities where the coordinates or coordinate system were missing, and another 29 facilities where the coordinates were likely incorrect, placing facilities in other countries or over open water, leaving 17,437 facilities. To match the available data of RMP chemical accidents examined by Guignet et al. (2023b), we sought to exclude any facilities that exited the RMP program prior to 2004. Although seven facilities did not submit an RMP since prior to 2004, they are maintained in our analysis because they did not deregister from the program until a later date.

[6] This is the same set of 2,275 reportable accidents examined by Guignet et al. (2023b) in their nationwide hedonic property value analysis. Further details regarding the RMP data can be found there.

being evacuated. Similar variation is reported among the accidents where the surrounding community had to shelter in place. Among those accidents, an average of 2,379 people were sheltered in place, and this ranged from just one person to 55,000 people.

Figure 1. RMP facilities and accidents



III.B. Community Demographic Data

We conduct a community-level analysis, defining communities according to the 2010 census tract boundaries. Based on the 2010 ACS, we obtain measures of the proportion of the population in each census tract within the contiguous U.S. who are White, Black, American Indian, Asian, Hispanic, and who are living below the 2010 poverty line.[7] As shown in Table 1, the average tract has a population that is approximately 74% White, 14% Black, less than one-percent American Indian and 4% Asian. Almost 15% of the population in a tract is Hispanic, on average.[8] The average tract consists of a population where approximately 15% of households are living in poverty.

The census tract data are spatially merged to the RMP data, and then measures of the presence and number of RMP facilities, reportable accidents, and offsite impact accidents are derived. Unfortunately, there are no direct measures of risk or exposure generally available for RMP facilities, and so proximity is often used as a surrogate (U.S. EPA 2023). In an analysis of potential risk exposure for the Safer Communities by Chemical Accident Prevention rule, the U.S. EPA

[7] In 2010 the US Census Bureau defined the poverty threshold for a family of four people as approximately $22,000.
[8] As defined in the 2010 ACS, Hispanic describes a person's ethnicity, which is separate from race. People who identify as Hispanic may also identify as White, Black, Asian, or American Indian in these data.

examined community demographics within one- and three-mile distances. The three-mile distance (about 4.8 km) was intended to capture worst-case release scenarios (U.S. EPA 2023). The U.S. EPA's EJ screening and mapping tool (EJScreen) builds an indicator of potential health and environmental hazard impacts from RMP facilities using a five-kilometer distance (U.S. EPA 2024). Hedonic studies have found adverse effects on surrounding home values out to about five kilometers (Guignet et al. 2023a; 2023b), suggesting that households perceive RMP risks out to this distance. Overall, the evidence suggests that five kilometers is a reasonable distance when identifying communities potentially affected by RMP facility and accident risks. We adopt five kilometers for our main analysis of the distributional implications of the RMP program (and examine the sensitivity of our findings when using alternative one- and three-kilometer distance bins). The five-kilometers distance also allows for direct comparison to a preliminary analysis of demographics around RMP facilities in MI, OH, and PA that used five kilometers (Guignet et al. 2023a).

As shown in Table 1, more than half of the tracts in the contiguous U.S. (54%) are within five kilometers of an RMP facility.[9] The average tract has 1.5 RMP facilities within five kilometers, but there is notable variation, ranging from 0 to 46 facilities. About 11% of tracts are within five kilometers of a reportable accident, and only 6% of tracts are within five kilometers of an offsite impact accident that directly affected the surrounding community.

Table 1. Descriptive statistics: Census tract demographics and proximity to RMP facilities and accidents.

	Obs[a]	Mean	Std. dev.	Min	Max
% White	71,897	73.690	25.619	0	100
% Black	71,897	13.694	22.625	0	100
% American Indian	71,897	0.857	4.489	0	100
% Asian	71,897	4.204	8.169	0	100
% Hispanic	71,897	14.725	20.907	0	100
% Poverty	71,774	14.828	12.334	0	100
RMP Facility w/in 5km[b]	72,539	0.540	0.498	0	1
# RMP Facilities w/in 5km	72,539	1.509	2.352	0	46
RMP Accident w/in 5km[b]	72,539	0.114	0.318	0	1
# RMP Accidents w/in 5km	72,539	0.228	0.930	0	36
Offsite Impact Accident w/in 5km[b]	72,539	0.061	0.238	0	1
# Offsite Impact Accidents w/in 5km	72,539	0.082	0.380	0	14

Notes: (a) There are 72,539 (2010) census tracts in the contiguous U.S., but due to low populations and confidentiality concerns, information on the number of people of different racial, ethnic, and income categories are not reported in the 2010 ACS for some tracts. (b) Denotes binary indicator variables where the indicator equals one if there is a facility or accident of that type within five kilometers, and a zero otherwise.

[9] Geodesic distances were calculated within a Geographic Information System (GIS) and are based on the population-weighted centroid for each 2010 census tract (https://www.census.gov/geographies/reference-files/time-series/geo/centers-population.html, accessed 13 Feb 2024).

IV. METHODS

Our objective is to identify whether historically underserved groups make up greater proportions of the population in communities near RMP facilities and accidents. To achieve this, we estimate a series of multivariate regression models that allow us to quantify the extent to which RMP facilities are in communities where (i) a greater proportion of residents are Black, American Indian, Asian, Hispanic, and/or living in poverty, relative to the rest of the contiguous U.S. population. Additionally, we evaluate whether the share of residents in these different demographic groups is even greater near facilities where a (ii) reportable chemical accident occurs, as well as where a (iii) more severe accident yielding offsite impacts occurs. We also estimate models of the proportion of residents who are White as a comparison to the other racial groups (Black, American Indian, and Asian). The dependent variable in our models is the percent of the population in census tract *j* in state *s* $(\%pop_{js})$ that is White, Black, American Indian, Asian, Hispanic, or living in poverty.

A separate regression model is estimated for each of these groups, where only the dependent variable is different across the models. In our base models, the independent variables include a binary indicator RMP_{js} that equals one if there is an RMP facility located within, for example, five kilometers of the population-weighted centroid of tract j in state s, and zero otherwise. Similar indicator variables denoting whether an RMP accident occurred within that distance bin (Acc_{js}), and whether an accident yielding offsite impacts occurred (Off_{js}) are also included as independent variables. The formal regression models to be estimated are of the following form:

$$\%pop_{js} = \alpha_0 + \alpha_1 RMP_{js} + \alpha_2 Acc_{js} + \alpha_3 Off_{js} + e_{js} \tag{1}$$

where e_{js} is an unobserved disturbance term that is allowed to be correlated across all tracts within each county of state *s*.

Although $\%pop_{js}$ is the outcome variable in equation (1), we emphasize that our interest is not in explaining the overall demographic composition in a tract. We are just trying to establish statistical associations between the presence of RMP facilities and chemical accidents with different demographic groups. We are not attempting to identify causal mechanisms of why populations near RMP facilities may consist of a greater composition of Black individuals, for example. Instead, we are simply attempting to identify population groups that tend to be near RMP facilities and accidents.

An alternative empirical approach would be to flip the model and include demographic information on the right-hand side and RMP activity variables on the left-hand side (for example, see Brodin and Guignet 2024), but we prefer the model in equation (1) for two reasons. First, we are interested in accounting for the incremental associations between RMP activities and the demographic composition of surrounding communities. The coefficient α_1 allows us to identify the percentage point change in the corresponding demographic group when an RMP facility is nearby (e.g., within five kilometers). This association is relative to tracts where there are no nearby RMP facilities. For example, if $\%pop_{js}$ corresponds to the percent of the population that is Black, then α_0 will capture the average percent of the population that is Black for tracts where no RMP facility is nearby. The coefficient α_1 captures the incremental difference in the share of the population that is Black among tracts where an RMP facility is nearby.

The next coefficient α_2 captures the incremental difference between tracts near an RMP facility with a reportable accident, compared to tracts near an RMP facility with no reportable accidents. Thus, the model allows us to identify any additional inequitable patterns associated with chemical accidents, conditional on the presence of an RMP facility. Similarly, α_3 captures the incremental association between the share of the population that is of a specific demographic group near facilities where a more severe, offsite impact accident has occurred. This latter association is relative to tracts where there was a reportable accident that did not result in offsite impacts to the surrounding community.

A second key reason for exploring demographic disparities using equation (1), where $\%pop_{js}$ is included as the dependent variable, is that taking the alternative approach and including $\%pop_{js}$ as independent variables for multiple demographic groups can result in multicollinearity concerns, and could suggest null effects where there are in fact inequitable patterns.[10] A second set of regression models is estimated to explore the distributional implications of areas with multiple RMP facilities and accidents. In equation (2), $RMP2_{js}$, $Acc2_{js}$, and $Off2_{js}$ are indicators denoting the presence of multiple (i.e., two or more) RMP facilities, reportable accidents, and offsite impact accidents, respectively, within the corresponding distance bin of tract *j* in state *s*. The coefficients β_1, β_2, and β_3 are additional parameters to be estimated. We estimate this specification to flexibly account for how potentially inequitable patterns might vary due to spatial clustering of multiple RMP facilities and accidents.

$$\%pop_{js} = \alpha_0 + \alpha_1 RMP_{js} + \beta_1 RMP2_{js} + \alpha_2 Acc_{js} + \beta_2 Acc2_{js} + \alpha_3 Off_{js} + \beta_3 Off2_j + e_{js} \quad (2)$$

In equation (2), we are decomposing the associations estimated under equation (1) into how much of the disparity is associated with being near a single facility (α_1), for example, versus being near multiple facilities (β_1).

Next, we estimate a variant of equation (1) that includes state fixed effects (θ_s), as shown:

$$\%pop_{js} = \alpha_0 + \alpha_1 RMP_{js} + \alpha_2 Acc_{js} + \alpha_3 Off_{js} + \theta_s + e_{js} \quad (3)$$

[10] As shown in Table A1 in Appendix A, there are fairly high pairwise correlations between the percent of the population in a tract that is White, Black, and living in poverty.

The state fixed effects account for any factors associated with $\%pop_{js}$ that are common across all tracts within a state. To understand how they impact the model, consider equation (1), which omits state-fixed effects. If states with high percentages of Black populations also have relatively large numbers of RMP facilities, then significant positive estimates of α_1 from equation (1) would suggest that RMP facilities tend to be located in communities with higher proportions of Black residents, relative to other tracts across the country. This would hold even if Black populations within states with high proportions of RMP facilities and Black residents were uniformly distributed within those states. In this example, however, including state fixed effects in equation (3) would account for the relatively greater shares of Black individuals in a state and α_1 would be zero, suggesting no *within-state* inequities in terms of the locations of RMP facilities. Alternatively, if α_1 in equation (3) was positive, it would suggest disparities within states—that on average, RMP facilities tend to be located in neighborhoods where a greater percent of the community is Black, for example, relative to other tracts within a state.

The inclusion of state fixed effects leads into our final model in equation (4), where we account for heterogeneity based on whether the EPA administers the RMP program versus when states have delegated authority. Such states are required to set standards at least as stringent as the federal program. Equation (4) includes interaction terms between the RMP and accident variables with an indicator denoting states that have been delegated the authority to (fully or partially) implement and enforce the RMP program (D_s). These states include DE, FL, GA, MS, NJ, NC, ND, OH, and SC (see Appendix B for details).

$$\begin{aligned}\%pop_{js} = \alpha_0 + \alpha_1 RMP_{js} + \gamma_1\left(RMP_{js} \times D_s\right) + \alpha_2 Acc_{js} + \gamma_2\left(Acc_{js} \times D_s\right) \\ + \alpha_3 Off_{js} + \gamma_3\left(Off_{js} \times D_s\right) + \theta_s + e_{js}\end{aligned} \tag{4}$$

Estimates of the coefficients γ_1, γ_2, and γ_3 will capture heterogeneity across delegated versus non-delegated states in terms of the associations between the demographic groups and the presence of nearby RMP facilities, chemical accidents, and offsite impact accidents, respectively. Any inequitable patterns identified among tracts in delegated states will shed light on who might be affected by differences in state and federal regulatory programs. In delegated states, there is less federal oversight, but at the same time standards must be at least as stringent as the EPA's federal program. Any identified heterogeneity could reflect pre-existing inequities in the spatial distribution of RMP facilities and population groups that differ on average, across states that do and do not have delegated authority; or alternatively, could reflect patterns that have developed after state delegation.

V. RESULTS

In this section, we present and discuss the main regression model results following equation (1). We then examine the distributional implications when accounting for the clustering of numerous facilities and accidents (equation (2)), followed by an assessment of within-state inequities based on models that employ state fixed effects (equation (3)). Lastly, we investigate potential heterogeneity in the distributional characterization of RMP facilities and accidents based on whether the corresponding state, as opposed to the U.S. EPA, is delegated to administer the RMP program and requirements (equation (4)).

V.A. Primary Regression Model Results

The base regression model results are presented in Table 2. Estimates from each model are presented in a separate column, and the dependent variable – the proportion of each demographic group – varies across columns.[11] The constant term reflects the average proportion of the population in the corresponding demographic group for tracts that are *not* within five kilometers of an RMP facility. For example, Model 1 suggests that a tract not near any RMP facilities has a population that is almost 80.0% White. If a tract is within five kilometers of one or more RMP facilities, then on average that is associated with a 9.6 point decrease in the percent of the population that is White. The occurrence of one or more accidents within five kilometers is associated with an additional 10.0 point decrease in the average share of the population that is White. We find no statistically significant association with respect to offsite impact accidents. Decreases in the proportions of the population that are White imply increases in the proportions of the local populations that identify with other races such as Black or American Indian, for example.

We next take a closer look at these historically underserved groups. The constant term estimate from Model 2 in Table 2 suggests that about 9.8% of the population is Black in the average tract that is not within five kilometers of any RMP facility. If a tract is within five kilometers of one or more RMP facilities, then that is associated with a 5.6 point increase in the percent of the population that is Black, suggesting that such tracts have populations that are about 15.4% (= 9.8+5.6) Black, on average. This difference is statistically significant and sizeable, indicating that the presence of at least one nearby RMP facility is associated with a 57.5% (= 5.6 / 9.8) increase in the proportion of the population that is Black. We emphasize that this is not a causal relationship, and there are important factors (perhaps unrelated to RMP facilities) that are not accounted for. Nonetheless, our results show that Black populations tend to be significantly more prominent in communities near these RMP facilities.

The results from Model 2 further suggest that the occurrence of one or more chemical accidents is associated with an *additional* 7.0 point increase in the share of the population that is Black. Cumulatively, this suggests that the proportion of the population that is Black is more than double

[11] Although there are 72,539 census tracts in the contiguous U.S., either 71,897 or 71,774 observations are included in the estimating sample (depending on the corresponding dependent variable). Due to low populations and confidentiality concerns, the U.S. Census Bureau did not report information on the number of people of different racial, ethnic, or income categories for some tracts in the 2010 ACS data.

among communities where there was at least one chemical accident within five kilometers, increasing from 9.8% to 22.4% (= 9.8+5.6+7.0). This is a 128.9% increase over the average percent of Black individuals in communities without nearby RMP facilities. The presence of one or more offsite impact accidents is associated with a positive, but small and statistically insignificant increase in the Black population.

We find little evidence of inequitable spatial distributions of RMP facilities and accidents in terms of American Indian populations (Model 3). If anything, the results from Model 3 suggest that American Indians are less likely to live near RMP facilities and accidents, perhaps reflecting that there is relatively less industrial activity near (possibly more rural) areas where American Indian communities tend to locate. However, we do find inequitable associations with respect to Asian populations (Model 4). Although the magnitudes in the coefficients are lower, the percent changes are substantial because the share of the population that is Asian is relatively lower for the average tract that is not near an RMP facility, at only 3.7% (see the constant term in Model 4). The presence of one or more RMP facilities is associated with a 25.9% (= 0.96 / 3.68) increase in the proportion of the population that is Asian; and cumulatively, one or more accidents is associated with a 44.1% increase (= (0.96+0.67) / 3.68). One interesting result from Model 4 is that the -1.2 coefficient estimate suggests that more severe offsite impact accidents tend to occur near tracts where the share of the population that is Asian is lower (compared to tracts near a reportable accident in general).

The results from Model 5 in Table 2 indicate that tracts within five kilometers of one or more RMP facilities tend to consist of populations where the proportion of people that are Hispanic is 7.6 percentage points greater. The share of the population that is Hispanic is even greater (an additional 4.1 points) in cases where a reportable chemical accident occurred at a nearby facility.

We find similar results when examining the proportion of households living in poverty, as seen in Model 6. The average tract not near an RMP facility has about 12.2% of households living in poverty. Tracts within five kilometers of an RMP facility are poorer, with a poverty rate that is 3.9 percentage points greater. This difference doubles among communities where a chemical accident occurs, suggesting an additional 3.7 point increase in the poverty rate. Cumulatively, this suggests that the average tract within five kilometers of one or more chemical accidents has a poverty rate that is 62.7% (= (3.9+3.7) / 12.2) higher than that of tracts where no RMP facilities are nearby.

Although the primary analysis above is based on five kilometers serving as a reasonable distance to proxy for perceived and actual risks (see Section III.B), the general patterns found are robust when alternative distances of three kilometers and one kilometer are used (see Tables A2 and A3 in Appendix A).[12]

[12] The results based on three kilometers are robust. The one-kilometer results are similar, suggesting that the presence of one or more RMP facilities is associated with a decrease in the share of the population that is White, and increases in the shares that are Black, Hispanic, and living in poverty. The one-kilometer results, however, suggest a slight decrease in the share of the population that is Asian. Additionally, when focusing on one kilometer, the estimated associations for one or more accidents are smaller in magnitude, and are statistically significant for only the model examining poverty. See Table A3 in Appendix A for details.

Table 2. Base regression model results examining distributional implications.

	(1) % White	(2) % Black	(3) % Am. Indian	(4) % Asian	(5) % Hispanic	(6) % Poverty
RMP Facility w/in 5km[a]	-9.5697***	5.6441***	-0.4594***	0.9551***	7.5751***	3.9474***
	(0.2076)	(0.1884)	(0.0426)	(0.0656)	(0.1696)	(0.1031)
RMP Accident w/in 5km[a]	-10.0081***	7.0062***	-0.0581**	0.6705***	4.0608***	3.7208***
	(0.5064)	(0.5112)	(0.0292)	(0.1789)	(0.4353)	(0.2499)
Offsite Impact Accident w/in 5km[a]	0.7987	0.2725	0.0673*	-1.2115***	0.1047	0.4430
	(0.6546)	(0.6653)	(0.0349)	(0.2092)	(0.5851)	(0.3255)
Constant	79.9738***	9.8164***	1.1089***	3.6828***	10.1477***	12.2349***
	(0.1551)	(0.1408)	(0.0415)	(0.0484)	(0.1255)	(0.0746)
Observations	71,897	71,897	71,897	71,897	71,897	71,774
Adjusted R-squared	0.063	0.034	0.003	0.004	0.044	0.047

Note: Cluster robust standard errors in parentheses, clustered at the county level. * p<0.10, ** p<0.05, *** p<0.01. (a) Binary indicators equal to one if one or more RMP facilities, accidents, or offsite impact accidents, respectively, are within five kilometers; and zero otherwise.

V.B. Accounting for Numerous Facilities and Accidents

In some cases, industrial chemical facilities (and accidents) are spatially clustered (see Figure 1). To flexibly account for the relationship between numerous RMP facilities and accidents and the composition of the surrounding population, we build on the previous models by adding indicator variables denoting when there are two or more RMP facilities and accidents within five kilometers, as shown by equation (2). The results in Table 3 suggest similar inequities as those found in the previous models, and in most cases the estimated disparities seem to be heightened when there are multiple RMP facilities within five kilometers. Model 1 in Table 3 suggests that on average the presence of one RMP facility is associated with a 5.3 percentage point decrease in the share of the population that is White, and when there are two or more RMP facilities within five kilometers we see an *additional* 7.7 point decrease. A chemical accident within five kilometers is associated with an additional 6.9 point decrease in the share of the population that is White, and there is another 2.8 point decrease associated with two or more chemical accidents occurring within five kilometers. We find that the occurrence of an offsite impact accident is actually associated with a significant increase in the share of the population that is White, but this is then countered by a greater in magnitude decrease that is associated with multiple offsite impact accidents within five kilometers. These decreases in the proportion of the population that is White imply increases in the proportion of other races living near these RMP facilities and accidents, especially in cases where there are multiple facilities and accidents.

Model 2 in Table 3 suggests that the racial disparities are most pronounced among Black populations. On average, the share of the population in a tract that is Black is positively associated the presence of an RMP facility, suggesting a 3.0 percentage point increase, all else constant. That share increases by 4.7 points when there are two or more facilities within five kilometers. When one or more chemical accidents within five kilometers occur, we see another 5.3 point increase in the Black population.

Similar inequitable patterns as before are found when examining the proportions of the population that are Asian, Hispanic, and living in poverty, as shown in Models 4, 5, and 6 in Table 3. We again find no robust evidence of potential inequities for American Indian populations in terms of RMP facilities and accidents, at least not on average (Model 3). The implications in terms of offsite impact accidents are a bit mixed across the Models in Table 3, with either null results or the coefficients corresponding to a single offsite impact accident versus multiple accidents mostly cancelling each other out.

Table 3. Regression model results: Accounting for numerous RMP facilities and accidents.

	(1) % White	(2) % Black	(3) % Am. Indian	(4) % Asian	(5) % Hispanic	(6) % Poverty
RMP Facility w/in 5km[a]	-5.2787***	3.0268***	-0.4284***	0.6693***	4.1264***	1.5271***
	(0.2476)	(0.2149)	(0.0455)	(0.0788)	(0.1903)	(0.1183)
Two or more RMP Facilities w/in 5km[b]	-7.7184***	4.7078***	-0.0558**	0.5140***	6.2033***	4.3528***
	(0.2809)	(0.2575)	(0.0248)	(0.0881)	(0.2383)	(0.1406)
RMP Accident w/in 5km[a]	-6.8826***	5.2957***	-0.0543*	0.7610***	0.7078	2.0904***
	(0.5692)	(0.5813)	(0.0279)	(0.1976)	(0.4735)	(0.2826)
Two or more RMP Accidents w/in 5km[b]	-2.7839***	1.1024	0.0372	-0.7226***	4.7941***	1.1734***
	(0.7265)	(0.7407)	(0.0449)	(0.2239)	(0.6949)	(0.3603)
Offsite Impact Accident w/in 5km[a]	2.3141***	-0.3521	0.1077***	-1.4615***	-1.1590*	0.1177
	(0.6888)	(0.7026)	(0.0380)	(0.2130)	(0.6037)	(0.3421)
Two or more Offsite Impact Accidents w/in 5km[b]	-3.8673***	1.4550	-0.1971***	1.5422***	1.5356	0.1282
	(1.1533)	(1.2243)	(0.0532)	(0.3515)	(1.1969)	(0.5906)
Constant	79.9738***	9.8164***	1.1089***	3.6828***	10.1477***	12.2349***
	(0.1551)	(0.1408)	(0.0415)	(0.0484)	(0.1255)	(0.0746)
Observations	71897	71897	71897	71897	71897	71774
Adjusted R-squared	0.075	0.039	0.003	0.005	0.057	0.062

Note: Cluster robust standard errors in parentheses, clustered at the county level. * p<0.10, ** p<0.05, *** p<0.01. (a) Binary indicators equal to one if one or more RMP facilities, accidents, or offsite impact accidents, respectively, are within five kilometers; and zero otherwise. (b) Binary indicators equal to one if two or more RMP facilities, accidents, or offsite impact accidents, respectively, are within five kilometers; and zero otherwise.

V.C. State Fixed Effects and within State Inequities.

Following equation (3), we next examine the robustness of the primary results from Section V.A to the inclusion of state fixed effects. Such fixed effects control for all observed and unobserved factors that are associated with the demographics of each individual state, and thus absorb any cross-state variation. As such, the subsequent results solely reflect within-state patterns and inequities. The results are similar to our earlier findings.

For example, as seen in Model 1 of Table 4, on average the presence of one or more RMP facilities is associated with a roughly 10.0 point decrease in the share of the population that is White, and we see an additional 9.8 percentage point decrease in cases where there was one or more chemical accidents. Again, decreases in the share of the population that is White imply increases in the share of the population that identifies with other races. This result is confirmed when specifically examining Black populations in Model 2. The results indicate a 7.2 point increase in the proportion of the population that is Black when there are one or more RMP facilities within five kilometers, and an additional 6.8 point increase when one or more chemical accidents occurred. Similar to our earlier models, there is little robust evidence of systematic inequities for American Indian populations, on average, in terms of RMP facilities and accidents. Any previously identified disparities among Asian populations are no longer statistically significant when including state fixed effects (Model 4). Similar to Black populations and our earlier findings, Models 5 and 6 suggest that on average disproportionate impacts are experienced by Hispanic populations and households living in poverty. After controlling for state-specific effects, we find evidence that one or more offsite impact accidents are associated with a now marginally significant 0.9 percentage point increase in the share of the population that is Hispanic. This suggests that it is not what states Hispanic populations tend to live in that is driving inequitable patterns associated with more severe offsite impact chemical accidents, but rather where Hispanic households are living within a state.

Table 4. Regression model results: State fixed effects.

	(1) % White	(2) % Black	(3) % Am. Indian	(4) % Asian	(5) % Hispanic	(6) % Poverty
RMP Facility w/in 5km[a]	-9.9609***	7.2253***	-0.3522**	0.4741	5.3709***	4.4379***
	(0.1891)	(0.1657)	(0.1316)	(0.3381)	(0.1350)	(0.2681)
RMP Accident w/in 5km[a]	-9.8302***	6.7747***	0.0642*	0.5687	4.3679***	3.6445***
	(0.4782)	(0.4638)	(0.0360)	(0.7451)	(0.3471)	(0.7999)
Offsite Impact Accident w/in 5km[a]	0.5518	0.3128	-0.0558	-1.0536	0.8775*	0.3437
	(0.6213)	(0.6051)	(0.0722)	(0.8784)	(0.4652)	(0.9502)
Constant	80.1805***	8.9835***	1.0442***	3.9455***	11.2604***	11.9838***
	(0.1230)	(0.0960)	(0.0698)	(0.1887)	(0.0851)	(0.1654)
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	71897	71897	71897	71897	71897	71774

Adjusted R-squared	0.197	0.192	0.103	0.186	0.351	0.093

Note: Cluster robust standard errors in parentheses, clustered at the county level. * p<0.10, ** p<0.05, *** p<0.01. (a) Binary indicators equal to one if one or more RMP facilities, accidents, or offsite impact accidents, respectively, are within five kilometers; and zero otherwise.

V.D. Implications of State Delegation

In most areas of the U.S. the RMP program is implemented and enforced by the Federal government, and in particular, by the U.S. EPA. In some cases, however, individual states (and sometimes counties) request and receive authority to run the RMP program in their jurisdictions.[13] States may apply for delegation for a variety of reasons, including that they already had a preexisting program that they wanted to retain when EPA started the federal program; or they prefer having a high degree of control over their own jurisdictions. Appendix B lists the nine states and four counties with delegated authority to oversee the RMP program (as of 2024). All but one of these jurisdictions received delegated authority prior to the start of our study period.[14] Following equation (4), we investigate whether the spatial patterns and demographic disparities regarding RMP facilities and accidents systematically vary across states that have or have not been delegated to implement and enforce (all or some of) the RMP program. We do so by including interaction terms between the RMP and accident variables with an indicator variable equal to one if a tract is within one of the delegated states, and zero otherwise. We maintain the state fixed effects in these models to ensure all broader state-specific differences are controlled for. The state fixed effects help account for whether a state, for example, has a greater proportion of the population that is Black and has a greater number of RMP facilities. When including stated fixed effects, any estimated inequities are based solely on within-state variation. Given the regional clustering of states with delegated authority, focusing on within-state variation is key; otherwise, the corresponding interaction term coefficients γ_1, γ_2, and γ_3 may just pick up general differences across states.

Model 1 in Table 5 suggests that the presence of one or more RMP facilities is associated with a 9.6 percentage point decrease in the proportion of the population that is White (or conversely a 9.6 percentage point increase the share of the population that identifies with a race other than White). Among states with delegated authority, an RMP facility being located within five kilometers is associated with an *additional* 1.3 point decrease in the share of the population that is White. Similarly, we see one or more chemical accidents within five kilometers is associated with another 9.2 point decrease, among non-delegated states. But this negative association is 3.2 points greater among delegated states, suggesting a roughly 12.4 (=9.2+3.2) point decrease in the White population in tracts where there are one or more accidents within five kilometers. The results from Model 1 also suggest additional inequities associated with offsite impact accidents. Although among non-delegated states an offsite impact accident is associated with a 1.2 point increase in the

[13] In a couple of cases the delegation is partial, and the state only has authority over a subset of facilities.
[14] North Dakota received delegated authority in 2014. The findings discussed next are robust when excluding tracts in North Dakota from the analysis.

share of the population that is White, we see among delegated states the White population share is smaller by a statistically significant, roughly 3.0 (= 4.2-1.2) percentage points (p=0.056).

Similar inequities are suggested when focusing on the percent of the population that is Black in Model 2. The presence of an RMP facility is associated with a 6.7 percentage point increase in the Black population. The positive coefficient on the corresponding interaction term coefficient (γ_1) suggests that communities in a delegated state tend to consist of an even greater proportion of Black residents when an RMP facility is nearby, an additional 2.0 percentage points. This greater increment for delegated states is also found when focusing on chemical accidents and accidents with offsite impacts. The share of a tract's population that is Black is an additional 5.7 percentage points greater when a chemical accident is within five kilometers, and this increases to 10.8 percentage points (=5.7+5.1) in delegated states. The estimated cumulative associations are worth emphasizing. The constant term in Model 2 suggests that the average tract that is not within five kilometers of an RMP has a population that is about 9.0% Black. In contrast, the average tract that is within five kilometers of an RMP facility where an accident takes place, and that is in a delegated state, has a population that is 28.5% Black (=9.0+6.7+2.0+5.7+5.1). Furthermore, the coefficient corresponding to the interaction term between offsite impact accidents and being in a delegated state (γ_3) in Model 2 suggests that offsite impact accidents tend to occur in areas where an even greater share of the population is Black, but only in delegated states.

In contrast to the above, the negative coefficients corresponding to the delegated state interaction terms in Model 5 suggest that any disparities experienced by Hispanic populations are less in delegated states. The significant and positive coefficients corresponding to the uninteracted terms, however, do still suggest inequitable patterns towards Hispanic populations in general.

In terms of poverty, the Model 6 results in Table 5 suggest no statistically significant differences in the estimated relationship between the presence of an RMP facility and the percent of households living in poverty based on whether a state has delegated authority or not. Still, we do find such heterogeneity with respect to chemical accidents. The uninteracted RMP accident coefficient suggests that an accident is associated with an almost 3.4 point increase in the percent of the population living in poverty. This relationship is an additional 1.4 percentage points greater among tracts in a delegated state. Similar to the findings focused on Black populations, the results from Model 6 suggest that in most states, a nearby offsite impact accident is not associated with an increase in the poverty rate; but among delegated states, an offsite impact accident is associated with an additional 1.7 point increase in poverty.

Model 3 again suggests little evidence of possible inequities towards American Indian populations in terms of RMP facilities and accidents. Model 4, however, indicates that the presence of an RMP facility and chemical accident are associated with an increase in the share of the population that is Asian, and that this positive association is even greater among delegated states, at least in terms of the presence of an RMP facility.

Table 5. Regression model results: Heterogeneity based on state delegation.

	(1) % White	(2) % Black	(3) % Am. Indian	(4) % Asian	(5) % Hispanic	(6) % Poverty
RMP Facility w/in 5km[a]	-9.6437***	6.7428***	-0.4364***	0.3963***	5.9552***	4.4817***
	(0.2118)	(0.1788)	(0.0441)	(0.0708)	(0.1557)	(0.1116)
× Delegated State	-1.3116***	2.0067***	0.3722***	0.3497***	-2.4957***	-0.2318
	(0.4698)	(0.4417)	(0.0685)	(0.1104)	(0.3050)	(0.2424)
RMP Accident w/in 5km[a]	-9.1618***	5.6976***	0.0667*	0.6718***	5.1107***	3.3530***
	(0.5205)	(0.4945)	(0.0356)	(0.1879)	(0.4113)	(0.2755)
× Delegated State	-3.1687**	5.0990***	-0.0172	-0.4930	-3.5010***	1.3920**
	(1.2730)	(1.2861)	(0.0602)	(0.3101)	(0.7056)	(0.5851)
Offsite Impact Accident w/in 5km[a]	1.1984*	-0.2895	-0.0486	-1.1285***	1.2769**	0.0712
	(0.6688)	(0.6377)	(0.0447)	(0.2230)	(0.5499)	(0.3511)
× Delegated State	-4.1902**	4.3172**	-0.0090	0.3651	-2.9858***	1.7046**
	(1.7053)	(1.7254)	(0.0667)	(0.3627)	(0.8805)	(0.8461)
Constant	80.1530***	9.0239***	1.0486***	3.9489***	11.2193***	11.9861***
	(0.1238)	(0.0962)	(0.0361)	(0.0445)	(0.0845)	(0.0608)
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	71897	71897	71897	71897	71897	71774
Adjusted R-squared	0.198	0.195	0.104	0.186	0.353	0.094

Note: Cluster robust standard errors in parentheses, clustered at the county level. * p<0.10, ** p<0.05, *** p<0.01. (a) Binary indicators equal to one if one or more RMP facilities, accidents, or offsite impact accidents, respectively, are within five kilometers; and zero otherwise.

Interpreting the state delegation results is challenging. In delegated states, there is a requirement that standards must be at least as strict as federal standards, and more stringent practices are observed, including more frequent inspections and lower threshold quantities for program participation. At the same time, however, there is less federal oversight and state regulators may have closer relationships to regulated entities. Together, such factors could lead to more relaxed enforcement in practice. Whatever the reasons, one thing is clear – our findings reveal that states with delegated authority are overseeing chemical facility safety in communities where historically underserved populations are more prominent. More research is needed to explore differences in program enforcement between the federal EPA and state regulators with delegated authority.

VI. CONCLUSION

This study contributes to a growing literature that has revealed significant environmental disparities in the U.S. among racial, ethnic, and income groups. Policymakers who wish to address inequities in environmental exposures need to understand where such disparities occur and their magnitudes. Our findings show that communities nationwide that are located near facilities using extremely hazardous substances are indeed disproportionately populated with Black, Asian, Hispanic, and low-income residents; and that even greater proportions of these historically underserved populations are located near facilities with histories of chemical accidents involving fires, explosions, and/or toxic vapors. These results are consistent with an earlier tri-state analysis of RMP facilities and accidents in MI, OH, and PA (Guignet et al. 2023a). In the current paper, we also find that these same groups are disproportionately located near clusters of facilities and accidents. The robustness of our results to the inclusion of state fixed effects suggests that these disparities are driven by within-state patterns, rather than just broader trends across states.

The increased disparities in delegated states suggest that state-run programs are in areas where there are even greater inequities. These heterogenous patterns could reflect pre-existing disparities, and might suggest that delegated states pursued more local control to, at least partially, better address potential inequities. The current structure of the RMP program is to default to federal regulations, but also offer states more control for programs that put forth more (or equally as) stringent requirements. At the same time, potentially offsetting that stringency is the possibility of more relaxed enforcement. The lack of federal oversight and potential for closer relationships between state regulators and regulated entities, could exacerbate any inequitable patterns and exploitive behaviors. A better understanding of the differences in regulatory practices between state and federal RMP programs is important given our finding of increased disparities in delegated states.

Guignet et al. (2023b) examine property value impacts of RMP facility accidents nationwide and find that accidents with direct offsite impacts involving deaths, injuries, evacuations, sheltering-in-place, or property or environmental damage have a significant negative impact on home values. For many families, their home is their single most important financial investment. Our findings demonstrate that those negative property value effects occur disproportionately to low income and historically underserved populations, thus further fueling the increased disparities associated with exposure to these hazardous chemicals and related environmental harms.

The U.S. EPA’s RMP program is in place to reduce the risk of chemical facility accidents and, when one occurs, ensure that facilities have procedures in place to minimize damages. Given the location of many industrial facilities, the risk of chemical accidents will increase as we face more frequent extreme weather caused by climate change (Flores et al. 2021; US Chemical Safety Board, 2017; Chemical Industries Association, 2015; Asadi et al. 2024). A recent analysis by the U.S. Government Accountability Office examined nationwide data on flooding, storm surge, wildfire, and sea level rise (all of which could be made worse by climate change), and concluded that almost a third of the over 10,000 RMP facilities they analyzed were located in areas with these natural hazards (U.S. Government Accountability Office 2022). Going forward, the required risk reduction activities at chemical facilities will become even more salient. Our results suggest that historically underserved populations will particularly benefit from risk-reducing activities under the RMP program.

WORKS CITED

Asadi, Mehrnoosh, Jean Dube, Pallab Mozumder, and Eric Strobl. 2024. Hurricane-induced discharges from Superfund sites: A hedonic price analysis of real estate market responses. *Land Economics*. Forthcoming, DOI: https://doi.org/10.3368/le.101.1.030423-0019R1.

Brodin, Sarah and Dennis Guignet. 2024. Layers of injustice: A distributional assessment of toxic chemical facilities, releases, and cleanups. *Journal of Environmental Management*. 370: 122415.

Bullard, Robert D., Paul Mohai, Robin Saha, and Beverly Wright. 2007. Toxic Wastes and Race at Twenty 1987 – 2007. United Church of Christ. March.

Burda, Martin and Matthew Harding. 2014. Environmental Justice: Evidence from Superfund cleanup durations. *Journal of Economic Behavior & Organization*. 107: 380-401.

Cain, Lucas, Danae Hernandez-Cortes, D., Christopher Timmins, and Paige Weber. 2024. Recent Findings and Methodologies in Economics Research in Environmental Justice. *Review of Environmental Economics and Policy*. 18(1): 116-142.

Chemical Industries Assocation, 2015. "Safeguarding chemical businesses in a changing climate: How to prepare a Climate Change Adaptation Plan." March. Available at: https://www.cia.org.uk/LinkClick.aspx?fileticket=KW8WF8CBZG0%3D&portalid=0.

Currie, Janet, John Voorheis, and Reed Walker. 2023. What Caused Racial Disparities in Particulate Exposure to Fall? New Evidence from the Clean Air Act and Satellite-Based Measures of Air Quality. *American Economic Review*. 113(1): 71-97.

Davis, Lucas W. 2011. The Effect of Power Plants on Local Housing Values and Rents. *The Review of Economics and Statistics.* 93(4): 1391-1402.

Elliot, M.R., Wang, Y., Lowe, R.A., and Kleindorfer, P.R. 2004. Environmental Justice: Frequency and Severity of U.S. Chemical Industry Accidents and the Socioeconomic Status of Surrounding Communities. *Journal of Epidemiology and Community Health.* 58: 24-30.

Federal Reserve Bank of St. Louis. 2024. FRED Economic Data. Available at https://fred.stlouisfed.org/series/RHORUSQ156N

Flores, David, Casey Kalman, Michelle Mabson, and Darya Minovi. 2021. Preventing "Double Disasters": How the U.S. Environmental Protection Agency can protect the public from hazardous chemical releases worsened by natural disasters. Center for Progressive Reform, Earthjustice, and the Union of Concerned Scientists. July. https://www.ucsusa.org/sites/default/files/2021-07/preventing-double-disasters%20FINAL.pdf

Gillingham, Kenneth and Pei Huang. 2021. Racial Disparities in the Health Effects from Air Pollution: Evidence from Ports. *NBER Working Papers* 29108, National Bureau of Economic Research, Inc.

Guignet, Dennis, Robin R Jenkins, James Belke, Henry Mason. 2023a. The Property Value Impacts of Industrial Chemical Accidents. *Journal of Environmental Economics and Management* 120.

Guignet, Dennis, Robin R Jenkins, Christoph Nolte, James Belke. 2023b. The External Costs of Industrial Chemical Accidents: A Nationwide Property Value Study. *Journal of Housing Economics* 62.

J.J. Keller Compliance Network. 2024. Risk management program (RMP) state comparison. https://jjkellercompliancenetwork.com/regsense/risk-management-program-rmp-state-comparison, accessed 19 Sep 2024.

Kleindorfer, P.R., Elliot, M.R., Wang, Y., and Lowe, R.A. 2004. Drivers of Accident Preparedness and Safety: Evidence from the RMP Rule. *Journal of Hazardous Materials*. 115: 9-16.

Madrigal, Jessica M., Abigail Flory, Jared A Fisher, Elizabeth Sharp, Barry I Graubard, Mary H Ward, Rena R Jones. 2024. Sociodemographic inequities in the burden of carcinogenic industrial air emissions in the United States. *Journal of the National Cancer Institute*, 116(5): 737—744.

Mikati, Ihab, Adam F. Benson, Thomas J. Luben, Jason D. Sacks, and Jennifer Richmond-Bryant. 2018. Disparities in Distribution of Particulate Matter Emission Sources by Race and Poverty Status. *American Journal of Public Health*. 108: 480-485.

Sheriff, Glenn. 2024. California's GHG Cap-and-Trade Program and the Equity of Air Toxic Releases. *Journal of the Association of Environmental and Resource Economists*. 11(1).

Solatyavari, Leili, Anna A. Klis, and Jeremy Groves. 2022. Superfund cleanup time and community characteristics: A survival analysis. *Journal of Environmental Management*. 320: 115705.

U.S. Chemical Safety and Hazard Investigation Board. 2018. Organic Peroxide Decomposition, Release, and Fire at Arkema Crosby Following Hurricane Harvey Flooding. Report Number: 2017-08-I-TX, May.

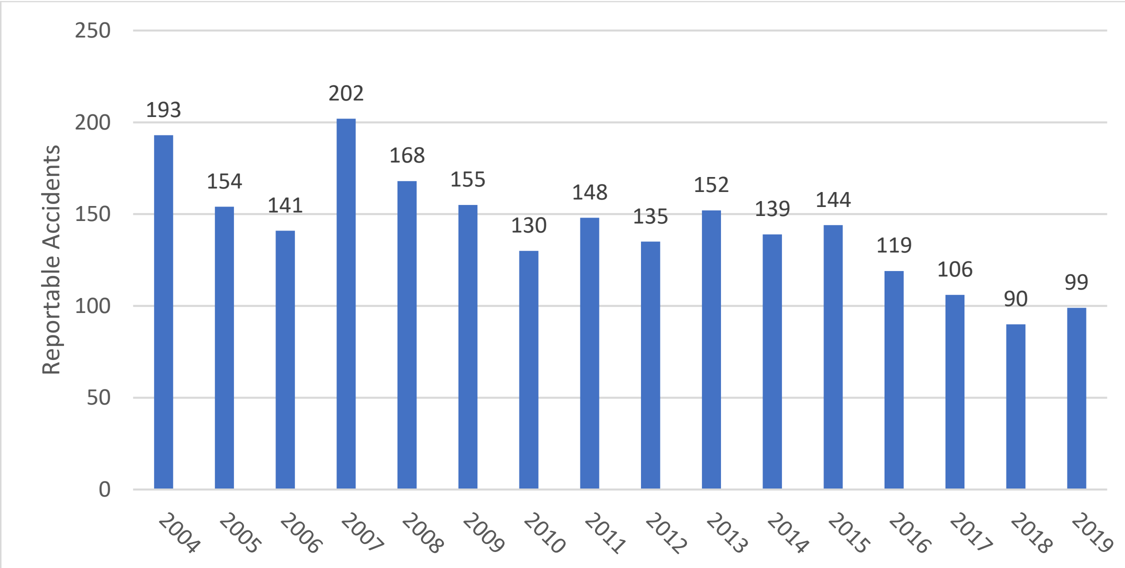
U.S. EPA (Environmental Protection Agency). 2023. Regulatory Impact Analysis: Safer Communities by Chemical Accident Prevention Final Rule. Office of Emergency Management, Washington, D.C. August 30.

U.S. EPA (Environmental Protection Agency). 2024. EJScreen: Environmental Justice Screening and Mapping Tool, https://www.epa.gov/ejscreen, accessed 24 Aug 2024.

U.S. Government Accountability Office. 2022. Chemical Accident Prevention: EPA Should Ensure Regulated Facilities Consider Risks from Climate Change. https://www.gao.gov/assets/gao-22-104494.pdf GAO-22-104494.

APPENDIX A. Supplemental Descriptive Statistics and Model Results.

Figure A1. Number of Reportable Accidents by Year.



Note: Study time period spanned from 2004 through September of 2019, so the count of reportable accidents for the final yearmay be incomplete.

Table A1. Correlations across population shares for different groups.

	% White	% Black	% Am. Indian	% Asian	% Hispanic	% Poverty
% White	1.0000					
% Black	-0.8270	1.0000				
% Am. Indian	-0.1206	-0.0567	1.0000			
% Asian	-0.2770	-0.1016	-0.0376	1.0000		
% Hispanic	-0.2631	-0.0845	0.0029	0.0811	1.0000	
% Poverty	-0.4601	0.4295	0.1073	-0.0973	0.2568	1.0000

Table A2. Regression model results: Alternative three-kilometer distance bin.

	(1) % White	(2) % Black	(3) % Am. Indian	(4) % Asian	(5) % Hispanic	(6) % Poverty
RMP Facility w/in 3km[a]	-8.6511***	5.2623***	-0.2997***	0.3731***	7.4397***	5.1262***
	(0.2304)	(0.2143)	(0.0319)	(0.0703)	(0.2023)	(0.1173)
RMP Accident w/in 3km[a]	-7.2571***	5.1083***	-0.0103	0.2484	3.1711***	2.7342***
	(0.7379)	(0.7441)	(0.0384)	(0.2489)	(0.6708)	(0.3524)
Offsite Impact Accident w/in 3km[a]	0.8794	-0.4443	0.0834	-0.8654***	0.5693	0.7786
	(0.9835)	(0.9933)	(0.0525)	(0.3037)	(0.9351)	(0.4864)
Constant	76.7721***	11.7828***	0.9509***	4.0943***	12.1922***	13.0459***
	(0.1334)	(0.1196)	(0.0285)	(0.0420)	(0.1090)	(0.0617)
Observations	71897	71897	71897	71897	71897	71774
Adjusted R-squared	0.034	0.017	0.001	0.001	0.033	0.047

Note: Cluster robust standard errors in parentheses, clustered at the county level. * p<0.10, ** p<0.05, *** p<0.01. (a) Binary indicators equal to one if one or more RMP facilities, accidents, or offsite impact accidents, respectively, are within three kilometers; and zero otherwise.

Table A3. Regression model results: Alternative one-kilometer distance bin.

	(1) % White	(2) % Black	(3) % Am. Indian	(4) % Asian	(5) % Hispanic	(6) % Poverty
RMP Facility w/in 1km[a]	-5.7603***	3.4588***	-0.1474***	-0.4550***	7.1149***	5.8812***
	(0.5198)	(0.4841)	(0.0460)	(0.1340)	(0.5099)	(0.2732)
RMP Accident w/in 1km[a]	-3.4929	3.2464	0.0112	-0.5983	2.3117	3.5375***
	(2.1620)	(2.2331)	(0.1267)	(0.4946)	(2.2541)	(1.3422)
Offsite Impact Accident w/in 1km[a]	-0.3427	0.2016	0.0109	-0.7029	-0.5188	-0.6671
	(3.0505)	(3.1079)	(0.1663)	(0.6480)	(3.0688)	(1.7352)
Constant	73.9607***	13.5260***	0.8637***	4.2282***	14.4020***	14.5539***
	(0.1198)	(0.1082)	(0.0211)	(0.0360)	(0.1048)	(0.0560)
Observations	71897	71897	71897	71897	71897	71774
Adjusted R-squared	0.002	0.001	0.000	0.000	0.005	0.011

Note: Cluster robust standard errors in parentheses, clustered at the county level. * p<0.10, ** p<0.05, *** p<0.01. (a) Binary indicators equal to one if one or more RMP facilities, accidents, or offsite impact accidents, respectively, are within one kilometer; and zero otherwise.

APPENDIX B. Regions and States with Authority to Directly Implement and Enforce the RMP program (as of 2024).

EPA Region 2

New Jersey

EPA Region 3

Delaware

EPA Region 4

Florida (partial – everything but propane facilities), Georgia, Mississippi, North Carolina, South Carolina,

Jefferson County (KY), Forsyth County (NC), Buncombe County (NC), and Mecklenburg County (NC)

EPA Region 5

Ohio

EPA Region 8

North Dakota (only Agricultural Ammonia facilities)

Source for list of delegated states: U.S. Environmental Protection Agency. 2024. States with authority to implement/enforce the risk management program rule. Accessed: https://www.epa.gov/rmp/states-authority-implement-enforce-risk-management-program-rule, 24 July 2024.

NOTE: From the above list, eight states received delegation from EPA in 1998, 1999, or 2000. North Dakota received it in 2014. Information on the year in which Mississippi received delegation is missing though believed to be in the 1998 to 2000 period.

Sources for years of delegation:

New Jersey and Delaware: Code of Federal Regulations: National Archives (2024) Title 40/Chapter I/ Subchapter C/ Part 63/ Subpart E. Subpart E – Approval of State Programs and Delegation of Federal Authorities https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-63/subpart-E

Florida: Burnaman, Ross Stafford. 1999. Florida's Accidental Release Prevention and Risk Management Planning Act. Environmental & Land Use Law. 73(5). https://www.floridabar.org/the-florida-bar-journal/floridas-accidental-release-prevention-and-risk-management-planning-act/

Georgia: Environment, Health and Safety Online. Risk Management Planning (RMP) Guide for Authorized States. https://www.ehso.com/RMP_states.htm

Mississippi: No information.

North Carolina: Letter from US EPA dated Jul 27, 2000 to Mr. Bill Holman, North Carolina Department of Environmental and Natural Resources. Provided by email by delegated state program officials.

South Carolina: Jun 26, 1995 as reported by email from Kevin Daniel, RMP program US EPA to Robin Jenkins, Office of Policy, US EPA dated Aug 6, 2024.

Kentucky: April 13, 1999 as reported in Dec 1999 Letter from EPA: Region 4, Atlanta Federal Center to Mr Arthur Williams, Director, Jefferson County Air Pollution Control District.

Ohio: Federal Register: The Daily Journal of the United States Government. National Archives. 1999. Approval of Delegation of the Accidental Release Prevention Requirements: Risk Management Programs Under Clean Air Act Section 112(r)(7): State of Ohio. https://www.federalregister.gov/documents/1999/11/03/99-28311/approval-of-delegation-of-the-accidental-release-prevention-requirements-risk-management-programs

North Dakota: January 19, 2014 as per North Dakota Department of Agriculture. Risk Management Program (RMP) for Agriculture Anhydrous Ammonia Facilities. https://www.ndda.nd.gov/divisions/pesticide-fertilizer-division/risk-management-program-rmp-agriculture-anhydrous-ammonia