Superfund Cleanup Time and Community Characteristics: A Survival Analysis

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Abstract

This paper investigates the correlation of socioeconomic characteristics of communities close to Superfund sites with the duration of cleanup using spatial survival analysis. Census-tract-level data is used to achieve a more accurate representation of affected areas. Overall, we find no evidence of slower cleanup in areas with higher minority population; rather, the median income of households is correlated with longer cleanup time. Additionally, sites located in communities with higher levels of education and voter turnout experience faster cleanup.

Keywords: ArcGIS, hazardous waste, income, minority, Superfund, survival analysis, voter participation

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1 Introduction

Commercial and industrial waste has created thousands of hazardous sites throughout the United States over the past century (Office of Superfund Remediation and Technology Innovation, 2011). From the 1940s until 1995, the Hooker Electrochemical Company disposed 21,000 tons of toxic byproducts into the Love Canal in Niagara Falls, NY. Nearby homeowners found chemicals leaking onto their lands, and health studies warned of serious diseases and possible genetic problems. In 1978, about 950 families were evacuated from their homes, and 237 homes were bulldozed (Brown, 1979; US Geological Survey and US Department of the Interior, 2016). This tragedy directed governmental attention, like that of Congress and the Environmental Protection Agency (EPA), to toxic lands, leading to the creation of Superfund cleanup program in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act. In 1981, the Love Canal was the first site listed in the history of Superfund, reaching "construction complete" in 2004 (US Environmental Protection Agency and Office of Superfund Remediation and Technology Innovation, 2013). Superfund is the name of the environmental program and also the trust fund established to address abandoned hazardous waste sites when no responsible party is identified.

The process of finding and negotiating with polluters often delays the actual start of cleanup construction, which can then vary in length depending on site pollution, chosen cleanup method, and administrative delay. This timeline concerns the public directly: in 2017 approximately 53 million people, or roughly 16% of the US population at the time, lived within three miles of a Superfund site; of those, 15 million lived within one mile of a Superfund site, of which 44% belong to a minority (US Environmental Protection Agency, National Institute for Environmental Health Sciences Columbia University Superfund Research Program, et al., 2017). Much of the environmental justice literature considers how minority communities may bear a disproportionate burden of the risks associated with living near hazardous waste sites. Lavelle and Coyle (1992) and Bullard (2008) argue that, in more than half of the ten EPA regions, the EPA chooses less desirable cleanup treatments and tends to face delays for contaminated lands in areas with a greater minority population, though Gupta, Houvten, and Cropper (1996) find no impact of minority status on the cost-permanence trade-off of cleanup choices.

We perform a spatial analysis using census-tract-level data to investigate the socioeconomic characteristics and engagement of Superfund communities and the correlation with the duration of cleanup. This is also our main contribution: survival analysis estimates hazard ratios, allowing for more meaningful interpretation of variable effects on cleanup duration.

Additionally, using census-tract-level data achieves a finer and more accurate representation of affected areas, as opposed to larger aggregates like zip codes. Overall, we find no evidence of slower cleanup of sites in areas with a high fraction of Black or Hispanic population. However, we do find that the median income of households is *negatively* correlated with the speed of site cleanup: sites in poorer neighborhoods are cleaned faster, provided they were listed in the first place. Sites with older and more engaged communities, as represented by voter participation and education, have a faster pace of cleanup. Moreover, site difficulty measures like Hazard Ranking Score and Net Present Value are associated with a prolonged cleanup time, as is federal site ownership. We also present evidence that Community Advisory Groups are important, but that their formation is likely endogenous to cleanup duration.

Section 2 describes the background of Superfund, the cleanup process, and environmental justice concerns. Section 3 describes data used, while Section 4 presents our estimation approach and results. Section 5 concludes.

2 Background

Under the Superfund program, sites with serious hazards are placed on the National Priority List (NPL). This step formalizes the Environmental Protection Agency's (EPA) commitment to permanently remove the contamination, as well as finding responsible parties and resolving fault and cleanup funding with them. When cleanup construction is finished, the EPA monitors NPL sites for some time after to assure that all threats have been addressed. The site is then deleted from the NPL.

According to the Comprehensive Environmental Response, Compensation and Liability Information System Public Access Database, at the time of writing there were 1,666 sites "listed on the NPL," of which 1,161 were sites with "construction complete" and 378 sites "deleted from the NPL." Figure 1 depicts the number of site cleanups completed since the beginning of Superfund until 2010.

Cleanup time itself can vary: some communities wait a long time for cleanup completion, while other sites resolve more quickly. For the sites under consideration in this paper, Table 1 lists a minimum cleanup duration of 221 days and a maximal duration of over 34 years, with a mean cleanup duration of 5,340 days ($\sim$14.6 years). Figure 2 shows a combined histogram of the distribution of duration times for sites which have reached the "construction complete" milestone, as well as the distribution of ongoing times for sites which have not reached "construction complete" status as of the time of writing.

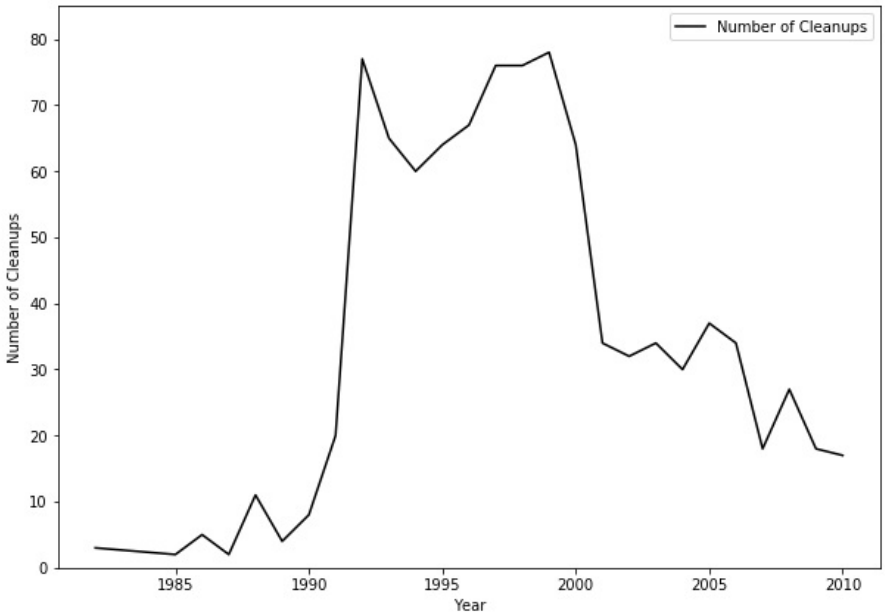

Figure 1: Superfund cleanups completed by year.

Cleanup duration of ongoing sites is important to communities living nearby, which may continually experience the effects of pollution in some form or other. It is important to note that cleanup duration consists of two main time-frames for a Superfund site: enforcement time and actual cleanup time. The time from listing until completion of construction does not directly reflect the effectiveness or quality of actions taken, though it may have some impact, and the endpoint does mark a turning point for the surrounding community.

The Superfund Amendments and Reauthorization Act (SARA) of 1986 "encouraged greater citizen participation in how sites are cleaned up" (US Environmental Protection Agency and Office of Land and Emergency Management, 2018). The EPA informs communities at each stage of the process, gathering input opinions about cleanup strategies. Sigman (2001) shows that community involvement in the form of voter turnout is indeed an important factor that affects the EPA's bureaucratic priorities in listing hazardous sites, while Viscusi and Hamilton (1999) demonstrate that regulators apply more effective cleanup actions in areas with more concerned and involved citizens. Communities have several incentives for involvement: addressing contaminated sites can mitigate the serious health risks of cancer, asthma, and skin problems or prevent a decline in property values (Kohlhase, 1991).

In SARA, Congress established more concrete opportunity for public engagement in Superfund through Community Advisory Groups (CAG). CAGs seek active community rep-

Table 1: Summary Statistics for Superfund Sites and Population within 1 Mile of Site

Variable (Observations: $N = 1327$)	Mean	S.D.	Min	Max
Completed cleanup	0.67	0.469	0	1
Duration of Cleanup (days)	5,340	3,051	221	12,540
NPV (in $10,000)	1510	6153	122	147,600
Pollution (Hazard Ranking Score)	43.46	8.74	28.5	84.91
Federal	0.11	0.31	0	1
CAG	0.03	0.18	0	1
Population	596	913.25	0	5736
Black (fraction of population, in percentage points)	0.54	1.57	0	0.96
Hispanic	0.33	1.29	0	0.85
Population over 65	0.41	1.2	0	0.96
Unemployed	0.13	0.17	0	0.8
Educated	0.10	0.06	0	0.2
Urban	0.61	0.38	0	0.72
Income (in $1)	25,010	12,628	5,000	94,320
Voter turnout	0.54	0.05	0.40	0.67
Democratic Representative	0.5	0.5	0	1

resentatives, enhancing public interest and participation. CAGs may be suitable for some – but not all – Superfund sites; specifically, they are beneficial for non-time-critical sites, as Daley and Layton (2004) find that the presence of a CAG may impose an additional cost on the EPA and lengthen cleanup time.

The degree to which communities are involved in environmental programs is driven by factors such education, income, and political power (Daniels et al., 2012; Office of Environmental Justice, 2017), factors which in turn may be influenced by race and its history in the United States. In addition, the US Commission on Civil Rights (2003) argues that disadvantaged communities may experience difficulty with EPA community involvement training and thus lack access to the technical data and other information necessary for environmental activism. Newer options like Alternative Dispute Resolution (ADR) require communities to possess a certain level of education and organization in order to understand technical documents and procedures. Language and cultural differences, education and income disparities, and even a lack of trust between community members and regulatory agencies can lead to decreased engagement in community involvement programs, and thus decreased influence (Office of Superfund Remediation and Technology Innovation, 2011).

Education, in particular, contributes to higher participation in politics and environmental programs, offering citizens the skills required to effectively express their concerns to politicians and regulatory organizations (Verba, Schlozman, and Brady, 1995) and to understand and evaluate environmental issues and campaigns (Howell and Laska, 1992; Rosenstone and

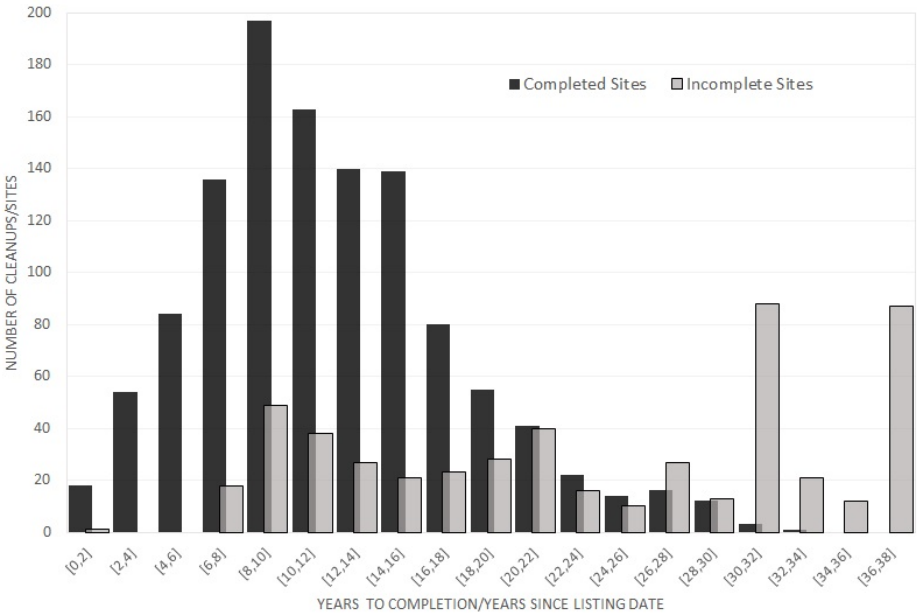

Figure 2: A combined histogram of process times for Superfund sites. The black columns show the distribution of cleanup times in 2-year bins for "Completed" sites. The light gray columns show the distribution of years (to February 2021) since listing date for sites listed on the NPL but which have not yet attained "Completed" status, including four sites that were "Deleted from the NPL" without having ever been "Completed."

Hansen, 1993). Activism depends on citizen's beliefs about the benefits, costs, and impacts of collective action (Finkel, Muller, and Opp, 1989), and so communities with lower educational attainment are less likely to participate. For example, Superfund cases are 1.9 times less likely to be resolved through ADR in communities with a higher percentage of less educated residents (Collins, 2008).

Lack of involvement may have less to do with community characteristics themselves and more to do with poverty's impact on time evaluation (Dunlap and Van Liere, 1978; Sigman, 2001): poorer individuals are more likely to spend time meeting basic economic needs, as opposed to taking active voice in environmental programs. If involvement entails a simple vote, then Nakada (2017) shows via theoretical model that low-income residents vote for higher environmental taxes because they live closer to polluted sites. For environmental campaigns larger than voting, affluent residents have more time and resources to contribute; on a national or global level, this pattern is often described as the Environmental Kuznets Curve. High income individuals may also have more concern that nearby wastelands – especially those proposed and listed as Superfund sites – depress property values (McClelland,

Schulze, and Hurd, 1990). Ready (2010) shows that residential property values decrease by 12.9% on average if a landfill is located nearby; this loss can extend three or more miles from a site and can lead to urban decay or "reverse gentrification," where affluent whites move away, while poor and/or minority groups take advantage of affordable housing and move in. Fixing undesirable sites, however, leads to an improvement in housing prices (Haninger, Ma, and Timmins, 2017). Furthermore, the EPA may respond to interest groups in prioritizing its resources; high-income communities can lobby for more costly, comprehensive remedies (Sigman, 2001; Gamper-Rabindran and Timmins, 2013; Burda and Harding, 2014), while Burda et al. (2013) suggest that sites in areas with a higher fraction of population over 65 are cleaned faster, since retirees have more free time to engage in environmental programs.

Others have found that capacity expansion of commercial hazardous waste facilities is negatively correlated with voter turnout (Hamilton, 1995) and that Superfund sites in pro-environmental counties (measured by higher voter turnout) are more likely receive targeted, cancer-risk-eliminating cleanup (Hamilton and Viscusi, 1999). Morello-Frosch and Jesdale (2006) observe a higher level of cancer risk due to toxic releases in areas with higher levels of ethnicity segregation. If segregated communities lack political clout over decisions on waste facility locations and pollution removal, then this results in adverse health effects for everyone in an area.

The level of demographic data plays an important role in understanding population patterns close to these sites. Previous studies often matched Superfund locations with demographic attributes through zip codes; notably, Burda and Harding (2014) do so and find evidence of racial discrimination prior in NPL sites prior to 1994. Newer studies of health and movement responding to pollution (e.g. the earlier-mentioned Morello-Frosch and Jesdale (2006), Gamper-Rabindran and Timmins (2013), and Depro, Timmins, and O'Neil (2015)) have used census tracts. Census tracts are small, relatively permanent statistical subdivisions of a county or equivalent entity that are updated by local participants prior to each decennial census as part of the Census Bureau's Participant Statistical Areas Program. Analysis based on census-tract-level data is expected to achieve a more accurate representation of affected areas due to increased granularity (Glimpse, 2019) and a richer set of demographic data. Additionally, census tracts provide more statistical uniformity between tracts, averaging a population of about 4,000, while the population of a single zip code can exceed 100,000.

Aydin and Morefield (2006) examine population changes in census tracts around Superfund sites in Harris County, TX. Using 2.5- and 5-mile radii and multiple census years, they find that site listing comes *before* increases in minority population, concluding – in contrast

to Burda and Harding (2014) – that environmental racism was unlikely to be the cause of Superfund site listing. However, they do find that lower income levels and higher percentages of Blue Collar workers were present near the sites prior to their listing. Though their paper examines site placement and ours examines cleanup time, the results are complementary; using census-tract-level data highlights the importance of wealth in polluted areas.

3 Data

Our data derive from four sources on Superfund sites. Data on dates of Superfund lifetime events and site characteristics are collected from the Environmental Protection Agency (EPA). Information regarding latitude and longitude of Superfund sites are extracted from NASA's Socioeconomic Data and Applications Center, managed by Colombia University. Demographic data by census tracts, as well as Geographic Information System (GIS) boundary files, come from the National Historical Geographic Information System (NHGIS), provided by the Minnesota Population Center at the University of Minnesota. The NHGIS survey contains a very broad set of demographic variables from the 1980, 1990, 2000 and 2010 Decennial Censuses. Finally, voter turnout and Congressional Representative party are extracted from the US Census Bureau historical voting database.

The research sample consists of 1,666 Superfund sites across the United States, which are either currently on the National Priority List (NPL) or deleted from the NPL. Since the US was not completely covered in census tracts in 1980, several sites are dropped due to lack of data in that time, leading to 1,327 sites for use in cross-sectional analysis. We analyze the duration of the enforcement/cleanup process in relation to the demographic profile of communities living close to the sites. ArcGIS intersects the US boundary files with demographic information for each decade located within an area of one mile and one-half mile centered on each site specified by their latitude and longitude. Populations of interest within these one-mile and half-mile buffers can be calculated as $\left[\frac{\text{area of buffer}}{\text{area of census tract}} \times \text{population of census tract}\right]$.

The main trade-off between census-tract-level and zip-code-level data is census collection timing. "Demographic data refer to the Decennial Census and other surveys of individuals and households administered by the Census Bureau" (US Census Bureau, 2020). This paper relies on the full US population demographics captured in the main Decennial Census. Since demographics can shift between census collection years, we avoid potential endogeneity between duration of cleanup and demographic changes by using the demographic variables at

the time of site listing. For example, we use the 1980 census to capture the demographics for sites listed between 1980 to 1989, and similarly for other decades. In this way, factors that influence the cleanup process are pre-determined with respect to the cleanup duration. Depro, Timmins, and O'Neil (2015) mention issues with census-tract data when investigating migration; the decennial data entries do not adequately capture demographic changes caused by those "fleeing from" and "coming to the nuisance." Our study does not investigate the effect of polluted sites on demographic mobility, but rather the effect of demographics on the cleanup of polluted sites. We include a robustness check with centered listing dates to test for endogeneity.

Demographic variables of interest include the fraction of population that are Black/Hispanic, fraction unemployed, fraction educated above high school, fraction living in urban areas, median household income, fraction of owner-occupied households, and fraction over 65 years.

Since measures of direct public participation in Superfund site cleanup do not exist, we use voter turnout and the existence of a Community Advisory Group (CAG) near the site as proxies for the level of public participation. The earlier mentioned level of education and median household income serve as controls. Voter turnouts for presidential elections 1980-2012 are matched based on the state where the Superfund is located and the closest presidential election date to the site's listing date. Unfortunately, we do not have detailed data on the formation timelines of CAGs, which are formed in response to site listing or duration, nor on the existence of any unofficial community organization efforts.

We do include site-specific characteristics, including the total present value of site remediation cost. Cost information for each site is available in its Record of Decision (ROD), available on the EPA website. Each ROD summarizes the details of the planned cleanup implementation, breaking down the estimated total present value into capital costs, which represent the actual cleanup construction costs, as well operation/maintenance costs, which comprise the annual costs of the selected remedy's administration and up-keep. Each ROD also presents detailed information regarding which costs are discounted and the discount rate used. Much of the sample used a 7% discount factor, in accordance with policy from the former Office of Solid Waste and Emergency Response (OSWER), now the Office of Land and Emergency Management.[1] The present value is thus an estimate of the entire expected cost of the remediation. We reviewed site RODs and manually extracted the stated net present

[1]The importance of discount factors is described in the 2000 "Guide to Developing and Documenting Cost Estimates During the Feasibility Study" from the EPA and US Army Corps of Engineers, and OSWER's 7% default is mentioned throughout 1999's "Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents."

worth of cleanup cost of the site's chosen method for the sample To keep NPVs consistent, we recalibrated any sites that did not use the 7% discount factor.

The nature of site contamination can also dictate the length of cleaning time.[2] Gupta, Houvten, and Cropper (1996) find that the EPA prefers permanent cleanup techniques, but not at any cost. To account for the nature of the pollution, we use the Hazard Ranking Score (HRS) scaling from 0 to 100, calculated by the EPA to show the level of toxicity and cleanup difficulty in sites. Sites with a higher HRS possess higher levels of contaminants. Naturally, we expect that the more polluted a site, the longer cleanup construction will take. Apart from technical difficulties caused by contamination level, organizational behavior may further hinder the process of cleanup: Daley and Layton (2004) find evidence that the EPA pays less attention to highly-contaminated sites and more to low-risk sites. Administrative convenience may decrease the likelihood of quick and full cleanup as the level of site difficulty increases; the organization is able to tackle a larger number of cleanup tasks if it prioritizes "easy sites" and shifts efforts away from "difficult sites."

Site ownership might also contribute to cleanup time. Since cleanup time is defined as the length of time between listing and reaching "construction complete" status, any delays in identifying and possibly litigating Potentially Responsible Parties (PRPs) are captured in total cleanup time. Certain sites belong to federal facilities (i.e. military branches, Department of Defense, Department of Energy), so we include an indicator for whether the Superfund site belongs to a federal facility. Without a full organizational investigation, it is difficult to say whether government ownership would shorten or lengthen cleanup time. In such a case, the regulator (EPA) and the regulated (federal site owners) belong to the same entity, the US government, which does not sue itself except under rare occasions of constitutional crisis. Therefore, it is possible that government ownership could avoid lengthy court battles and thus shorten cleanup time. However, since the funding source for the project must ultimately come from taxpayers, the EPA may lack incentive to establish quick funding responsibility from an outside party, while the federal offices involved may take additional time to negotiate the handling of cleanup and its payment or may even need to wait for additional funding from the legislative branch.

We also control for the availability of resources to accommodate fast and efficient enforcement and cleanup process with regional indicators. Figure 3 maps which EPA regions serve

[2]Contaminated media usually include debris, groundwater, sediment, surface water, or waste, and the type of contaminants are acids, metals, Volatile Organic Compounds and Polycyclic Aromatic Hydrocarbons substances. Generally, cleanup is easier if the contaminated media is waste or debris, while it is much harder for groundwater or soil.

which states; certain EPA Regions also serve tribal nations. Resources and funding allocation may vary across EPA-designated regions. State spending derives from site frequency, whether PRPs perform the cleanup, and population density. From 1999-2013, the EPA spent the most Trust Fund dollars on site cleanup in Region 2. This region includes New York and New Jersey and has a considerable number of large sites with no responsible parties found. The EPA spent about $2.5 billion in this region, comprising about 32% of the total cleanup funds on non-federal NPL sites during that time (US Government Accountability Office, 2015). The methods of assigning pollution responsibility and recouping funding also vary across Superfund regions: Church and Nakamura (2001) find that Regions 3 and 10 utilize alternative dispute resolution more often, while Regions 2 and 5 tend to litigate. Thus, we include dummies to control for unobserved differences at the regional level.

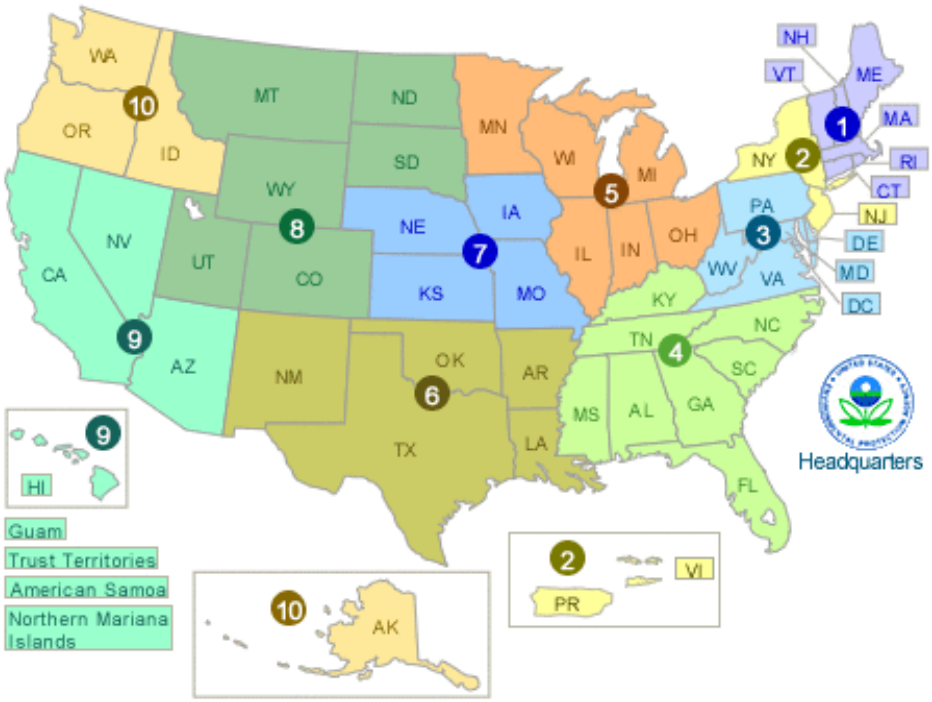

Figure 3: A map from the EPA's website showing the ten EPA regions (https://www.epa.gov/aboutepa/visiting-regional-office).

Finally, questions of environmental protection are rather politicized in the United States. To control for any unobserved heterogeneity caused by local party preference, we include a binary variable equal to one if the district hosting the Superfund site is Democratic-controlled and zero if the district is Republican-controlled. To add this variable to the analysis, a district layer for the 97th and 114th Congressional assemblies is intersected with

previous layers (demographics and CAG) in ArcGIS.

Table 1 presents the summary statistics for the relevant community characteristics and control variables near Superfund sites. Cleanup completion occurs for 67% of sites in our dataset, and the average time of cleanup is 5,340 days (∼14.5 years). With regard to different time periods, cleanup is finished for 83% of sites listed during the 1980s (with 5,935 days average duration), 67% listed in the 1990s (5,236 days), 21% from the 2000s (4,261 days), and for only 1% of sites listed during the 2010s (2,176 days). The sample consists of 1,177 non-federal sites and 150 federal sites, while the average present worth of a site's cost is $15,103,198. The average population within a one-mile radius of a Superfund site is 596 people, and the median yearly income of nearby households is $25,010. Additionally, some of the census tract populations have higher values of minority and elderly population than are commonly seen in typical zip code demographic variables; as mentioned before, because census tracts are smaller, they can capture more granularity in population distribution close to a site. Unfortunately, the comparison of Superfund site demographics to non-polluted location demographics throughout the rest of the US and the question of how this came to be is beyond the scope of this paper. We can, however, note that the median US household income in 2017 was $60,336 (Guzman, 2018), which is a stark difference from the median near Superfund sites.

4 Empirical Models and Findings

We use survival analysis to estimate the length of time from final listing on the National Priority List (NPL) until cleanup completion and how this time relates to various demographic characteristics of the affected community and site-specific characteristics. Survival analysis applies when subjects are tracked until an event occurs (called "failure" in the jargon; success of cleanup completion is a failure of survival). In our study, the "event" has happened for sites which have reached "construction completion" status. The sites which have not reached this point are right-censored as we cannot observe their full survival time. Additionally, we are interested in the *risk* of failure, called the hazard ratio, which can only be measured by this econometric method; in our analysis, the hazard ratio represents the likelihood of site reaching the cleanup construction status.

The survival function $S(t)$, denotes the probability of duration from the starting point of study until time t:

$$S(t) = \text{Prob}(T_i > t) = 1 - F(t) \tag{1}$$

where T_i denotes the time until which Superfund site i is still "alive" or not yet cleaned, and $F(\cdot)$ is the cumulative distribution function of survival times. Thus $F(t)$ measures the probability of survival – remaining on the NPL – until time t.

We estimate the length of time from listing date to cleanup completion date with Cox proportional hazards regression analysis, a semi-parametric method which allows us to determine how different variables affect the hazard. Using an exponential distribution, the model takes the form:

$$\lambda_i(t|X_i) = \lambda_0(t)\exp(\beta \text{CommunityChars}_i + \gamma X_i) \tag{2}$$

where both CommunityChars_i and controls $X_i = (x_{i1}, x_{i2}, ..., x_{ik})$ are column vectors of covariates for site i, β and γ are row vectors of regression coefficients, λ_i is the expected hazard calculated for each subject at the time that construction completion takes place, and the baseline hazard λ_0 represents the probability of event occurrence when all explanatory variables have zero value. The interpretation of the hazard ratio (H.R.) is more straightforward. As an illustration, if we consider two sites, $i = \{1, 2\}$, with covariates X_1 and X_2, then the ratio of their hazards at time t is:

$$\frac{\lambda(t|X_1)}{\lambda(t|X_2)} = \frac{\lambda_0(t)\exp(\gamma X_1)}{\lambda_0(t)\exp(\gamma X_2)} = \frac{\exp(\gamma X_1)}{\exp(\gamma X_2)} = \exp(\gamma(X_1 - X_2)) \tag{3}$$

Thus the hazard ratio depends on the difference between two sites' covariates. If there is only one covariate considered ($k = 1$), and if the difference in the two sites' explanatory variable is exactly one unit ($x_{11} - x_{21} = 1$), then the hazard ratio is the exponential of the regression coefficient (H.R. $= e^{\gamma_1}$). A hazard ratio greater than one indicates that a unit increase in the variable of interest increases the "hazard" and thus *decreases* the duration of cleanup completion, whereas a hazard ratio of less than one indicates less hazard, a higher likelihood of survival, and thus *lengthens* the cleanup duration. For interpretation, if a hazard ratio is greater than one, a unit increase in the variable increases the probability of event occurrence by a percentage of (H.R. $- 1) \times 100$.

Table 2 presents the first two specifications of the Cox proportional hazards model analyzing Superfund cleanup time. Model 1 includes only the socioeconomic characteristics of census tracts within one mile of Superfund sites, while Model 2 adds two measures of community participation and two measures of cleanup difficulty.

Table 2: Cox regression estimates of cleanup time within one mile of a Superfund site, basic specification including socio-economic, participation, and some site characteristics only.

	Model 1			Model 2		
	Estimate	H.R.	S.E.	Estimate	H.R.	S.E.
Minority	-0.03	0.97	0.03	-0.03	0.97	0.03
Population over 65	0.26**	1.30	0.10	0.24*	1.27	0.10
Unemployed	0.16	1.17	0.38	0.18	1.20	0.40
Educated	0.06**	1.07	0.04	0.04**	1.05	0.04
Urban	-0.06***	0.93	0.02	-0.06**	0.93	0.02
Logincome	-0.39***	0.67	0.07	-0.37***	0.68	0.07
Home Ownership	0.19*	1.22	0.10	0.20*	1.22	0.10
Voter Turnout				0.02***	1.03	0.01
CAG				-0.72**	0.48	0.24
LogNPV				-0.04***	0.96	0.01
Pollution (HRS)				-0.01***	0.98	0.00
Likelihood Ratio	66.66***			157.9***		
Wald Test	75.93***			166.9***		
Score (LogRank)	77.41***			172.2***		

$^{***}p \leq 0.001$, $^{**}p \leq 0.01$, $^{*}p \leq 0.05$

Model 1 provides no evidence that sites in minority areas are cleaned up any slower; the coefficient estimate is not significant and the hazard ratio is close to one. However, an increase in the fraction of residents with higher education increases the likelihood of cleanup by 7% (H.R. = 1.07), which can also be interpreted as a decrease in average cleanup duration by 373 days (a little over a year) which, in context of the 14.5-year average cleanup time, is perhaps not so much shorter than it first appears. Sites located in urban areas take longer to clean, as do sites in areas with higher median household income. The hazard ratio for the log-income of the median household is 0.67, suggesting that a one-unit increase from the median log-income decreases the probability of cleanup at time t by approximately 33%, implying an astounding 1,760 days (almost five years) longer on average to clean up the site.[3] This is consistent with prior results that an increase in median household income of one standard deviation is associated with a 1.5% increase in cleanup time (Sigman, 2001), though on a larger magnitude.

Model 2 adds Voter Turnout and an indicator for associated Community Advisory Group (CAG) as proxies of community participation, as well as the log of Net Present Value (NPV) and Hazard Ranking Score (HRS) as proxies of cleanup difficulty. The coefficients for variables from Model 1 are largely unchanged, and all four of the added variables are highly

[3]From Table 1, mean income is \$25,010; the median is slightly higher at \$27,202. This gives $\log(\text{MedianIncome}) = \log(27,202) \approx 10.2$. Solving for x in $\log(x) = 11.2$ gives an income level of around \$73,010, so an increase of \$45,808, almost triple.

significant, emphasizing the importance of their inclusion. Results indicate that a 1% increase in voter turnout is associated with a slight increase in the likelihood of completing cleanup at time t. The presence of a CAG, however, is correlated with a longer time until cleanup, a result consistent with prior literature (Daley and Layton, 2004). Whether the CAG is formed in response to an already lengthy duration or actually delays the cleanup is not something that our data and model can answer, though the hazard ratio may give some context. In Model 2, the CAG hazard ratio of 0.48 indicates a 52% decrease in likelihood of cleanup when a CAG is present. If this were direct causation, we would expect to never see community involvement in this form; thus we anticipate some endogeneity in CAG formation, which is further investigated in Models 3e-5e.

We also see that an increase in the cleanup cost[4] of a site is associated with a 4% decrease in the likelihood of cleanup, while an increase in the toxicity of a site via HRS shows a 2% decrease. Additionally, both Models 1 and 2 indicate that larger fractions of the population over 65 years of age and larger fractions of home ownership are associated with shorter cleanup, suggesting that either these population groups are helpfully involved in the process and push for a faster cleanup, or that the EPA prioritizes sites with elderly residents or ownership stake. Elderly residents may be more impacted by nearby contamination, or may be more aware of a shorter time horizon, while homeowners may have fewer options for relocation and desire higher home prices.

The models in Table 3 incorporate further controls through party of the district's Congressional Representative, regional dummies (with Region 10 dropped), and the federal site indicator. We also examine a few interaction terms in Models 4 and 5. These additions retain the null effects of minority population and unemployment, as well as the positive and significant effects of educated and senior population (if at somewhat smaller magnitudes) and the negative and significant effects of income, NPV, and CAG presence. The effects of urban population, home ownership, and voter turnout are no longer significant in these specifications, indicating that the new controls have absorbed their effect.

[4]From Table 1, the mean NPV of a site is $15,100,000. We use log-NPV because of suspected decreasing marginal benefits to the dollar and to keep the coefficients at a comparable magnitude for all variables.

Table 3: Cox regression estimates of cleanup time within one mile of a Superfund site, with added regional effects and interaction terms.

	Model 3			Model 4			Model 5		
	Estimate	H.R.	S.E.	Estimate	H.R.	S.E.	Estimate	H.R.	S.E.
Minority	-0.06	0.94	0.03	-0.05	0.95	0.03	-0.06	0.94	0.03
Population over 65	0.157**	1.17	0.10	0.27**	1.32	0.09	0.17**	1.19	0.10
Unemployed	0.19	1.21	0.46	0.23	1.26	0.46	0.26	1.30	0.46
Educated	0.12*	1.13	0.05	0.12*	1.13	0.05	0.12*	1.13	0.05
Urban	-0.04	0.96	0.02	-0.04	0.96	0.02	-0.04	0.96	0.02
Logincome	-0.29**	0.74	0.09	-0.31***	0.73	0.09	-0.31**	0.73	0.09
Home Ownership	0.02	1.02	0.08	0.10	1.10	0.08	0.03	1.03	0.08
Voter Turnout	-0.00262	0.9974	0.01183	-0.004867	0.99514	0.0117	-0.001416	0.9986	0.01141
Dem. Rep.	0.16**	1.18	0.07*	0.11**	1.11	0.05	0.15*	1.17	0.08
CAG	-0.75**	0.47	0.26	-0.74**	0.47	0.26	-0.74**	0.47	0.26
Minority× Voter Turnout				0.00	1.00	0.01			
Minority× Dem. Rep.				0.04	1.04	0.04			
Minority×CAG							-0.17	0.85	0.16
Educated× Dem. Rep.							0.10*	1.11	0.04
Educated×CAG							0.02	1.02	0.07
LogNPV	-0.05***	0.95	0.01	-0.05***	0.95	0.01	-0.05***	0.95	0.01
Pollution (HRS)	-0.01***	0.99	0.00	-0.01***	0.99	0.00	-0.01***	0.99	0.00
Federal	-1.05***	0.35	0.13	-1.06***	0.35	0.13	-1.07***	0.34	0.13
Region1	-0.62***	0.53	0.18	-0.65***	0.52	0.18	-0.55***	0.58	0.22
Region2	-0.76***	0.47	0.17	-0.74***	0.47	0.17	-0.62***	0.53	0.18
Region3	-0.50**	0.60	0.17	-0.55***	0.57	0.17	-0.43**	0.65	0.19
Region4	-0.18	0.83	0.18	-0.12	0.89	0.18	0.03	1.03	0.19
Region5	-0.35*	0.70	0.15	-0.35*	0.70	0.15	-0.26	0.77	0.20
Region6	0.13	1.14	0.20	0.18	1.20	0.20	0.31	1.36	0.19
Region7	-0.22	0.80	0.20	-0.19	0.82	0.20	-0.10	0.91	0.24
Region8	-0.65*	0.52	0.26	-0.57*	0.56	0.26	-0.46	0.63	0.28
Region9	-0.88***	0.41	0.24	-0.96***	0.38	0.24	-0.87***	0.42	0.22
Likelihood Ratio	312.4***			317.3***			314.6***		
Wald Test	296.1***			302.1***			295.9***		
Score (LogRank)	309.8***			317.2***			310.5***		

$^{***}p \leq 0.001$, $^{**}p \leq 0.01$, $^{*}p \leq 0.05$

Models 3 through 5 indicate that Superfund sites located within districts that lean Democratic are about 11-18% more likely to reach "construction complete" status. Additionally, Regions 1, 2, 3, 5, 8 and 9 are all less likely than Region 10 (AK, WA, OR, ID) to experience cleanup completion. This is not so surprising, as New York, New Jersey, and California have

the most Superfund sites in the country, while their regions receive the most EPA funding. Model 2 already indicated that costlier sites move more slowly, and these results further suggest that regional differences beyond money are significantly correlated with remedial progress. The federal indicator shows a consistent effect in all three models in Table 3, suggesting that cleanup work at federal sites takes longer compared to non-federal sites. Of the earlier hypotheses, this appears to indicate that intra-governmental negotiation is not as hurried as litigation and settlement with private firms.

Model 4 focuses on any differential effect of minority presence with community participation, adding the interaction of minority fraction with voter turnout and party preference, to no effect. Model 5 examines the interaction of minority and higher eduction with CAG presence and education with party preference. Only the interaction between education and Congressional party has any significance, exhibiting a differential effect of education in so-called "blue" states; education has an additional positive association with cleanup hazard – meaning faster cleanup – in Democratic-leaning areas. This interaction decreases the negativity of the estimated coefficients for Regions 1, 2, and 3 (northeastern states) and removes significance of the Region 5 (Great Lakes region); hence the regional dummies absorb this differential effect when not controlled for.

Each specification so far has used demographic variables from the census *prior* to the site's listing to ensure the determinants of cleanup are exogenous. Models 3e through 5e use the same variable specifications as those in Table 3, but instead implement ten-year periods centered around the census year as an endogeneity check. Sites listed between 1980 and 1985 use the 1980 census as a reference, while sites listed 1986-1995, 1996-2005, and 2006-2013 use the 1990, 2000, and 2010 censuses respectively. Table 4 displays results mostly consistent with the initial specifications, particularly with regard to race and CAG presence. Education and party preference lose significance, while urban population and voter turnout gain it, which may indicate some endogenous movement of the populace. The fact that minority population remains non-significant confirms the earlier results in this section, but CAG's continued significance indicates concern regarding the construction and inclusion of the variable. Further study into CAG establishment timeline, possibly controlling for significant historical periods in the Superfund program's history, is needed in order to better understand the method of impact: does a CAG itself slow cleanup down, or are such groups established after some time in order to speed things up?

Table 4: Endogeneity check of Cox regression estimates of cleanup time within one mile of a Superfund site using closest census date, same model specifications as Table 3.

	Model 3e			Model 4e			Model 5e		
	Estimate	H.R.	S.E.	Estimate	H.R.	S.E.	Estimate	H.R.	S.E.
Minority	-0.07	0.93	0.03	-0.43	0.65	0.29	-0.07	0.93	0.04
Population over 65	0.14**	1.16	0.10	0.15**	1.16	0.10	0.14*	1.15	0.10
Unemployed	0.35	1.42	0.39	0.34	1.40	0.39	0.34	1.41	0.40
Educated	0.10	1.11	0.04	0.09	1.09	0.04	0.09	1.10	0.06
Urban	-0.05**	0.95	0.02	-0.05**	0.94	0.02	-0.04**	0.95	0.02
Logincome	-0.18***	0.83	0.07	-0.18***	0.83	0.07	-0.19***	0.83	0.07
Home Ownership	0.01	1.01	0.10	0.04	1.04	0.10	0.02	1.02	0.11
Voter Turnout	0.01***	1.01	0.01	0.02**	1.00	0.01	0.02**	1.01	0.01
Dem. Rep.	0.16	1.18	0.08	0.12	1.13	0.08	0.16	1.17	0.10
CAG	-0.68***	0.51	0.24	-0.69**	0.50	0.24	-0.98***	0.37	0.34
Minority× Voter Turnout				0.01	1.01	0.01			
Minority× Dem. Rep.				0.15	1.16	0.08			
Minority×CAG							-0.98	0.38	0.76
Educated× Dem. Rep.							0.01*	1.01	0.04
Educated×CAG							0.21	1.24	0.14
LogNPV	-0.05***	0.95	0.01	-0.05***	0.95	0.01	-0.05***	0.95	0.01
Pollution (HRS)	-0.01***	0.98	0.00	-0.02***	0.98	0.00	-0.01***	0.98	0.00
Federal	-1.07***	0.34	0.13	-1.07***	0.34	0.13	-1.08***	0.34	0.13
Region1	-0.51*	0.60	0.21	-0.48*	0.61	0.21	-0.51*	0.60	0.21
Region2	-0.65**	0.52	0.18	-0.66**	0.52	0.18	-0.64**	0.52	0.18
Region3	-0.46	0.63	0.19	-0.47	0.63	0.19	-0.45	0.64	0.19
Region4	0.00	1.00	0.18	-0.03	0.97	0.18	0.00	1.00	0.18
Region5	-0.28	0.76	0.20	-0.27	0.76	0.20	-0.27	0.76	0.20
Region6	0.26	1.29	0.19	0.26	1.29	0.19	0.26	1.29	0.19
Region7	-0.22	0.80	0.23	-0.23	0.79	0.23	-0.22	0.80	0.23
Region8	-0.31	0.73	0.24	-0.32	0.72	0.24	-0.32	0.73	0.24
Region9	-0.98***	0.37	0.23	-1.01***	0.36	0.23	-0.97***	0.38	0.23

$^{***}p \leq 0.001$, $^{**}p \leq 0.01$, $^{*}p \leq 0.05$

Finally, Table 5 verifies whether the results of the survival analysis thus far are robust to distance specification. Models 3h through 5h investigate a half-mile radius around Superfund sites instead of the one-mile radius used previously.

Table 5: Specification check of Cox regression estimates of cleanup time within a half-mile distance of a Superfund site, same model specifications as Table 3.

	Model 3h			Model 4h			Model 5h		
	Estimate	H.R.	S.E.	Estimate	H.R.	S.E.	Estimate	H.R.	S.E.
Minority	-0.17	0.85	0.07	-0.86	0.42	0.76	-0.15	0.86	0.07
Population over 65	0.25**	1.30	0.10	0.24**	1.27	0.10	0.20**	1.22	0.09
Unemployed	0.99	2.68	0.82	0.91	2.49	0.82	0.97	2.64	0.82
Educated	0.25	1.28	0.10	0.25	1.29	0.10	0.22	1.24	0.12
Urban	-0.08**	0.92	0.04	-0.08**	0.92	0.04	-0.08***	0.92	0.04
Logincome	-0.30***	0.74	0.08	-0.31**	0.74	0.08	-0.30***	0.74	0.08
Home Ownership	0.19*	1.22	0.10	0.18**	1.20	0.10	0.21**	1.23	0.08
Voter Turnout	0.02**	1.00	0.01	-0.01**	1.00	0.01	0.01**	1.00	0.01
Dem. Rep.	0.16	1.17	0.08	0.15	1.17	0.09	0.11	1.12	0.12
CAG	-0.73***	0.48	0.26	-0.73**	0.48	0.26	-0.75***	0.47	0.34
Minority× Voter Turnout				0.01	1.01	0.01			
Minority× Dem. Rep.				0.02	1.02	0.13			
Minority×CAG							0.11	1.11	0.41
Educated× Dem. Rep.							0.05	1.05	0.10
Educated×CAG							-0.02	0.98	0.20
LogNPV	-0.05***	0.94	0.01	-0.06***	0.94	0.01	-0.05***	0.94	0.01
Pollution (HRS)	-0.01***	0.99	0.00	-0.01***	0.99	0.00	-0.01***	0.99	0.00
Federal	-1.03***	0.35	0.13	-1.04***	0.35	0.13	-1.04***	0.35	0.13
Region1	-0.52**	0.59	0.22	-0.50**	0.59	0.22	-0.52*	0.59	0.22
Region2	-0.62***	0.54	0.18	-0.63**	0.53	0.18	-0.62**	0.54	0.18
Region3	-0.42	0.66	0.20	-0.42	0.65	0.20	-0.41	0.66	0.20
Region4	0.09	1.10	0.19	0.09	1.10	0.20	0.09	1.09	0.20
Region5	-0.26	0.77	0.21	-0.25	0.78	0.20	-0.26	0.77	0.21
Region6	0.29	1.34	0.20	0.28	1.33	0.20	0.28	1.33	0.20
Region7	-0.08	0.93	0.25	-0.07	0.93	0.25	-0.07	0.93	0.25
Region8	-0.35	0.70	0.28	-0.36	0.70	0.28	-0.35	0.70	0.28
Region9	-0.99***	0.37	0.23	-1.01***	0.36	0.23	-0.98***	0.37	0.23
Likelihood Ratio	261.5***			262.4***			261.8***		
Wald Test	246.4***			247.1***			246.8***		
Score (LogRank)	253.8***			254.5***			254.4***		

$^{***}p \leq 0.001$, $^{**}p \leq 0.01$, $^{*}p \leq 0.05$

All three models demonstrate overall robustness of results, other than a few notable

variables. Education, which was significant in the one-mile specification of Models 3 through 5, is now insignificant, while urban population and home ownership now are, with home ownership again shortening time to cleanup and urban lengthening it. This perhaps indicates some residential sorting with respect to education as the radius around the Superfund site shrinks. Additionally, for the half-mile radius, voter turnout is more important than party: though the coefficients are small in magnitude and flip signs in Model 4h, the effect of voter turnout is significant, while that of party preference is not. This may indicate that cleanup is no longer a partisan issue for those closest to a site.

5 Conclusion

Over the past century, more than one thousand hazardous sites in the US originated from commercial and industrial waste spilled by industrial sites (Office of Superfund Remediation and Technology Innovation, 2011). These sites pose substantial health risks to nearby communities; contaminated sites impact health in both the short and long term, sometimes even through decreased learning outcomes in school-aged children (Pastor, Sadd, and Morello-Frosch, 2004) or through birth defects in future generations. The Love Canal disaster led Congress to establish the Superfund program in 1980. Since then, the EPA has targeted and removed numerous hazardous sites. However, the pace of cleanup varies among sites, while the average time between listing sites and removing them has grown since instantiation. In this paper, we investigated the underlying factors of cleanup time differences, particularly the demographics and involvement of a site's surrounding community.

Our findings suggest that cleanup time does not depend on the racial composition of communities living in vicinity of Superfund sites, though again, this says nothing about the location of polluted sites themselves. However, we do find evidence that median household income correlates with a longer remediation process. This suggests that sites in wealthy neighborhoods are more difficult, in some regard: perhaps the litigation process is more complex, or perhaps those communities favor more comprehensive, costly remedies. Faster cleanup is associated with less costly, "easy" sites, evidenced by our results for site-specific characteristics like cleanup cost, pollution level, and regional differences. Additionally, since the EPA prioritizes funding ongoing projects, the organization may delay starting cleanup for sites with a high estimated cost or a high level of pollution (US Government Accountability Office, 2015), and the complexity of cleanup at these sites naturally drags out the process as well. It would be elucidating to further investigate this result to pinpoint the root cause:

whether the longer cleanup of Superfund sites in wealthier communities is because the EPA overly invests in a comprehensive strategy or shelves the project for litigation/administrative reasons. Unfortunately, our data provides the length of time between listing, completion, and removal, but not the intermediate point of litigation completion and construction start – especially because these two points may overlap.

On the other hand, we do find that community participation on a whole, proxied by voter turnout, the presence of a Community Advisory Group (CAG), and even education on some level, greatly affects the efficiency and time of cleanup. We observe that education and voter turnout both contribute to a shorter cleanup, but the mechanism is unclear. Some plausible mechanisms are that an educated, engaged populace prefers quick removal or that it assists the EPA in its efforts in the community. Our robustness check with centered census-dates indicates endogeneity issues with the CAG indicator; it appears as if the presence of a CAG is positively correlated with cleanup duration, but improved, as-of-yet-unaccessible data and a more exact time-series approach are needed to disentangle cause and effect.

Our main limitation is the need to use only data at time of listing. This is necessitated by the survival analysis approach of the Cox model and our concerns for endogeneity that could arise from community mobility if using data from during the cleanup process. This is also why we use the listing's calculated Net Present Value as cost estimate created prior to the actual cleanup, and why CAG existence – which is not determined prior to the cleanup but during – is such a problematic variable.

Our results do, however, have some value, particularly regarding the correlation of *ex ante* community characteristics and overall site cleanup length. They also provide some limited policy implications about boosting public awareness of the true impact of communities on the EPA's Superfund decisions. In this study, we found that many more complex factors may impact the whole Superfund process than demographics alone. Furthermore, the racial bias observed in the 80's may have come from or been exacerbated by the extent to which communities were or were not involved in the process; this involvement depends on community factors such as income, voter turnout, or education, all of which may be correlated with race in various US regions. Therefore, local campaigns and groups, especially environmental justice networks focusing on hazard education and voter turnout, would play an extremely important role in facilitating well-informed communities that can influence the EPA's policies regarding hazardous waste lands. Future administrative action and legislation, like the resolution to create a "Green New Deal" (Ocasio-Cortez and Markey, 2019), can aid communities by working within the established Superfund bureaucratic structure by providing

further community education to reduce enforcement delays and improve the cost efficiency of chosen cleanup methods.

Competing Interests Declaration

The authors declare none.

References

Aydin R and Morefield R (2006). Superfund sites and race: Evidence from Houston. *Southwestern Economic Review* 36: 187–196.

Brown MH (Dec. 1979). Love Canal and the poisoning of America. *The Atlantic*: 1–24.

Bullard RD (2008). *Dumping in Dixie: Race, Class, and Environmental Quality*. Boulder, CO: Westview Press.

Burda M and Harding M (2014). Environmental justice: Evidence from Superfund cleanup durations. *Journal of Economic Behavior & Organization* 107: 380–401.

Church TW and Nakamura RT (2001). *Cleaning up the mess: Implementation strategies in Superfund*. Washington, DC: Brookings Institution Press.

Collins M (2008). Collaborative dispute resolution in Superfund enforcement: Does the resolution approach vary by community-level sociodemographic characteristics? M.A. Thesis #3442. In Electronic Theses and Dissertations. University of Central Florida.

Daley DM and Layton DF (2004). Policy implementation and the environmental protection agency: What factors influence remediation at Superfund sites? *Policy Studies Journal* 32(3): 375–392.

Daniels DP et al. (2012). Public opinion on environmental policy in the United States. *Handbook of US Environmental Policy*: 461–486.

Depro B, Timmins C, and O'Neil M (2015). White flight and coming to the nuisance: Can residential mobility explain environmental injustice? *Journal of the Association of Environmental and Resource Economists* 2(3): 439–468.

Dunlap RE and Van Liere KD (1978). The 'New Environmental Paradigm'. *The Journal of Environmental Education* 9(4): 10–19.

Finkel SE, Muller EN, and Opp KD (1989). Personal influence, collective rationality, and mass political action. *American Political Science Review* 83(3): 885–903.

Gamper-Rabindran S and Timmins C (2013). Does cleanup of hazardous waste sites raise housing values? Evidence of spatially localized benefits. *Journal of Environmental Economics and Management* 63(3): 345–360.

Glimpse W (2019). *10 reasons to use census tract versus ZIP code geography demographics*. http://proximityone.com/tracts_zips.htm (accessed 29 May 2019).

Gupta S, Houvten G van, and Cropper M (1996). Paying for permanence: An economic analysis of EPA's cleanup decisions at Superfund sites. *The RAND Journal of Economics* 27(3): 563–582.

Guzman GG (2018). *Household Income: 2017*. Tech. rep. US Census Bureau. www.census.gov/programs.

Hamilton JT (1995). Testing for environmental racism: Prejudice, profits, political power? *Journal of Policy Analysis and Management* 14(1): 107–132.

Hamilton JT and Viscusi WK (1999). *Calculating risks?: The spatial and political dimensions of hazardous waste policy*. Cambridge: MIT Press.

Haninger K, Ma L, and Timmins C (2017). The value of brownfield remediation. *Journal of the Association of Environmental and Resource Economists* 4(1).

Howell SE and Laska SB (1992). The changing face of the environmental coalition: A research note. *Environment and Behavior* 24(1): 134–144.

Kohlhase JE (1991). The impact of toxic waste sites on housing values. *Journal of Urban Economics* 30(1): 1–26.

Lavelle M and Coyle M (1992). Unequal protection: The racial divide in environmental law. *National Law Journal* 15(3): S1–S12.

McClelland GH, Schulze WD, and Hurd B (1990). The effect of risk beliefs on property values: A case study of a hazardous waste site. *Risk Analysis* 10(4): 485–497.

Morello-Frosch R and Jesdale BM (2006). Separate and unequal: Residential segregation and estimated cancer risks associated with ambient air toxins in U.S. metropolitan areas. *Environmental Health Perspectives* 114(3): 386–393.

Nakada M (2017). Distance to hazard: An environmental policy with income heterogeneity. *Environment and Development Economics* 22(1): 51–65.

Ocasio-Cortez A and Markey E (2019). *H.Res. 109 – 116th Congress: Recognizing the duty of the Federal Government to create a Green New Deal*. Washington, DC.

Office of Environmental Justice (2017). *Factsheet on the EPA's Office of Environmental Justice*. Tech. rep. Washington, DC: US Environmental Protection Agency. https://www.epa.gov/environmentaljustice/factsheet-epas-office-environmental-justice.

Office of Superfund Remediation and Technology Innovation (2011). *Superfund Community Involvement Handbook (EPA Publication No. 540-R-11-021)*. Tech. rep. Silver Spring, MD: US Environmental Protection Agency.

Pastor M, Sadd JL, and Morello-Frosch R (2004). Reading, writing, and toxics: Children's health, academic performance, and environmental justice in Los Angeles. *Environment and Planning C: Government and Policy* 22(2): 271–290.

Ready R (2010). Do landfills always depress nearby property values? *Journal of Real Estate Research* 32(3): 321–339.

Rosenstone SJ and Hansen J (1993). *Mobilization, participation, and democracy in America*. London: Macmillan Publishing Company.

Sigman H (2001). The pace of progress at Superfund sites: policy goals and interest group influence. *The Journal of Law & Economics* 44(1): 315–343.

US Census Bureau (2020). *Demographic Data*. `https://www.census.gov/programs-surveys/ces/data/restricted-use-data/demographic-data.html` (accessed 28 June 2021).

US Commission on Civil Rights (2003). *Not in my backyard: Executive order 12,898 and Title VI as tools for achieving environmental justice, alternative dispute resolution and meaningful public participation*. Washington, DC: US Government Printing Office.

US Environmental Protection Agency, National Institute for Environmental Health Sciences Columbia University Superfund Research Program, et al. (2017). *EPA National Priorities List (NPL) Sites Point Data with CIESIN Modifications, Version 2*. Palisades, NY. `http://dx.doi.org/10.7927/H44X55RB`.

US Environmental Protection Agency and Office of Land and Emergency Management (2018). *Superfund History - Printable Version*. `https://www.epa.gov/superfund/superfund-history-printable-version` (accessed 20 Oct. 2020).

US Environmental Protection Agency and Office of Superfund Remediation and Technology Innovation (2013). *Love Canal Niagara Falls, NY Cleanup Activities*. `https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.Cleanup&id=0201290` (accessed 20 Oct. 2020).

US Geological Survey and US Department of the Interior (2016). *Love Canal NPL Site*. `https://www.cerc.usgs.gov/orda_docs/CaseDetails?ID=142` (accessed 20 Oct. 2020).

US Government Accountability Office (2015). *Trends in Federal Funding and Cleanup of EPA's non-federal National Priorities List Sites (GAO Publication No. 15812)*. Tech. rep. Washington, DC: US Government Printing Office. `https://www.gao.gov/assets/680/672734.pdf`.

Verba S, Schlozman KL, and Brady HE (1995). *Voice and equality: Civic voluntarism in American politics*. Harvard University Press.

Viscusi WK and Hamilton JT (1999). Are risk regulators rational? Evidence from hazardous waste cleanup decisions. *American Economic Review* 89(4): 1010–1027.