Regulation's Hidden Benefits: Evidence from Waste Crime*

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July 2026

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Abstract

Environmental regulation imposes visible costs on firms and governments, while its benefits often take the less observable form of environmental and health damages prevented through compliance. This paper estimates one component of these benefits by examining the mortality damages that arise when regulated waste management channels are circumvented. I construct a novel dataset on environmentally harmful waste crimes in Italy from police investigations and Supreme Court rulings. Exploiting staggered variation in the first recorded occurrence of illegal burning, dumping or burial, and discharges into water bodies, I find that recorded exposure increases total mortality by approximately 2%, cancer mortality by 1%, and cardiovascular mortality by 1.5%. The effects emerge with delay and extend to neighboring municipalities. The estimates imply approximately 460–810 additional deaths per year, corresponding to average annual mortality costs of €2.2–3.9 billion, or 0.11–0.20% of Italian GDP. The findings quantify an important component of the benefits at stake in effective environmental regulation and enforcement.

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I am highly indebted to Jonas Hjort and Gabriel Ulyssea for their guidance and continuous support throughout this project. I also thank Francesco Dodaro, Enrico Fontana, Pasquale Fimiani, Antonio Pergolizzi, and Luca Ramacci for generously sharing their data and invaluable institutional knowledge. I have benefited from helpful comments from Francois Gerard, Marion Leroutier, Rob Metcalfe, Lucia Rizzica, Andrea Smurra and Davide Zufacchi. I gratefully acknowledge financial support from the UBEL DTP Research Training Support Grant (ES/P000592/1). Flavia Di Sano and Beatrice Soresina provided excellent research assistance.

1 Introduction

> *"Flooding a territory with toxic waste, surrounding their own towns with mountain ranges of poison, can only be a problem for those who possess a long-term, socially responsible view of power. In the short term, however, there is only the high profit margin and no downside."*
>
> —Roberto Saviano, *Gomorrah* (2006)

Environmental regulation is costly to implement. Firms incur compliance costs, while governments devote substantial resources to monitoring, inspections, auditing, and enforcement. Whether these expenditures are socially justified depends on the environmental and health damages that regulation prevents (Pigou, 1920). Yet while the costs of regulation are relatively visible and have been extensively studied, its benefits are harder to quantify because they often take the form of harms that do not occur when regulated actors comply. One way to recover these benefits is to examine what happens when compliance fails: whether violations generate measurable downstream harm and, if so, how large that harm is.

Waste management provides a particularly informative setting in which to study this question. Waste regulation governs the different stages through which waste must pass, including its classification, collection, transport, treatment, recovery, and final disposal. These rules are intended to ensure that potentially harmful materials are handled through authorized channels and do not contaminate air, water, or soil. Compliance, however, is costly and difficult to monitor throughout the disposal chain. Firms and intermediaries may therefore circumvent regulatory requirements through illegal dumping, burial, burning, or discharge, shifting the resulting environmental and health risks onto nearby communities.[1] While the potential health consequences of exposure to improperly managed waste are well documented in the biomedical and epidemiological literature, primarily through observational and correlational evidence (e.g., Martuzzi *et al.*, 2009b; Triassi *et al.*, 2015; Alberti, 2022), the realized damages caused by violations of waste regulation remain difficult to quantify. Waste crime is concealed and selectively detected, and it often occurs in locations that differ in institutional capacity and pre-existing environmental conditions. As a result, the mortality costs of circumventing waste regulation—and thus an important component of the benefits at stake in effective regulation and enforcement—remain largely unquantified.

[1] Waste crime is an increasingly important international concern (Wikipedia, 2026). International reports identify it as a major and growing component of environmental crime and document the expanding scale and transnational organization of illegal waste flows and related pollution offenses (UNEP & INTERPOL, 2016; UNODC, 2024).

This paper provides evidence on this missing quantity by estimating the mortality consequences of recorded environmentally harmful violations of waste regulation in Italy – hereafter, waste crimes. I assemble a novel dataset by combining textual information from police investigations, environmental organizations, and Supreme Court rulings. From these sources, I recover the timing and location of offenses, the firms involved, the type and quantity of waste, and the legal classification of the crime. I then link these events to firm-level balance-sheet data and municipality-level outcomes over time. This approach makes it possible to quantify an important component of the social damages that arise when regulated waste-management channels are circumvented.

Italy provides a particularly informative setting for this analysis. Illegal waste disposal has received sustained attention from law-enforcement authorities, courts, environmental organizations, and the media, in part because of its historical association with organized crime.[2] This attention has generated an unusually rich documentary record of police operations and judicial proceedings, making it possible to recover the timing and location of offenses that would otherwise remain hidden (e.g., European Court of Human Rights, 2024). At the same time, the phenomenon is not confined to mafia organizations or their traditional areas of influence. It involves both organized crime groups and otherwise legitimate firms operating within ordinary production and waste-management chains. Italy therefore combines the documentary record needed to recover otherwise concealed violations with substantial variation across institutional, economic, and environmental contexts.

I first document the geography of recorded violations and the characteristics of the firms involved. Although environmentally harmful waste crime has often been associated with organized crime and particular areas of Southern Italy, recorded offenses involving direct environmental release occur across the country, including dense and economically important municipalities in Central and Northern Italy. The firms involved are similarly dispersed, and their locations often differ from those in which the environmental offense occurs. These patterns suggest that circumvention of waste regulation is embedded in production and waste-management networks that connect firms, disposal sites, and communities across space, rather than being confined to a small number of territories traditionally associated with organized crime.

I then estimate the reduced-form effects of recorded environmentally harmful violations of waste regulation on local mortality. The empirical design exploits variation in the timing of first recorded exposure across municipalities using the staggered difference-in-

[2]Legambiente, a major Italian environmental NGO, coined the term *ecomafia* in 1994 and began systematically documenting environmental crime with the first *Rapporto Ecomafia* (Legambiente, 1994), published annually thereafter.

differences framework of Callaway & Sant'Anna (2021). I define treatment using offenses most plausibly associated with direct environmental release: illegal burning, dumping or burial, and discharges into water bodies. Recorded exposure increases total mortality by approximately 2 percent, cancer mortality by about 1 percent, and cardiovascular mortality by about 1.5 percent. Relative to pre-treatment levels, these estimates correspond to roughly 18 additional deaths per 100,000 residents for total mortality and about 2.5 additional cancer deaths per 100,000 residents. The effects emerge with delay and extend beyond the municipality in which the crime is recorded, affecting neighboring communities within a radius of up to 10 kilometers.

Scaling the mortality estimates to the population and duration of exposure implies an average burden of approximately 810 additional deaths per year over the sample period. Using the OECD value of a statistical life adjusted to the Italian context, these deaths correspond to an annual mortality cost of approximately €3.9 billion, or 0.20% of Italian GDP in 2022. An alternative treatment definition that includes municipalities within 10 kilometers of a recorded crime yields a lower but still substantial estimate of approximately €2.2 billion per year. These figures capture only the welfare cost of excess mortality and therefore provide a partial measure of the broader social costs of environmentally harmful waste crimes.

Because the offenses in the treatment group differ in the type of waste involved and in their likely routes of environmental release, I interpret these estimates as the overall mortality consequences of recorded circumvention of regulated waste-management channels, rather than as the effect of a single pollutant or environmental pathway.

The findings are robust to alternative specifications and treatment definitions. They remain qualitatively similar when I include richer controls and more demanding fixed effects, when I vary the assignment of crimes to municipalities based on the underlying textual evidence, and when I distinguish municipalities with single and repeated recorded exposure. Placebo exercises based on random reassignment of treatment yield no comparable effects. The delayed response, the effects on cancer and cardiovascular mortality, the spatial spillovers, and the absence of an effect on causes of death unrelated to environmental exposure are jointly consistent with recorded waste crimes affecting health through environmental contamination. Taken together, the results indicate that violations of waste regulation generate mortality damages that are economically meaningful, spatially diffuse, and not confined to the locations in which the violations are formally recorded.

This paper first contributes to the economics of environmental regulation by providing evidence on the benefits at stake in regulatory compliance. A large literature studies the costs of environmental regulation for firms, including its effects on productivity, in-

vestment, employment, and location choices (e.g., Greenstone, 2002; Walker, 2013; Curtis, 2018; Shapiro & Walker, 2018). Another literature examines how inspections, monitoring technologies, auditor incentives, and sanctions affect environmental performance and compliance (Gray & Shimshack, 2011; Duflo *et al.*, 2013, 2018; Zou, 2021). These studies identify important components of the costs of regulation and the effectiveness of different enforcement instruments. Much less is known about the downstream social damages that these instruments are intended to prevent. An important exception is Alexander & Schwandt (2022), who estimate the health consequences of automobile manufacturers' emissions cheating. I contribute by estimating the mortality consequences of noncompliance with waste regulation. The estimates quantify an important component of the welfare losses generated when regulated actors circumvent environmental safeguards and therefore inform the benefit side of environmental regulation and enforcement.

Second, this paper contributes to the large literature, primarily in epidemiology, public health, and the biomedical sciences, that studies the health consequences of exposure to waste and contaminated sites. In Italy, this literature received particular attention following early evidence of unusually high mortality and adverse health outcomes in the so-called *Land of Fires* in Campania (Senior & Mazza, 2004). A subsequent body of work has examined cancer, congenital anomalies, respiratory disease, and other health outcomes associated with waste disposal and environmental contamination (e.g., Martuzzi *et al.*, 2009b; Triassi *et al.*, 2015; Alberti, 2022). Much of this evidence, however, continues to focus on Campania or on a small number of heavily contaminated areas and is based primarily on cross-sectional comparisons, spatial correlations, or descriptive epidemiological designs. A recent exception is Beraldo *et al.* (2026), who provide econometric evidence on the relationship between mafia presence and cancer incidence in the *Land of Fires*. I contribute to this literature by studying recorded environmentally harmful violations across the universe of Italian municipalities and exploiting variation in the timing of first recorded exposure to estimate the causal effect of recorded exposure on mortality. This design provides systematic evidence on the realized health damages associated with circumvention of waste regulation, beyond a small number of especially contaminated or historically salient areas.

2 Background

2.1 Illegal Waste Management

Waste management comprises a broad set of activities, including the collection, transport, treatment, recovery, and disposal of household, industrial, and hazardous waste (Favarin & Thachuk, 2022). In practice, these activities are carried out by firms operating at different stages of the waste cycle, including collection companies, transport intermediaries, treatment plants, and disposal operators. Because waste management involves potentially harmful materials, the sector is heavily regulated and subject to authorization, monitoring, and traceability requirements. When these rules are circumvented, waste activities can generate substantial negative externalities, including soil and water contamination, air pollution, and risks to human health.

In Italy, the regulatory framework governing waste management covers multiple stages and activities, giving rise to violations that differ substantially in form, scale, and organizational complexity. At a basic level, the Italian Environmental Code prohibits unauthorized waste activities, including collection, transport, recovery, disposal, trade, or brokerage carried out without the required authorization, registration, or notification procedures (art. 256, d.Lgs. 152/2006). At a more serious level, the Criminal Code sanctions organized illegal waste trafficking, defined as repeated and coordinated activities involving the unlawful handling of large quantities of waste for unjust profit (art. 452-quaterdecies).

These legal categories are useful for the present analysis because they identify behaviors through which firms or individuals deliberately avoid the costs of lawful waste disposal. From an economic perspective, waste crimes are profit-driven activities: bypassing treatment standards, transport requirements, or authorized disposal channels reduces private costs while shifting the environmental and health burden onto nearby communities. The resulting private gains can therefore be substantial.

These features make waste crimes an important form of environmental crime, with potentially severe consequences for local ecosystems and public health.

2.2 Environmental and Health Risks

Waste crimes are heterogeneous in the extent to which they pose direct risks to environmental quality and human health. Some violations primarily reflect non-compliance with authorization, registration, or handling requirements, such as transport or management activities carried out without the appropriate permits. Although unlawful, these offenses are not necessarily associated with immediate environmental release or direct human ex-

posure.

Other waste crimes are more likely to generate substantial environmental and health externalities because they involve the direct release of pollutants into air, soil, or water. Illegal dumping and burial can contaminate soil, with pollutants potentially persisting over time, entering agricultural production through crops and livestock, or migrating into groundwater. Burning-related offenses may release toxic pollutants into the air, exposing nearby residents through inhalation. Illegal discharges into rivers, canals, or other water bodies can contaminate surface water and, depending on local hydrogeological conditions, groundwater as well. These exposure pathways are well established in the environmental-health literature and are consistent with the types of outcomes studied in this paper, including mortality from cancer and cardiovascular disease.

This heterogeneity implies that waste crimes should not be treated as homogeneous from the standpoint of environmental and health risk. Activities involving dumping, burial, burning, or illegal discharges are more plausibly linked to subsequent effects on local ecosystems and nearby populations than violations that mainly reflect failures to comply with authorization requirements. These mechanisms also imply that the consequences of waste crimes need not be confined to the municipality in which the offense is recorded, since pollutants can travel through air, water, and soil.

3 Data

This paper combines several data sources on waste management crimes, firm characteristics, and municipal-level outcomes in Italy over the period 1980–2024.

Waste Management Crimes. I assemble a novel dataset on waste management crimes from several textual sources. First, I use *Legambiente*'s archive of police operations related to waste management crimes, which covers 473 investigations conducted between 2002 and 2024. Legambiente is an Italian environmental NGO that has played a prominent role in documenting and publicizing environmental crime: it coined the term *ecomafia* in 1994 and has published the annual *Rapporto Ecomafia* since then (Legambiente, 1994). Second, I collect information from Supreme Court rulings on waste crimes using two complementary sources: Lexambiente's archive of criminal decisions on waste and ecocrimes, and the universe of rulings mentioning the offense of organized illegal waste trafficking between 2020 and 2024 from Italgiure.

From these texts, I extract information on the timing of the police operation or court ruling, the individuals and firms involved, the offenses mentioned, the type and quantity

of waste involved, and the timing and location—typically the municipality—where the unlawful activity took place. I carry out this extraction through a structured, language-model-assisted text-analysis procedure. Because the underlying documents differ in scope and detail, some observations do not contain both a precise year and a sufficiently fine geographic location for the unlawful activity. I then use the names of the firms involved, together with other identifying information contained in the documents, to hand-collect the firms' unique fiscal codes.

Firms. Using the fiscal codes of the firms involved in waste crimes, I merge these observations with firm-level information from CERVED's Company Account Data Service (CADS), which contains balance-sheet data for the universe of Italian corporations. These data allow me to characterize the firms involved in waste crimes along several dimensions, including sector, size, location, and financial conditions.

Health Outcomes. I obtain annual municipal-level cause-of-death data from the Italian statistical institute (ISTAT) for the period 1980–2023. These data cover the universe of deaths occurring in Italy in each calendar year and include both medical information reported by the certifying doctor and socio-demographic information provided by the municipal civil registry. Causes of death are coded according to the WHO's ICD classification, ensuring consistency and international comparability.

I construct mortality outcomes as the number of deaths in a municipality-year divided by the resident municipal population in the previous year, multiplied by 100. In the baseline regressions, I use the logarithm of these mortality rates, winsorised at the 2nd and 98th percentile to smooth the effect of outliers. The main outcomes include total mortality, mortality from malignant cancers, mortality from environmentally mediated cancers (lung, larynx, stomach, bladder, and kidney), and mortality from cardiovascular diseases. As a robustness check, I also consider causes of death unlikely to be affected by waste exposure, defined as the sum of deaths from transport accidents, accidental falls, and other accidental injuries or exposures.

Other Controls. I further collect municipality-level controls from ISTAT, including the yearly age and gender composition of the resident population, municipal surface area, municipal elevation, and ecoregion characteristics based on climatic, biogeographical, physiographic, and hydrographic conditions. I also use the municipal fragility index developed by ISTAT, together with additional indicators of territorial and environmental fragility, including unsorted waste per capita, the share of municipal area under protected

status, the share of area exposed to landslide risk, and the share of artificial land cover. I complement these data with information on municipal-level income from the Italian Ministry of Economy and Finance, available from 2000 onward.[3] To account for local energy infrastructure, I collect information on the presence of open local energy plants from the Global Energy Monitor, distinguishing coal, oil and gas, wind, hydroelectric, bioenergy, geothermal, and nuclear facilities. I also collect data from the Italian Ministry of Health on hospital beds available in each municipality in 2009–2024. Finally, I assemble additional measures capturing local institutional and social conditions. These include municipal council dissolutions for mafia infiltration since 1991 from WikiMafia; the number of firms, buildings, and land assets seized from mafia-related organizations and reassigned at the municipal level from ANBSC; and proxies for social capital commonly used in the literature, such as turnout in the 1974 divorce referendum and the number of non-profit associations and employees in 2001 (Nannicini *et al.*, 2013).

3.1 Treatment Definition and Estimation Sample

The underlying corpus of waste crimes includes heterogeneous offenses, not all of which are equally likely to generate direct environmental or health externalities. I therefore define treatment using only the subset of crimes plausibly associated with harmful exposure. Specifically, I focus on offenses involving the direct release of pollutants into the environment, which I group into three broad categories: burning-related practices, illegal discharges into water bodies, and dumping- or burial-related practices.[4] By contrast, offenses that mainly reflect authorization, transport, or procedural violations remain in the broader corpus but do not enter the main treatment indicator.

Because the analysis links waste crimes to local outcomes, I retain only events for which both the timing of the unlawful activity and the municipality in which it occurred can be identified with sufficient precision. These treated events are then merged with municipal-level health and demographic data and other controls. I also exclude municipalities for which an environmentally harmful waste crime is observed but the timing of first recorded exposure cannot be dated precisely enough. This avoids misclassifying treated municipalities as controls.

The analysis is conducted on a municipality-year panel. Treatment is assigned at the municipality level based on the earliest recorded occurrence of an environmentally harm-

[3] Municipal surface area is available annually from 2001 to 2024. For 1981–2000, I impute the 1991 Census value.

[4] These include *incendio*, *incenerimento*, *combustione*, and *bruciatura*; *sversamento* and *scarico*; and *interramento*, *abbandono*, and *discarica abusiva*.

ful waste crime.

A limitation of this treatment definition is that the observed treatment year corresponds to the first environmentally harmful waste crime that can be detected and dated in the available sources, rather than necessarily to the first actual occurrence of such a crime. This distinction is inherent to the study of illegal activities such as waste crime. Some offenses may remain entirely undetected, while others may begin before the date that can be established from police or judicial records. Treatment status and timing are therefore measured with error: municipality-years that are already exposed may be classified as untreated temporarily, until the first recorded event, or permanently if the underlying crime is never observed. To the extent that this misclassification places exposed observations in the comparison group or in the pre-treatment period, it is likely to attenuate the estimated effects toward zero. I therefore interpret the results as the effects of recorded environmentally harmful waste crimes, rather than of all underlying waste-crime activity.

3.2 Descriptive Statistics

My final sample covers 7,889 municipalities over the period 1981–2024, harmonized according to municipal boundaries as of January 1, 2024. I define a municipality as treated if it has at least one recorded environmentally harmful waste crime during the sample period. Based on this definition, 217 municipalities are treated. Among treated municipalities, recorded exposure can be further classified according to the main environmental channel involved: soil-related offenses (dumping- and burial-related practices), air-related offenses (burning-related practices), and water-related offenses (illegal discharges into water bodies). Table 1 documents the staggered timing of recorded treatment adoption. Recorded treatment is concentrated in the middle of the sample period: approximately 75% of first treatment events occur between 1998 and 2013.

The spatial distribution of these crimes is one of the most striking features of the data. Public debate often frames illegal waste activity as a phenomenon tied primarily to a limited number of territories historically associated with organized crime. Figure 1 suggests a substantially broader picture. The left panel reports mafia presence according to the Mafia Presence Index developed by Dugato *et al.* (2020), while the middle and right panels report, respectively, the municipalities in which environmentally harmful waste crimes occur and the municipalities in which the involved firms are incorporated.

Several patterns emerge. First, mafia presence is highly concentrated in the traditional regions of organized crime—Campania, Puglia, Calabria, and Sicily—with additional clusters in large and economically dynamic areas such as Rome, Milan, Turin,

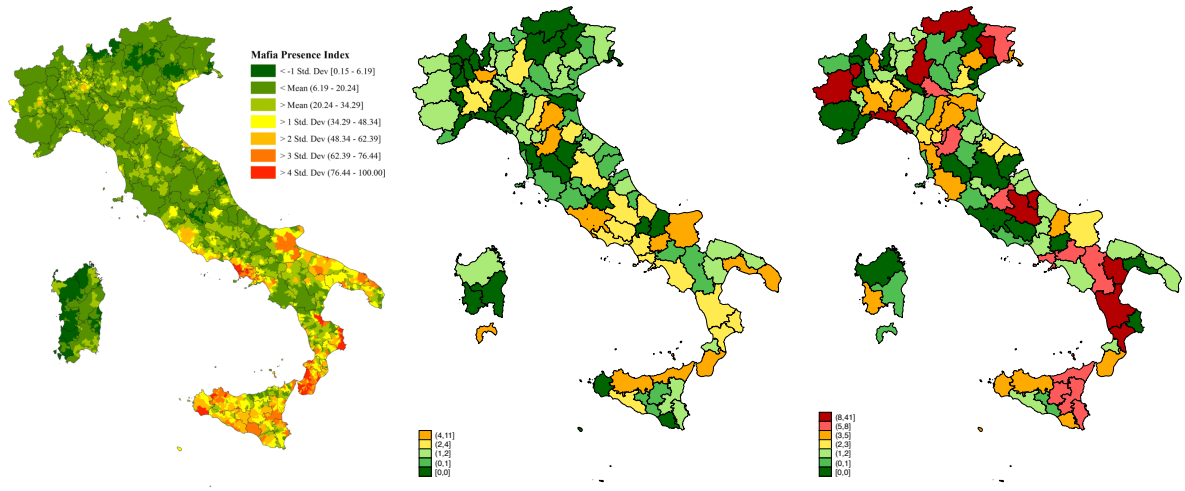
Table 1: Distribution of Treatment Years

Year	Frequency	Percent
1988	1	0.46
1992	2	0.92
1993	2	0.92
1995	2	0.92
1996	1	0.46
1997	1	0.46
1998	11	5.07
1999	7	3.23
2000	9	4.15
2001	10	4.61
2002	15	6.91
2003	11	5.07
2004	9	4.15
2005	7	3.23
2006	12	5.53
2007	12	5.53
2008	8	3.69
2009	12	5.53
2010	15	6.91
2011	3	1.38
2012	14	6.45
2013	12	5.53
2014	19	8.76
2015	4	1.84
2016	3	1.38
2017	4	1.84
2018	6	2.76
2019	3	1.38
2020	2	0.92
Total	217	100.00

Notes: The table reports the distribution of first recorded treatment years across municipalities with at least one recorded environmentally harmful waste crime. Each observation corresponds to a treated municipality, and the year refers to the first recorded occurrence of such a crime. Frequencies and percentages are computed over the set of treated municipalities (217 in total). The sample covers 7,889 municipalities over the period 1981–2024, harmonized to 2024 administrative boundaries. Treatment is defined based on offenses involving the direct release of pollutants, including dumping and burial, burning, and discharges into water bodies.

Venice, and the Romagna Riviera. Reassuringly, this overall spatial distribution is broadly in line with that suggested by other commonly used sources on organized crime presence (Mirenda *et al.*, 2022; Arellano-Bover *et al.*, 2024; Castelluccio & Rizzica, 2025). Second, environmentally harmful waste crimes are far more geographically dispersed than a conventional organized-crime narrative would suggest. Although some concentration remains in historically exposed areas, these offenses are also widespread across Central Italy and the industrial North. Third, the geography of firm incorporation points to a related but distinct pattern: firms involved in these crimes are disproportionately incorporated in selected areas of both the North and the South, suggesting that illegal waste flows may connect distant parts of the country.

Figure 1: Geographic Distribution of Mafia Presence, Waste Crimes, and Involved Firms



Notes: The figure presents, from left to right, the geographic distribution of the Mafia Presence Index, as measured by Dugato *et al.* (2020), the geographic distribution of waste crimes, and the locations of incorporation of firms involved in waste crimes. Whereas the Mafia Presence Index is measured at the municipal level, the other two maps are constructed at the provincial level (111 provinces).

Taken together, these patterns indicate that environmentally harmful waste crimes are not confined to a narrow set of municipalities or to the canonical areas of mafia activity. Instead, the data reveal a remarkably widespread phenomenon, reaching well beyond the settings that dominate public discussion and the existing literature. In particular, although existing work has rightly focused on the Campania "triangle of death" as a paradigmatic case of the health consequences of illegal waste disposal (e.g., Senior & Mazza, 2004), the geography of the crimes in my data points to a substantially broader phenomenon, involving municipalities across a wide range of institutional and economic contexts.

A related question is whether municipalities with recorded exposure to environmentally harmful waste crimes differ systematically from those that are never exposed. Table 2 compares baseline characteristics of treated and control municipalities. Several differ-

ences emerge. Treated municipalities are larger and denser than control municipalities, although this difference is partly driven by the presence of the three largest cities—Rome, Milan, and Naples—in the treated group. They also have greater hospital capacity and a younger population structure, with higher shares of residents below age 35 and lower shares of older residents.

Baseline mortality is lower in treated municipalities, both overall and across specific causes of death. Treated municipalities also differ along some institutional and geographic dimensions: they are more likely to be located in traditional mafia regions, to have experienced a municipal council dismissal for mafia infiltration, and to have reassigned mafia-confiscated assets. At the same time, the phenomenon is far from confined to these areas: about one third of treated municipalities are located in Northern Italy. Differences in broader socio-economic and civic characteristics are more limited. Income per capita, referendum turnout, and the municipal fragility index are broadly similar across treated and control municipalities, while treated municipalities appear somewhat more urbanized, with higher artificial land cover and unsorted waste per capita.

Taken together, these differences indicate that treated municipalities are not randomly drawn from the national distribution of local characteristics. At the same time, they do not appear to be negatively selected in terms of pre-treatment health conditions, nor are they confined to the traditional geography of mafia activity. If anything, treated municipalities exhibit lower baseline mortality than control municipalities, which reduces concerns that the estimated effects simply reflect pre-existing adverse health conditions.

As an additional transparency check, Appendix Tables A1 and A2 compare treated municipalities by recorded treatment timing and recorded exposure intensity. Early- and late-treated municipalities – defined as municipalities first treated before and after 2006, respectively – look broadly similar along many baseline dimensions, including income, population structure, mafia-related indicators, social-capital measures, and municipal fragility, although early-treated municipalities are larger, denser, and somewhat more urbanized. By contrast, municipalities with multiple recorded waste crimes differ more clearly from those with only one recorded crime. The evidence shows that municipalities with multiple recorded treatment events differ in underlying characteristics – including mafia presence, demographic structure, and geographic location – from municipalities treated only once. These patterns motivate the robustness exercises below, where I examine whether the main results are sensitive to treatment intensity and treatment timing.

Table 2: Descriptive Statistics

Variable	(1) Control	(2) Treated	(3) Δ
Income per capita	12040.147	12326.617	286.470*
	(2505.364)	(2620.987)	(165.763)
Population	5390.466	55582.031	50191.566***
	(18576.492)	(2.28e+05)	(14145.590)
Pop Density	240.359	653.445	413.086***
	(567.902)	(1406.098)	(87.626)
Share (0,14)	0.190	0.218	0.028***
	(0.049)	(0.048)	(0.003)
Share (15,34)	0.282	0.295	0.014***
	(0.043)	(0.029)	(0.002)
Share (45,64)	0.244	0.229	-0.015***
	(0.038)	(0.034)	(0.002)
Share (65,75)	0.108	0.088	-0.019***
	(0.040)	(0.028)	(0.002)
Share >75	0.056	0.043	-0.013***
	(0.029)	(0.019)	(0.001)
Beds for Acute Hosp	16.377	288.189	271.812***
	(119.781)	(1160.209)	(71.975)
Beds for Long-Term Hosp	1.062	9.158	8.096***
	(9.706)	(42.128)	(2.615)
Beds for Rehab	2.274	31.792	29.517***
	(16.543)	(183.282)	(11.370)
Tot Deaths (%)	1.211	0.928	-0.283***
	(0.544)	(0.330)	(0.022)
Cancer Deaths (%)	0.244	0.196	-0.048***
	(0.170)	(0.104)	(0.007)
Env Cancer Deaths (%)	0.095	0.076	-0.019***
	(0.091)	(0.055)	(0.004)
Cardiovascular Deaths (%)	0.557	0.439	-0.118***
	(0.316)	(0.202)	(0.013)
Unrelated Deaths (%)	0.057	0.044	-0.012***
	(0.064)	(0.031)	(0.002)
Coal Plants	0.006	0.000	-0.006
	(0.080)	(0.000)	(0.006)
Oil & Gas Plants	0.301	0.739	0.438**
	(0.731)	(0.810)	(0.176)
Wind Farms	0.635	0.609	-0.026
	(0.937)	(1.469)	(0.311)
Hydropower Plants	0.301	0.087	-0.214***
	(0.488)	(0.288)	(0.071)
North	0.564	0.320	-0.243***
	(0.496)	(0.468)	(0.030)
Centre	0.119	0.189	0.070***
	(0.324)	(0.392)	(0.025)
South	0.317	0.490	0.173***
	(0.465)	(0.501)	(0.032)
Mafia Regions	0.195	0.413	0.218***
	(0.396)	(0.493)	(0.031)
City Council Dismissed for Mafia	0.030	0.120	0.090***
	(0.170)	(0.325)	(0.020)
Assigned Mafia-Seized Firms	0.001	0.003	0.002***
	(0.008)	(0.010)	(0.001)
Assigned Mafia-Seized Buildings/Land	0.037	0.080	0.043***
	(0.471)	(0.236)	(0.016)
Turnout 1974 Referendum	85.094	85.111	0.017
	(10.341)	(10.737)	(0.696)
Non-Profit Associations (2001)	0.557	0.435	-0.122***
	(0.429)	(0.226)	(0.015)
Non-Profit Employees (2001)	0.500	0.697	0.197**
	(2.240)	(1.148)	(0.077)
City Max Heigth	876.189	597.981	-278.208***
	(801.882)	(599.885)	(38.335)
City Average Heigth	471.082	265.978	-205.104***
	(457.517)	(312.066)	(20.059)
City Heigth Range	659.730	490.490	-169.239***
	(646.593)	(496.924)	(31.707)
Municipal Fragility Index (0-10)	5.035	4.946	-0.089
	(2.882)	(2.877)	(0.181)
Unsorted waste per capita	145.417	171.846	26.429***
	(110.403)	(112.304)	(7.081)
Protected area share (%)	16.530	13.280	-3.250**
	(25.648)	(20.226)	(1.289)
Landslide risk area share (%)	8.925	6.627	-2.298***
	(14.505)	(12.295)	(0.781)
Artificial land cover share (%)	9.769	15.432	5.664***
	(10.001)	(13.676)	(0.856)

Notes: Columns (1) and (2) report mean values for control and treated municipalities, respectively. Column (3) shows the raw difference in means between (2) and (1). Robust standard errors are reported in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels, respectively. *Treated* equals one for municipalities with at least one recorded environmentally harmful waste mismanagement crime crime during the sample period. All variables are measured in 1981 or, if not available in that year, in the first year in which they are observed. Income per capita is defined as total municipal net income divided by the number of taxable individuals and is first available in 2000. The *Share* variables denote the share of residents in each age group relative to total municipal population. Hospital-bed variables are first available in 2009. The *Deaths* variables are measured as deaths divided by the resident population in the previous year and are winsorized at the 2nd and 98th percentiles, as some values are implausibly high relative to the national mortality statistics reported by ISTAT. *North*, *Centre*, and *South* are macro-area indicators, while *Mafia Regions* identifies municipalities located in Campania, Puglia, Calabria, and Sicily.

4 Empirical Strategy

As discussed above, environmentally harmful waste crimes are staggered both across municipalities and over time. To estimate their effects on local health outcomes, I exploit variation in the timing of first recorded exposure at the municipal level within a staggered difference-in-differences framework. Let E_i denote the first year in which an environmentally harmful waste crime is recorded in municipality i. Event time is therefore defined relative to the first recorded occurrence of an environmentally harmful waste crime. To estimate dynamic treatment effects, I use the following baseline event-study specification:

$$Y_{it} = \alpha_i + \lambda_t + \sum_{k \neq -1} \delta_k \mathbb{I}[t - E_i = k] + \beta X_{it} + \epsilon_{it}, \tag{1}$$

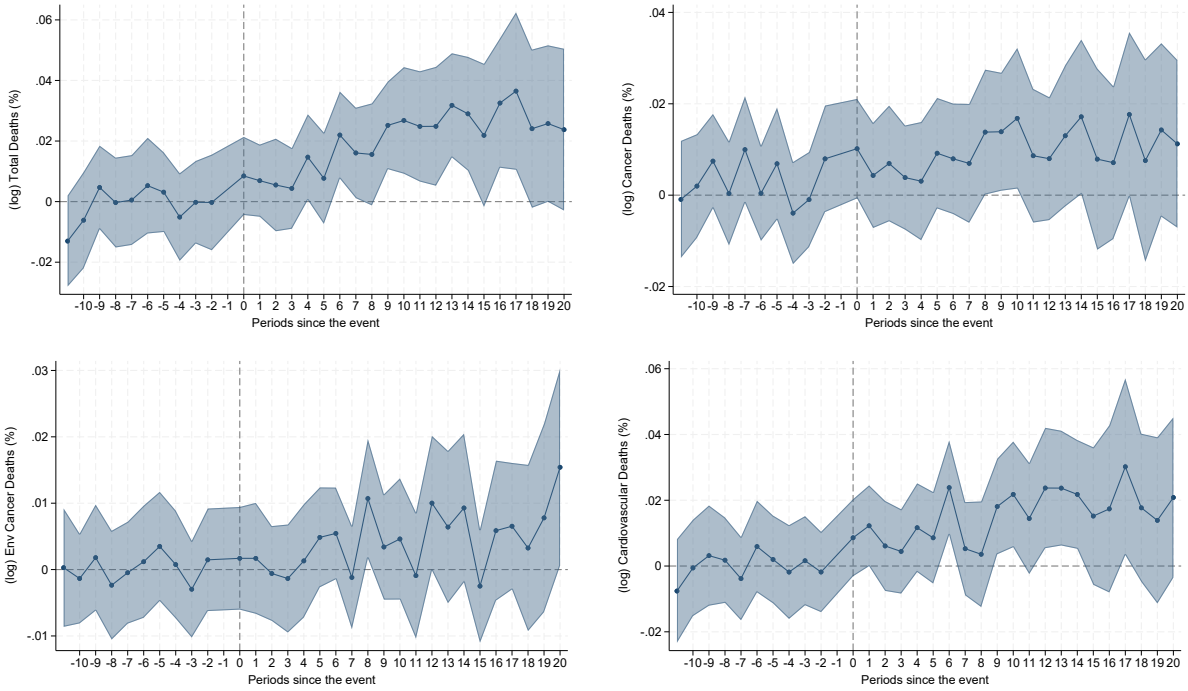
where Y_{it} denotes the outcome of interest in municipality i and year t, α_i are municipality fixed effects, and λ_t are year fixed effects. The coefficients δ_k trace the evolution of the outcome in event time relative to the year immediately preceding treatment ($k = -1$), which is omitted as the reference period. X_{it} is a vector of time-varying municipal controls, including population density, the shares of residents aged below 15, between 35 and 64, between 65 and 75, and above 75, and indicators for the presence of open local energy plants by technology type: coal, oil and gas, wind, hydroelectric, bioenergy, geothermal, and nuclear. Standard errors are clustered at the municipality level.

In the baseline specification, I estimate treatment effects using the estimator proposed by Callaway & Sant'Anna (2021). This estimator is well suited to the present setting because treatment timing varies across municipalities and treatment effects may be heterogeneous both across cohorts and over event time. In such environments, conventional two-way fixed-effects estimators may yield difficult-to-interpret estimates, since already treated municipalities can act as controls for later-treated municipalities. Callaway & Sant'Anna (2021) instead identify group-time average treatment effects by comparing each treated cohort only to municipalities that are not yet treated, thereby delivering treatment-effect estimates that remain well defined under staggered adoption and can be transparently aggregated into overall and dynamic ATT parameters.

For these estimates to admit a causal interpretation, treated and control municipalities must have followed similar outcome paths in the absence of treatment. I assess the plausibility of this parallel-trends assumption by inspecting pre-treatment event-study coefficients and by comparing the evolution of outcomes in treated and control municipalities prior to first recorded exposure. Figure 2 reports these comparisons for the main outcomes—the log mortality rates for total mortality, malignant cancers, environmentally

mediated cancers, and cardiovascular diseases—and suggests that treated and control municipalities followed similar trends before treatment.

Figure 2: Dynamic Treatment Effects



Notes: The figure plots dynamic average treatment effects and 95% confidence intervals estimated using the method of Callaway & Sant'Anna (2021). Coefficients are reported relative to the year prior to treatment, $k = -1$. Outcomes are log mortality percentages, where mortality percentages are defined as deaths per 100 residents. The panels report, from top left to bottom right, total mortality, malignant cancer mortality, environmentally mediated cancer mortality, and cardiovascular mortality.

A further issue is that the effects of environmentally harmful waste crimes may not be confined to the municipality in which the crime is observed. This is particularly plausible for the studied crimes, since the resulting pollutants can spread through the air, soil, and groundwater and may therefore affect nearby municipalities as well. Consistent with this view, the environmental-health literature documents adverse health risks for populations living near waste-burning facilities and hazardous waste sites, and highlights the role of proximity and contaminant migration in shaping exposure. This possibility also motivates my choice not to include fine-grained space-time fixed effects in the baseline specification, since these could absorb part of the relevant treatment variation if neighboring municipalities are themselves indirectly exposed. I therefore estimate alternative specifications in which treatment is defined using buffers around the centroid of the treated municipality. These specifications test whether the impacts of waste crimes spill over across municipal boundaries.

5 Results

5.1 Crimes Increase Mortality

Table 3 reports the baseline estimates for the main health outcomes based on Equation 1. Recorded exposure to an environmentally harmful waste crime increases total mortality by about 2%, cancer mortality by about 1%, and cardiovascular mortality by about 1.5%. The coefficient on environmentally mediated cancers is positive but smaller and statistically insignificant, which is perhaps unsurprising given that this outcome includes only five specific cancer sites and is therefore substantially less frequent than overall cancer mortality. Column (5) reports estimates for a placebo outcome based on unrelated deaths and yields a coefficient close to zero, which helps rule out the concern that treatment is simply capturing a general deterioration in mortality unrelated to environmental exposure.

To gauge magnitudes, it is useful to compare these estimates with pre-treatment mortality levels in treated municipalities reported in the table. In the year before treatment, the average total mortality rate in treated municipalities is 957 deaths per 100,000 residents, while the corresponding cancer mortality rate is 248 per 100,000. Interpreting the coefficients as semi-elasticities, the estimates imply an increase of approximately 18 deaths per 100,000 residents per year for total mortality and about 2.3 deaths per 100,000 residents per year for cancer mortality.

The magnitude of these estimates is smaller than the excess risks reported in prominent epidemiological studies of the Campania "Land of Fires." For example, Martuzzi *et al.* (2009a) report that municipalities in the highest waste-exposure category exhibit approximately 9–12% higher all-cause mortality and 4–7% higher all-cancer mortality than municipalities in the lowest category. The sign and relative magnitude of these estimates are consistent with the effects documented here, although direct comparisons should be interpreted cautiously. Existing studies largely rely on correlational comparisons within highly contaminated hotspot areas, whereas the present paper identifies mortality effects using staggered treatment timing across the universe of Italian municipalities and across crimes of heterogeneous intensity. The estimates reported here are therefore best interpreted as average causal effects across a broad range of contexts, rather than as the effects of residence in the most severely exposed areas.

Through Figure 2 we can also examine the dynamic evolution of these effects and notice substantial heterogeneity across outcomes. Total mortality becomes significantly different from zero about 6–10 years after treatment and continues to increase thereafter. Cancer mortality displays a more delayed and less stable pattern: it becomes statistically

Table 3: Main Results: Mortality Outcomes

	(1) (log) Tot Deaths (%)	(2) (log) Cancer Deaths (%)	(3) (log) Env Cancer Deaths (%)	(4) (log) Cardiovascular Deaths (%)	(5) (log) Unrelated Deaths (%)
Post $*$ Treated	0.0191***	0.0093**	0.0034	0.0150***	0.0010
	(0.0058)	(0.0047)	(0.0032)	(0.0058)	(0.0021)
N	308211	308472	308472	308472	308472
Mean Mortality Rate	957.19	247.64	85.03	385.29	41.57
Year FE	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes

Notes: The table reports average treatment effects of recorded exposure to environmentally harmful waste crimes, estimated using the method of Callaway & Sant'Anna (2021). The dependent variables are log mortality percentages, where mortality percentages are defined as deaths per 100 residents. The treatment indicator equals one from the year of first recorded exposure onward. All specifications include municipality and year fixed effects, demographic controls, population density, and indicators for the presence of open local energy plants by technology type. Standard errors, clustered at the municipality level, are reported in parentheses. Column (5) reports a placebo outcome unlikely to be affected by environmental exposure. For ease of interpretation, mean pre-treatment mortality rates for treated municipalities are reported in levels as deaths per 100,000 residents. ***, **, and * denote statistical significance at the 1, 5, and 10 percent levels, respectively.

significant roughly eight to ten years after treatment, before losing precision at longer horizons. Cardiovascular mortality shows an earlier response, becoming significant around six years after treatment and again over the nine- to fifteen-year horizon. These dynamic patterns are broadly consistent with the medical literature, which emphasizes that the health consequences of exposure to toxic pollutants—and cancer outcomes in particular—may emerge only after several years. By contrast, the estimates for environmentally mediated cancers remain imprecise throughout the event window.

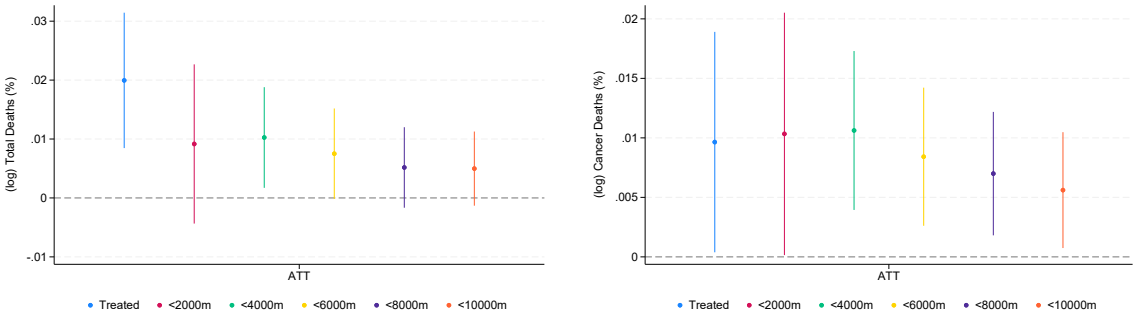
5.2 Crimes Affect Neighbouring Communities

Defining treatment at the municipality level may understate the spatial reach of environmentally harmful waste crimes, since pollutants can propagate through air, soil, and water beyond administrative borders. To address this issue, Figure 3 compares the estimated effects on total mortality and cancer mortality across alternative treatment definitions based on buffers around the centroid of the treated municipality, ranging from the baseline specification to a radius of 10 kilometers.

For total mortality, estimated effects decline monotonically as the treatment radius expands. In particular, the coefficient is roughly halved when moving from the baseline municipality-based definition to a buffer of 2 kilometers, and continues to shrink as the radius increases. Confidence intervals also become narrower, consistent with the larger number of municipalities classified as treated under wider buffers. The estimates become statistically insignificant once the treatment radius reaches 6 kilometers.

The pattern is different for cancer mortality. Although the estimated coefficients also decline with distance, they remain statistically significant even when treatment is defined using a radius of 10 kilometers. This contrast is informative. It suggests that the increase in cancer mortality is more spatially persistent than the increase in total mortality, and therefore more tightly linked to the environmental consequences of waste mismanagement. Even at wider radii, the estimated cancer effects remain above one half of the baseline

Figure 3: Coefficients for Different Treatment Buffers



Notes: The figure reports average treatment effects on log mortality percentages under alternative treatment definitions based on distance buffers around treated municipalities. Mortality percentages are defined as deaths per 100 residents. The baseline specification defines treatment at the municipality level, while alternative specifications classify municipalities as treated if they lie within the indicated radius of a treated municipality. Points denote estimated coefficients and vertical bars represent 95% confidence intervals. Estimates are obtained using the method of Callaway & Sant'Anna (2021).

municipality-level estimate.

This evidence also supports the baseline choice not to saturate the specification with location-by-time fixed effects. If the consequences of waste mismanagement crimes spill over across nearby municipalities, then a specification that absorbs local time variation may inadvertently net out part of the relevant treatment contrast.

5.3 Aggregate Mortality Burden and Social Costs

The baseline estimate implies approximately 18.5 additional deaths per 100,000 exposed residents per year. The 212 treated municipalities have an average pre-treatment population of approximately 48,800 residents, implying about 1,900 additional deaths in a year in which all treated municipalities are exposed. Since each treated municipality contributes an average of approximately 17 post-treatment years, the estimates imply roughly 32,500 additional deaths across all observed post-treatment municipality-years. Annualized over the 40-year sample period, this corresponds to approximately 810 additional deaths per year.

I monetize this mortality burden using the OECD value of a statistical life adjusted to the Italian context, equal to approximately €4.8 million in 2022 prices (OECD, 2025). This implies an average annual mortality cost of approximately €3.9 billion, or 0.20% of Italian GDP in 2022 (Istat, 2023). This figure captures only the welfare cost associated with excess mortality. It excludes non-fatal illness, health-care expenditure, productivity losses, environmental remediation, and damages to ecosystems and local amenities, and should therefore be interpreted as a partial measure of the social costs of environmentally

harmful waste crimes.

For comparison, total environmental protection expenditure in Italy amounted to approximately €51 billion in 2022, or 2.5% of GDP (ISPRA, 2025). The estimated annual mortality cost of waste crime is therefore equivalent to approximately 8% of total national environmental protection expenditure. Although the two quantities measure different objects, the comparison provides a useful indication of economic magnitude.

Using the alternative 10-kilometer treatment definition yields approximately 460 additional deaths per year, corresponding to an annual mortality cost of around €2.2 billion, or 0.11% of Italian GDP. The lower estimate reflects the decline in the treatment coefficient as the exposure radius expands, which more than offsets the increase in the population classified as exposed. Across the two treatment definitions, the implied annual mortality costs therefore range from approximately €2.2 billion to €3.9 billion.

6 Robustness Checks

This section presents several robustness checks aimed at assessing the validity of the baseline estimates.

First, one may be concerned that the baseline specification omits local economic conditions that are important determinants of health. To address this concern, Table 4 reports estimates that additionally control for municipal income per capita. Because income data are available only from 2000 onward, all regressions in the table are estimated on the post-2000 sample. Panel B reports the baseline specification on this restricted sample, which already includes controls for the presence of open local energy plants, while Panel A adds municipal income per capita.

Relative to the full-sample baseline, coefficients are smaller in the post-2000 sample, consistent with the shorter post-treatment horizon and the reduced number of treatment events (Panel B). Comparing across panels, however, shows that adding income leads to only a modest further attenuation of the estimates-by roughly 5-20%. Overall, the results remain qualitatively unchanged, suggesting that the baseline findings are not driven by omitted variation in local economic conditions.

This specification also partly addresses concerns that the results may be driven by earlier-treated municipalities. However, in this setting treatment timing is mechanically linked to the length of the post-treatment window: earlier-treated municipalities can be followed for longer after recorded exposure, while later-treated municipalities necessarily contribute shorter post-treatment periods. For this reason, I interpret Table 4 as a robustness check for the more recent sample, rather than as a clean test of heterogeneity by

treatment timing.

Table 4: Robustness: Controlling for Income

Panel A: Controlling for Income					
	(1)	(2)	(3)	(4)	(5)
	(log) Tot Deaths (%)	(log) Cancer Deaths (%)	(log) Env Cancer Deaths (%)	(log) Cardiovascular Deaths (%)	(log) Unrelated Deaths (%)
Post ∗ Treated	0.0091	0.0053	0.0024	0.0063	0.0000
	(0.0065)	(0.0055)	(0.0038)	(0.0062)	(0.0025)
N	169603	169712	169712	169712	169712
Mean Mortality Rate	974.16	249.96	84.01	387.36	40.70
Year FE	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes
Panel B: W/o Controlling for Income					
	(1)	(2)	(3)	(4)	(5)
	(log) Tot Deaths (%)	(log) Cancer Deaths (%)	(log) Env Cancer Deaths (%)	(log) Cardiovascular Deaths (%)	(log) Unrelated Deaths (%)
Post ∗ Treated	0.0112*	0.0058	0.0026	0.0083	0.0001
	(0.0065)	(0.0055)	(0.0038)	(0.0062)	(0.0024)
N	169627	169736	169736	169736	169736
Mean Mortality Rate	972.61	250.20	84.08	386.38	40.71
Year FE	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes

Notes: The table reports robustness checks controlling for municipal income. All regressions are estimated on the post-2000 sample. Panel B reports the baseline specification, which includes municipality and year fixed effects, demographic controls, population density, and indicators for the presence of open local energy plants. Panel A additionally controls for municipal income per capita. The dependent variables are log mortality percentages, where mortality percentages are defined as deaths per 100 residents. For ease of interpretation, mean pre-treatment mortality rates for treated municipalities are reported in levels as deaths per 100,000 residents. Standard errors, clustered at the municipality level, are reported in parentheses. ***, **, and * denote statistical significance at the 1, 5, and 10 percent levels, respectively.

Second, results may depend on how the municipality affected by the crime is identified from the underlying textual sources. In many cases, the documents do not report the location of environmental impact in a perfectly standardized way, so assigning treatment requires some degree of interpretation. In the baseline classification, I assign treatment when the text provides sufficiently clear evidence that the crime generated environmental consequences in a given municipality, even if the location of impact is not stated in fully explicit terms. I then assess the sensitivity of the results to two alternative coding rules. Under a looser definition, treatment is assigned whenever the text points to a municipality as the likely location of environmental crime. Under a stricter definition, treatment is assigned only when the text explicitly identifies the municipality in which the environmental impact occurred. Table 5 reports the corresponding estimates. Reassuringly, the main results remain qualitatively similar across these alternative definitions, suggesting that the findings are not driven by a particular interpretation threshold in the text-classification procedure. In particular, the estimates for total mortality remain statistically significant across specifications, while those for cancer mortality remain marginally significant at conventional levels.

Third, one may worry that the baseline treatment indicator captures only a relatively small subset of environmentally harmful waste crimes, and that the estimated effects may therefore reflect chance rather than systematic exposure. To address this concern, I implement a random-treatment placebo exercise. I construct 50 placebo treatment assignments, each preserving the total number of treated municipalities observed in the actual

Table 5: Robustness: Alternative Definitions of Treatment

Panel A: Looser Treatment					
	(1)	(2)	(3)	(4)	(5)
	(log) Tot Deaths (%)	(log) Cancer Deaths (%)	(log) Env Cancer Deaths (%)	(log) Cardiovascular Deaths (%)	(log) Unrelated Deaths (%)
Post ∗ Treated	0.0186***	0.0060	0.0017	0.0162***	0.0027
	(0.0048)	(0.0040)	(0.0026)	(0.0045)	(0.0018)
N	308205	308466	308466	308466	308466
Mean Mortality Rate	969.12	254.97	86.40	384.14	40.81
Year FE	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes
Panel B: Stricter Treatment					
	(1)	(2)	(3)	(4)	(5)
	(log) Tot Deaths (%)	(log) Cancer Deaths (%)	(log) Env Cancer Deaths (%)	(log) Cardiovascular Deaths (%)	(log) Unrelated Deaths (%)
Post ∗ Treated	0.0133**	0.0084	0.0037	0.0029	0.0011
	(0.0066)	(0.0055)	(0.0038)	(0.0058)	(0.0024)
N	308231	308492	308492	308492	308492
Mean Mortality Rate	945.77	245.73	82.33	380.48	40.11
Year FE	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes

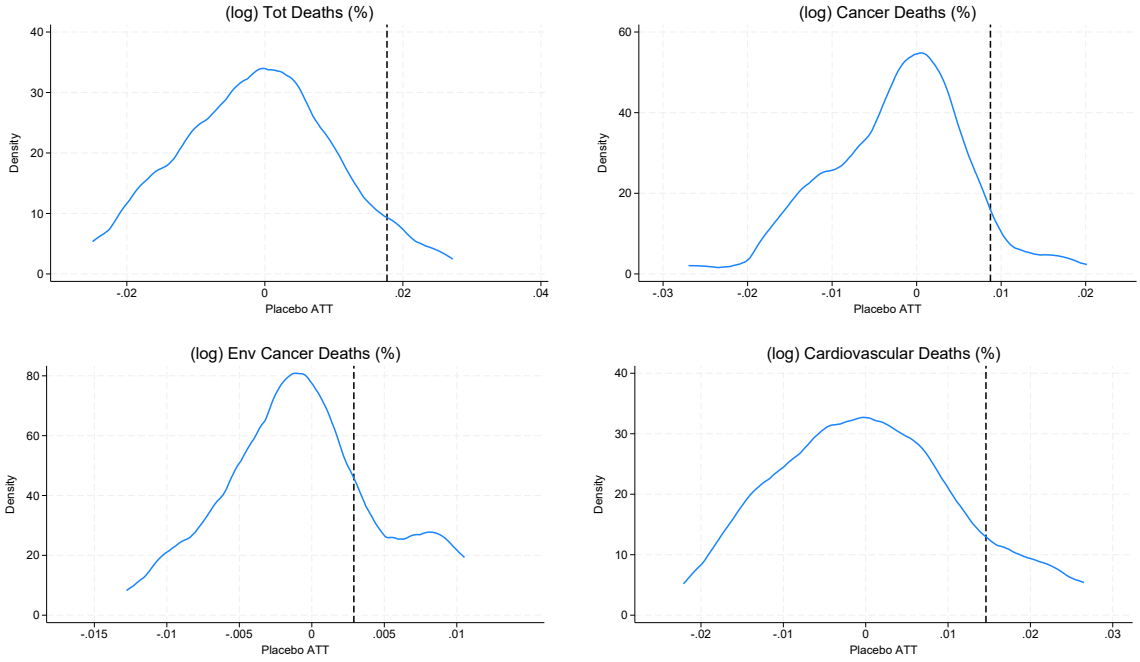
Notes: The table reports robustness checks using alternative definitions of treatment assignment. Panel A uses a looser definition, assigning treatment when the text points to a municipality as the likely location of environmental crime. Panel B uses a stricter definition, assigning treatment only when the text explicitly identifies the municipality in which the environmental impact occurred. The dependent variables are log mortality percentages, where mortality percentages are defined as deaths per 100 residents. For ease of interpretation, mean pre-treatment mortality rates for treated municipalities are reported in levels as deaths per 100,000 residents. All specifications include municipality and year fixed effects, demographic controls, population density, and indicators for the presence of open local energy plants. Standard errors, clustered at the municipality level, are reported in parentheses. ***, **, and * denote statistical significance at the 1, 5, and 10 percent levels, respectively.

data, while randomly reallocating treatment across municipalities and years. By doing so, the placebo procedure removes the systematic relationship between actual exposure and treatment status, while maintaining the same overall treatment intensity as in the baseline analysis. I then estimate the baseline specification separately for each placebo assignment. If the main results were driven by chance, one would expect the placebo estimates to be similar in magnitude to the baseline estimate; instead, systematically smaller or statistically insignificant placebo effects would support the interpretation that the baseline findings reflect recorded exposure rather than random variation.

Figure 4 reports the distribution of placebo average treatment effects obtained from 50 random-treatment assignments. For each outcome, the placebo estimates are generally centered around zero, indicating that randomly reallocating treatment across municipalities and years does not reproduce the systematic mortality patterns observed in the baseline analysis. The vertical dashed line reports the estimate obtained using the actual treatment assignment. In all panels, the actual estimate is located in the right tail of the placebo distribution, lying above the bulk of estimates generated under random assignment. This indicates that the baseline effects are larger than those typically produced by random treatment reassignment. Taken together, these results provide reassurance that the baseline findings are unlikely to be an artifact of chance treatment assignment.

A further concern is that the baseline estimates may be driven by municipalities exposed to multiple recorded environmentally harmful waste crimes, which may differ from municipalities with only one recorded environmentally harmful waste crime. This is rele-

Figure 4: Robustness: Random Treatments



Notes: The figure reports the distribution of placebo average treatment effects obtained from 50 random-treatment assignments. In each placebo iteration, the total number of treated municipalities is kept equal to the true number of treated municipalities, while treatment is randomly reallocated across municipalities and years. The baseline specification is then re-estimated using each placebo treatment assignment. The blue line plots the density of the resulting placebo ATT estimates, while the vertical dashed line indicates the corresponding estimate obtained using the actual treatment assignment. Outcomes are log mortality percentages, where mortality percentages are defined as deaths per 100 residents. The panels report, from top left to bottom right, total mortality, malignant cancer mortality, environmentally mediated cancer mortality, and cardiovascular mortality.

vant because municipalities with repeated recorded exposure are more likely to have underlying characteristics associated with a higher propensity for waste-crime activity. To assess this issue, Appendix Table A3 re-estimates the baseline specification separately for municipalities exposed to a single recorded waste crime and for municipalities exposed to multiple recorded crimes.

The results are reassuring. The estimated effects remain positive in both samples for the main mortality outcomes. Among municipalities exposed only once, the coefficients are positive for total mortality, cancer mortality, environmentally mediated cancer mortality, and cardiovascular mortality, with statistically significant effects for cancer and cardiovascular deaths, and borderline significant for total deaths ($p = 0.137$). Among municipalities exposed multiple times, the effect on total mortality is larger and statistically significant, while the coefficient for cardiovascular mortality is very similar to the single-treatment estimate. In both samples, the coefficient on unrelated deaths is close to zero. These results suggest that the baseline findings are not solely driven by municipalities with repeated exposure, although the stronger total-mortality effect among repeatedly treated municipalities is consistent with more intense local exposure producing larger health effects.

7 Conclusions

Environmental regulation imposes visible costs on firms and governments, while many of its benefits take the less observable form of environmental and health damages prevented through compliance. This paper sheds light on these benefits by studying what happens when regulated waste-management channels are circumvented. Using a novel dataset constructed from police investigations, environmental organizations, and Supreme Court rulings, I find that recorded exposure to environmentally harmful waste crimes increases total mortality by approximately 2%, cancer mortality by about 1%, and cardiovascular mortality by about 1.5%. At pre-treatment mortality levels, the estimate for total mortality corresponds to roughly 18.5 additional deaths per 100,000 exposed residents per year. The effects emerge with delay and extend beyond the municipality in which the crime is recorded, indicating that the resulting health damages are persistent and spatially diffuse.

These estimates translate into economically substantial aggregate losses. Across the observed post-treatment municipality-years, the baseline estimates imply approximately 32,500 additional deaths. Annualized over the 40-year sample period, this corresponds to roughly 810 additional deaths per year. Valuing these deaths using the OECD value of a statistical life adjusted to the Italian context yields an average annual mortality cost

of approximately €3.9 billion, equivalent to 0.20% of Italian GDP in 2022. This amount corresponds to approximately 8% of Italy's total environmental protection expenditure in the same year (ISPRA, 2025). Although this comparison does not constitute a complete cost-benefit analysis, it shows that the mortality damages generated by waste crime are large relative to economically meaningful national aggregates. Moreover, because the calculations exclude morbidity, health-care expenditure, productivity losses, environmental remediation, and ecological damage, they provide only a partial measure of the resulting social costs.

The findings show that non-compliance with environmental regulation is not merely a procedural or enforcement failure. When waste is diverted from authorized channels, private actors retain the savings from unlawful disposal while transferring the resulting health costs to surrounding communities, including residents outside the municipality in which the offense is formally recorded. This raises broader questions about the distribution and persistence of environmental harm. Future research could examine whether these costs are disproportionately borne by poorer or institutionally weaker communities and whether exposure affects human-capital accumulation, educational achievement, residential choices, property values, and local economic development. It would also be particularly valuable to study the firms involved in these activities. Many appear to operate in a gray area between the formal and illegal economies, participating in otherwise legal production and waste-management chains while circumventing environmental rules at particular stages of the disposal process. Understanding their characteristics, their relationships with local governments and organized crime, and the competitive advantages they obtain by avoiding lawful disposal costs would shed light on how environmental crime is organized and how it distorts markets.

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Appendix

A Additional Figures and Tables

Table A1: Descriptive statistics: Late vs Early Treated

Variable	(1) Early T	(2) Late T	(3) Δ
Income per capita	12313.030	12268.918	-44.112
	(2661.230)	(2605.432)	(366.791)
Population	94734.438	13819.009	-8.09e+04**
	(3.53e+05)	(14645.157)	(35447.539)
Pop Density	816.219	372.984	-443.235**
	(1828.550)	(850.290)	(200.528)
Share (0,14)	0.220	0.210	-0.010
	(0.050)	(0.053)	(0.007)
Share (15,34)	0.298	0.291	-0.006
	(0.029)	(0.033)	(0.004)
Share (45,64)	0.227	0.233	0.005
	(0.035)	(0.037)	(0.005)
Share (65,75)	0.088	0.093	0.005
	(0.031)	(0.030)	(0.004)
Share >75	0.042	0.047	0.006*
	(0.020)	(0.022)	(0.003)
Beds for Acute Hosp	487.091	31.761	-455.330**
	(1767.058)	(76.151)	(177.681)
Beds for Long-Term Hosp	15.657	2.389	-13.267**
	(63.590)	(9.468)	(6.451)
Beds for Rehab	55.141	3.823	-51.318*
	(286.488)	(18.692)	(28.837)
Tot Deaths (%)	0.908	0.981	0.073
	(0.326)	(0.351)	(0.047)
Cancer Deaths (%)	0.192	0.221	0.030*
	(0.097)	(0.127)	(0.016)
Env Cancer Deaths (%)	0.078	0.088	0.010
	(0.062)	(0.067)	(0.009)
Cardiovascular Deaths (%)	0.425	0.460	0.035
	(0.207)	(0.195)	(0.028)
Unrelated Deaths (%)	0.045	0.049	0.004
	(0.032)	(0.042)	(0.005)
Coal Plants	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Oil & Gas Plants	0.010	0.035	0.025
	(0.101)	(0.297)	(0.030)
Wind Farms	0.051	0.035	-0.015
	(0.220)	(0.186)	(0.028)
Hydropower Plants	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
North	0.263	0.416	0.153**
	(0.442)	(0.495)	(0.064)
Centre	0.222	0.159	-0.063
	(0.418)	(0.368)	(0.054)
South	0.515	0.425	-0.090
	(0.502)	(0.497)	(0.069)
Mafia Regions	0.404	0.336	-0.068
	(0.493)	(0.475)	(0.067)
City Council Dismissed for Mafia	0.091	0.133	0.042
	(0.289)	(0.341)	(0.043)
Assigned Mafia-Seized Firms	0.004	0.003	-0.001
	(0.012)	(0.011)	(0.002)
Assigned Mafia-Seized Buildings/Land	0.091	0.079	-0.012
	(0.298)	(0.198)	(0.035)
Turnout 1974 Referendum	84.799	84.800	0.001
	(9.872)	(12.607)	(1.629)
Non-Profit Associations (2001)	0.419	0.393	-0.025
	(0.226)	(0.168)	(0.028)
Non-Profit Employees (2001)	0.606	0.554	-0.052
	(0.746)	(0.789)	(0.107)
City Max Heigth	647.010	513.133	-133.877*
	(639.006)	(515.355)	(80.458)
City Average Heigth	275.660	219.472	-56.188
	(346.345)	(240.046)	(41.486)
City Heigth Range	540.212	433.522	-106.690
	(522.074)	(450.160)	(67.422)
Municipal Fragility Index (0-10)	5.081	4.761	-0.320
	(2.863)	(3.013)	(0.404)
Unsorted waste per capita	181.267	148.063	-33.204**
	(133.655)	(97.509)	(16.264)
Protected area share (%)	14.096	11.854	-2.242
	(20.885)	(19.243)	(2.772)
Landslide risk area share (%)	8.579	5.429	-3.150*
	(14.014)	(8.942)	(1.640)
Artificial land cover share (%)	15.818	12.830	-2.988*
	(14.587)	(10.947)	(1.791)

Notes: Columns (1) and (2) report mean values for early (pre-2006) and late (post-2006) municipalities, respectively. Column (3) shows the raw difference in means between (2) and (1). Robust standard errors are reported in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels, respectively. *Treated* equals one for municipalities with at least one recorded environmentally harmful waste mismanagement crime crime during the sample period. All variables are measured in 1981 or, if not available in that year, in the first year in which they are observed. Income per capita is defined as total municipal net income divided by the number of taxable individuals and is first available in 2000. The *Share* variables denote the share of residents in each age group relative to total municipal population. Hospital-bed variables are first available in 2009. The *Deaths* variables are measured as deaths divided by the resident population in the previous year and are winsorized at the 2nd and 98th percentiles, as some values are implausibly high relative to the national mortality statistics reported by ISTAT. *North*, *Centre*, and *South* are macro-area indicators, while *Mafia Regions* identifies municipalities located in Campania, Puglia, Calabria, and Sicily.

Table A2: Descriptive statistics: Multiple vs Single Treated

Variable	(1) Single T	(2) Mult. T	(3) Δ
Income per capita	12044.045	12161.406	117.361
	(2509.191)	(2721.715)	(244.266)
Population	6172.185	11867.904	5695.720***
	(43436.594)	(14151.704)	(1353.531)
Pop Density	240.716	469.146	228.429**
	(577.338)	(1255.060)	(111.582)
Share (0,14)	0.190	0.208	0.018***
	(0.049)	(0.048)	(0.004)
Share (15,34)	0.281	0.292	0.010***
	(0.043)	(0.031)	(0.003)
Share (45,64)	0.244	0.235	-0.009***
	(0.038)	(0.035)	(0.003)
Share (65,75)	0.108	0.094	-0.014***
	(0.040)	(0.030)	(0.003)
Share >75	0.056	0.046	-0.010***
	(0.029)	(0.021)	(0.002)
Beds for Acute Hosp	21.122	29.772	8.650
	(231.841)	(89.767)	(8.379)
Beds for Long-Term Hosp	1.170	1.661	0.492
	(11.435)	(7.930)	(0.713)
Beds for Rehab	2.960	3.819	0.858
	(37.456)	(19.630)	(1.789)
Tot Deaths (%)	1.212	0.994	-0.218***
	(0.546)	(0.374)	(0.034)
Cancer Deaths (%)	0.244	0.222	-0.022*
	(0.171)	(0.127)	(0.012)
Env Cancer Deaths (%)	0.095	0.090	-0.004
	(0.091)	(0.070)	(0.006)
Cardiovascular Deaths (%)	0.557	0.464	-0.093***
	(0.317)	(0.228)	(0.021)
Unrelated Deaths (%)	0.057	0.047	-0.010***
	(0.065)	(0.037)	(0.003)
Coal Plants	0.000	0.000	-0.000
	(0.012)	(0.000)	(0.000)
Oil & Gas Plants	0.007	0.000	-0.007***
	(0.123)	(0.000)	(0.001)
Wind Farms	0.014	0.047	0.033*
	(0.181)	(0.213)	(0.019)
Hydropower Plants	0.006	0.000	-0.006***
	(0.083)	(0.000)	(0.001)
North	0.566	0.417	-0.149***
	(0.496)	(0.495)	(0.044)
Centre	0.118	0.157	0.039
	(0.323)	(0.366)	(0.033)
South	0.316	0.425	0.109**
	(0.465)	(0.496)	(0.044)
Mafia Regions	0.194	0.339	0.144***
	(0.396)	(0.475)	(0.042)
City Council Dismissed for Mafia	0.028	0.110	0.082***
	(0.166)	(0.314)	(0.028)
Assigned Mafia-Seized Firms	0.001	0.003	0.002**
	(0.008)	(0.012)	(0.001)
Assigned Mafia-Seized Buildings/Land	0.037	0.080	0.043**
	(0.475)	(0.223)	(0.021)
Turnout 1974 Referendum	85.104	84.489	-0.614
	(10.329)	(12.843)	(1.199)
Non-Profit Associations (2001)	0.558	0.418	-0.140***
	(0.429)	(0.210)	(0.019)
Non-Profit Employees (2001)	0.505	0.514	0.009
	(2.263)	(0.845)	(0.080)
City Max Heigth	875.546	569.953	-305.593***
	(803.033)	(605.147)	(54.300)
City Average Heigth	471.767	267.378	-204.389***
	(458.242)	(328.900)	(29.557)
City Heigth Range	658.583	464.071	-194.512***
	(647.904)	(488.272)	(43.813)
Municipal Fragility Index (0-10)	5.040	4.858	-0.182
	(2.876)	(3.078)	(0.274)
Unsorted waste per capita	145.850	157.698	11.848
	(110.747)	(134.852)	(11.990)
Protected area share (%)	16.587	12.393	-4.194**
	(25.674)	(20.194)	(1.810)
Landslide risk area share (%)	8.917	7.436	-1.481
	(14.516)	(12.883)	(1.151)
Artificial land cover share (%)	9.753	13.251	3.498***
	(10.000)	(12.020)	(1.069)

Notes: Columns (1) and (2) report mean values for single treated and multiple municipalities, respectively. Column (3) shows the raw difference in means between (2) and (1). Robust standard errors are reported in parentheses. ***, **, and * indicate significance at the 1, 5, and 10% levels, respectively. *Treated* equals one for municipalities with at least one recorded environmentally harmful waste mismanagement crime crime during the sample period. All variables are measured in 1981 or, if not available in that year, in the first year in which they are observed. Income per capita is defined as total municipal net income divided by the number of taxable individuals and is first available in 2000. The *Share* variables denote the share of residents in each age group relative to total municipal population. Hospital-bed variables are first available in 2009. The *Deaths* variables are measured as deaths divided by the resident population in the previous year and are winsorized at the 2nd and 98th percentiles, as some values are implausibly high relative to the national mortality statistics reported by ISTAT. *North*, *Centre*, and *South* are macro-area indicators, while *Mafia Regions* identifies municipalities located in Campania, Puglia, Calabria, and Sicily.

Table A3: Robustness: Treatment Intensity

Panel A: Single Treatment

	(1) (log) Tot Deaths (%)	(2) (log) Cancer Deaths (%)	(3) (log) Env Cancer Deaths (%)	(4) (log) Cardiovascular Deaths (%)	(5) (log) Unrelated Deaths (%)
Post $*$ Treated	0.0128	0.0128*	0.0043	0.0145*	0.0011
	(0.0086)	(0.0065)	(0.0048)	(0.0081)	(0.0032)
N	304592	304852	304852	304852	304852
Mean Mortality Rate	1000.21	252.15	85.67	393.81	41.20
Year FE	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes

Panel B: Multiple Treatment

	(1) (log) Tot Deaths (%)	(2) (log) Cancer Deaths (%)	(3) (log) Env Cancer Deaths (%)	(4) (log) Cardiovascular Deaths (%)	(5) (log) Unrelated Deaths (%)
Post $*$ Treated	0.0251***	0.0052	0.0007	0.0153*	0.0022
	(0.0082)	(0.0072)	(0.0043)	(0.0089)	(0.0030)
N	302278	302528	302528	302528	302528
Mean Mortality Rate	912.82	246.05	87.80	381.55	42.17
Year FE	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes

Notes: The table reports robustness checks by treatment intensity. Panel A restricts the estimation sample to control municipalities and municipalities with a single recorded environmentally harmful waste crime. Panel B restricts the estimation sample to control municipalities and municipalities with multiple recorded environmentally harmful waste crimes. Control municipalities are therefore included in both panels, while treated municipalities are split according to whether they experience one or more than one recorded treatment event. The dependent variables are log mortality percentages, where mortality percentages are defined as deaths per 100 residents. The treatment indicator equals one from the year of first recorded exposure onward. All specifications include municipality and year fixed effects, demographic controls, population density, and indicators for the presence of open local energy plants by technology type. For ease of interpretation, mean pre-treatment mortality rates for treated municipalities are reported in levels as deaths per 100,000 residents. Standard errors, clustered at the municipality level, are reported in parentheses. ***, **, and * denote statistical significance at the 1, 5, and 10 percent levels, respectively.