Cancer Mortality in an Area of Campania (Italy) Characterized by Multiple Toxic Dumping Sites

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ABSTRACT: Several recent studies have documented that a widespread practice of dumping toxic wastes has taken place for many years in the Provinces of Naples and Caserta. Extensive programs of environmental monitoring are currently ongoing in the area. In this frame, the Department of Civil Defence of the Italian Government has appointed an ad hoc study group in order to assess the health status of the population resident in the area of interest. The first investigation performed by the study group has been a geographic study on cancer mortality and occurrence of malformations in 196 municipalities constituting the two Provinces. The study detected an area located in the southeastern part of the Province

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of Caserta and in the northwestern part of the Province of Naples, where cancer mortality and congenital malformations show significantly increased rates with respect to expected figures derived from the regional population. The area highlighted by the study is, in general terms, overlapping with the area where most illegal dumping of toxic wastes took place. It is now recommended that mortality studies be extended to take into account other health outcomes, to search for correlations with environmental exposures, and consider possible confounding factors.

KEYWORDS: toxic wastes; dumping sites; cancer; malformations

INTRODUCTION

The possible health effects associated with residential proximity to waste disposal sites have been the object of many epidemiological studies over the last 20 years. Several reports of increased risk of different diseases are available, but causal links have not been adequately proven; for a comprehensive review the reader is referred to Vrijheid,1 who examines 50 papers published from 1980 through 1998. Difficulties of conducting epidemiological studies around waste disposal sites include exposure assessment, because many different chemicals released in the environment may be absorbed by contact, inhalation, and ingestion of food and water.2 Furthermore, the sites of interest are often located in areas characterized by other sources of environmental pollution, and the resident population is often sparse. Finally, some of the reported increases in risk are small, making their interpretation difficult.

Different study designs have been adopted in epidemiological studies of waste disposal sites. Ecological and geographical studies have reported increases in lung cancer risk in men3–5 and in women,5 bladder cancer in both sexes6,7 and in men only,3,5 leukemia,8 childhood leukemia,9 liver cancer in men,4 prostate cancer,4 gastric cancer in both sexes3 and in men only,4 uterine cancer,4 rectum cancer,3 breast cancer,3 perinatal mortality,10 and birth defects.10,11 Cohort studies have reported increases of low birth weight12,13 and birth defects.14–17 Case–control studies have reported increases in the risk of low birth weight,18 birth defects,19–21 bladder cancer, and leukemia in women,22 and cancer of the pancreas, liver, prostate, and non-Hodgkin’s lymphoma.23

The issue of possible health effects of waste disposal sites was specifically addressed in Campania, a Region of Southern Italy, where Naples is located. Since the 1980s, thousands of illegal and uncontrolled sites of urban, toxic, and industrial waste disposal, including land filling and unauthorized incineration, have been known to be active in this region (FIGS. 1 and 2). The issue of waste treatment in Campania has been constantly surrounded by controversy and social conflict, periodically making national headlines. Local communities are worried about severe health effects and express frustration over their compromised level of well-being and quality of life. A Commissioner appointed by the
FIGURE 1. Waste disposal site.

FIGURE 2. Treatment of waste that was illegally burnt.
national government and holding special power has held executive authority for waste treatment and disposal policy in the region since 1994. For a review, the reader is referred to the annual report on “Ecomafia.” A census of waste dumping sites has been made available by Campania Region’s Environmental Protection Agency since 2003.

Possible adverse health effects of the waste cycle in Campania were first investigated with respect to childhood cancer mortality in the Province of Caserta. More recently, two papers published in *Lancet Oncology* have addressed the question of waste and health in Campania. A first report identified a “triangle of death” consisting of three municipalities; subsequently, Bianchi et al. revealed a more complex picture and advocated a different and wider approach.

The Department of Civil Defence of the Italian Government requested the World Health Organization (WHO) to design and conduct an epidemiological study on the health impact of the waste cycle in Campania. To this end, a working group comprising WHO, National Research Council, Istituto Superiore di Sanità, Campania Region Health Authority Epidemiologic Observatory, and Campania Region Environmental Protection Agency was appointed, and a network of cooperation has been constructed with local health authorities, cancer and malformation registries, and environmental organizations. The working group was set up to include technical expertise, access to local information, and the ability to establish a dialogue with the numerous stakeholders involved.

The purpose of this article is to present the findings of the first phase of the study, concerning the distribution of cancer mortality and birth defects in the Provinces of Naples and Caserta, the part of Campania most severely affected by illegal waste dumping sites.

**MATERIALS AND METHODS**

**Mortality**

The geographical distribution of mortality in the 196 municipalities of the Provinces of Naples and Caserta, with a population of around 4 million people, was analyzed using data from ISTAT (National Bureau of Statistics); mortality records were provided by the Regional Epidemiological Observatory of Campania. A total of 20 causes of death were studied for the period 1994–2001, including all-cause mortality, all-cancer mortality, and a set of cancer causes reported in excess in previous epidemiological studies conducted in the surroundings of waste landfills or incinerators. Availability of such data at the municipality level, relatively small units on average with the exception of large cities, allows the analysis of risk variability by small area and in relation to the spatial occurrence of exposures produced by known sources. The analyses were carried out separately for men and women. At the provincial level, analyses
were carried out using standardized mortality rates with national reference and through standardized mortality ratios (SMRs) with regional reference. At the municipality level, analyses were carried out using SMRs, with 95% confidence intervals, and hierarchical Bayesian estimators (BMRs, and 95% uncertainty intervals), calculated as suggested by Besag et al.\textsuperscript{29} and Mollié.\textsuperscript{30} BMRs improve the quality of the risk estimates by removing part of the large random variability due to sparseness of data, and the possible “confounding by location” from unknown, spatially structured determinants.\textsuperscript{31} Risk estimates (SMRs and BMRs) were mapped at the municipality level.

**Congenital Malformations**

This component of the study is based on data recorded by the Campania Region Birth Defects Registry, which include data for the population residing in the Provinces of Naples and Caserta, 1996–2002. For a long time the Campania registry has been part of the EUROCAT & ICBDMS networks of Congenital anomalies.\textsuperscript{32,33} Cases have been ascertained at birth and during the postnatal period; fetal deaths after the 20th week and therapeutic abortion prior to week 24 have also been included. The number of observed birth defects in each municipality is contrasted to the corresponding number of expected cases based on regional demographic figures. As in the mortality analysis, both SMRs and BMRs are computed and mapped.

**RESULTS**

Results show that the cancer mortality profile of the area is characterized by numerous excesses, as summarized in Table 1. In the Province of Naples, 8 of 19 (42%) of all the risks that were estimated are in significant excess for men, and 11 of 19 (58%) for women. Excess risks range from 6.1% (mortality for all causes) to 32.9% (cancer of pleura) in men, and from 7.3% (all-cause mortality) to 27.3% (cancer of esophagus) in women. Fewer excesses were found for the Province of Caserta (16% for men, 11% for women) even though some risk estimates are high (cancer of the stomach: 29.3% for men, 18.2% for women). At the municipality level, results indicate the occurrence of increased risks for several causes of cancer death, in 11 municipalities of the southeastern part of the Province of Caserta and 13 adjacent municipalities of the northern part of the Province of Naples. In 19% of the municipalities of the Province of Caserta and in 43% of the municipalities of the Province of Naples all-cause mortality is statistically significantly elevated in men; in 23% of the municipalities of the Province of Caserta and in 47% of municipalities of the Province of Naples all-cause mortality is statistically significantly elevated in women (Fig. 3).

The specific cancer causes frequently in excess in these municipalities (cancer of the stomach, kidney, liver, trachea, bronchus and lung, pleura, bladder)
<table>
<thead>
<tr>
<th>Causes of death</th>
<th>Province of Naples</th>
<th>Province of Caserta</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>All-cause mortality</td>
<td>95,951</td>
<td>106.1*</td>
</tr>
<tr>
<td>All cancers</td>
<td>29,185</td>
<td>108.7*</td>
</tr>
<tr>
<td>All cancers (0–14)</td>
<td>137</td>
<td>101.9*</td>
</tr>
<tr>
<td>Cancer of the esophagus</td>
<td>262</td>
<td>98.8</td>
</tr>
<tr>
<td>Cancer of the stomach</td>
<td>1,696</td>
<td>100.3</td>
</tr>
<tr>
<td>Cancer of rectum</td>
<td>655</td>
<td>101.6</td>
</tr>
<tr>
<td>Cancer of the liver and biliar ducts</td>
<td>1,910</td>
<td>117.6*</td>
</tr>
<tr>
<td>Cancer of the pancreas</td>
<td>821</td>
<td>103.4</td>
</tr>
<tr>
<td>Cancer of the larynx</td>
<td>728</td>
<td>111.8*</td>
</tr>
<tr>
<td>Cancer of the trachea, bronchus, and lung</td>
<td>9,681</td>
<td>114.1*</td>
</tr>
<tr>
<td>Cancer of the pleura</td>
<td>212</td>
<td>132.9*</td>
</tr>
<tr>
<td>Soft Tissues Sarcoma</td>
<td>107</td>
<td>114.4</td>
</tr>
<tr>
<td>Cancer of the breast</td>
<td>3,475</td>
<td>110.7*</td>
</tr>
<tr>
<td>Cancer of the testis</td>
<td>34</td>
<td>93.8</td>
</tr>
<tr>
<td>Cancer of the bladder</td>
<td>1,745</td>
<td>110.7*</td>
</tr>
<tr>
<td>Cancer of the kidney</td>
<td>494</td>
<td>105.7</td>
</tr>
<tr>
<td>Cancer of the brain</td>
<td>526</td>
<td>98.6</td>
</tr>
<tr>
<td>Non-Hodgkin lymphomas</td>
<td>682</td>
<td>100</td>
</tr>
<tr>
<td>Leukemias</td>
<td>894</td>
<td>95.9</td>
</tr>
<tr>
<td>Ill-defined causes</td>
<td>2,860</td>
<td>125.4*</td>
</tr>
</tbody>
</table>

*lower limit of 95% confidence interval > 100.
FIGURE 3. Municipalities with significant excesses of mortality and congenital malformations and waste disposal sites in the provinces of Naples and Caserta.

Two sets of municipalities with significant excesses in the total of congenital malformations and on some specific groups were identified. First, the southern part of the Province of Caserta, where there are frequent excesses for congenital malformations overall and for the group of urogenital malformations; second, Naples and its northeastern neighboring municipalities, where there are frequent excesses for the total of congenital malformations, cardiovascular malformations and, to a lesser extent, urogenital malformations (Fig. 3).

DISCUSSION

Consistently with previously published data, residents in the Provinces of Naples and Caserta have cancer mortality significantly raised compared to the Campania region. Increased risks are observed for several cancers; similarly, the occurrence of congenital malformations is significantly in excess. The reliability of the malformation data collected, in terms of accuracy and completeness, is documented by the comparability of the Campania data with other European and International registries.

Analysis of mortality data by municipalities entails multiple comparison of observed counts with expected numbers of deaths. Even under the null
hypothesis of uniform risk across municipalities, using a 5% threshold for statistical significance would result in approximately 5% of the municipalities (around 10 of them) differing statistically from the null. However, even discounting for this proportion of spurious significance, the statistically significant large risks observed in the municipalities of the two provinces far exceed what can be expected by chance alone. In addition, BMRs remove substantial part of the random variability and are not subject to the inflation of statistically significant risk estimates due to multiple comparison. Thus, the occurrence of excesses is unlikely to be due to chance. On the other hand, the number of expected cases may be systematically overestimated, compared to the value of real interest, that is, the number of cases that would be expected in a situation of no exposure to environmental risk factors linked to waste management. Expected numbers were calculated using, as reference, the regional rates. These are based, in turn, on the data for the whole population of Campania, which includes the exposed areas and whose average exposure, therefore, is nonzero. Hence, it is likely that a comparison between exposed municipalities with unexposed ones, rather than with the regional average, could produce generally higher risk estimates.

Within the two Provinces, there is geographical variability in mortality across municipalities, by cause of cancer death. The distributions of these excesses might provide some indication as to the possible role of environmental exposures, in particular those associated with the cycle of waste treatment. Increased risks in cancer mortality tend to be more frequent in municipalities in the southern part of the Caserta Province and in the northern part of the Naples Province. A similar pattern is also shared by the distribution of risk of congenital malformations (Fig. 3). This similarity may be casual or may be explained, in part, by the presence of one or more risk factors occurring with more intensity in the area between the two Provinces. The area where municipalities at higher risk of mortality and congenital malformations aggregate overlaps with the presence of landfills and sites of uncontrolled disposal of waste (Fig. 3).

These recurring patterns of mortality and congenital malformations that were observed are suggestive, but the underlying complexity should be emphasized; concern is more than justified, even without the support from epidemiological findings, but oversimplifications are likely to result in sensationalism and be of little help in dispelling the social controversy.28

The Province of Caserta and some municipalities of the northern part of the Province of Naples show high rates of mortality from gastric cancer, a disease that is decreasing in industrialized societies, but still frequent in rural areas. The most important risk factors of gastric cancer are infection from Helicobacter pylori.35–37 A diet poor in fresh vegetables and fruit, and rich in salt and nitrates adds to gastric cancer risk,38–42 while occupational exposures do not seem to play an appreciable role.43 Increases in gastric cancer risk near landfills were reported by Griffith et al.3 and Goldberg et al.4 as previously mentioned.
The southern part of Caserta Province and some municipalities in the northern part of Naples Province show high mortality rates from kidney cancer. Tobacco smoking, diet, and some drugs have been associated with kidney cancer; among occupational risk factors an etiologic role has been suggested, but not confirmed, for combustion products, heavy metals, and solvents. An increased risk of renal cancer for the population resident in the neighborhood of landfills has been reported by Goldberg et al. Several municipalities in the southern part of Caserta Province and in the northern part of Naples Province are characterized by high mortality rates from liver cancer. Figures produced by the Naples Cancer Registry indicate a high occurrence of hepatocellular carcinoma in this area, where both B and C type hepatitis show high incidence rates. Exposure to hepatotoxic chemicals may have particularly strong adverse effects among subjects who are seropositives for hepatitis virus, as has recently been shown by Mastrangelo et al. with reference to vinyl chloride. An increased risk of liver cancer near landfills has been reported by Goldberg et al. Elevated mortality from lung cancer has been described in the southern part of Caserta Province and in the northern part of Naples Province. Tobacco smoking, and several occupational carcinogens (namely arsenic, asbestos, chromates, chloromethylethers, nickel, and polycyclic aromatic hydrocarbons) are established causes of lung cancer; recently the etiologic role of urban air pollution has been documented. An increased risk of lung cancer near landfills has been reported by Griffith et al., Goldberg et al., and Mitis et al. Several municipalities of the northwestern part of the Province of Naples have high mortality rates from pleural mesothelioma, which can be attributed to a variety of occupations with exposure to asbestos, which have been described in the area. High mortality from bladder cancer occurs in the south of Caserta Province and in the north of Naples Province. Cigarette smoking is the main cause of this disease, followed by occupational exposure to aromatic amines in textile and rubber industries and by exposure to solvents, paints, leather dust, inks, some metals, polycyclic aromatic hydrocarbons, combustion products, diesel exhaust, and environmental exposure to water chlorination. An increased risk of bladder cancer in areas close to landfills has been reported by Budnick et al., Griffith et al., Mallin, Lewis-Michl et al., and Mitis et al. The findings of the present study indicate the presence of an area characterized by elevated cancer mortality rates and by the elevated occurrence of birth defects, corresponding with the area where most waste disposal sites are concentrated. In the area under study, in addition, there are many environmental stressors, deriving from intensive agriculture, widespread industrial activities, and a very high population density. These preliminary findings are consistent with a possible contributory role of waste-related exposures in determining ill health in the area over time. The consistency of the patterns may reflect an effect on cancer mortality, which requires a long latency time (variable by cancer type) to become manifest, while
congenital malformations might be affected by concurrent exposures. Given
the sizeable excesses observed, the past and present waste disposal activities,
legal and illegal, and considering that waste disposal facilities are being built
or planned, more detailed investigation is warranted. Besides further epidemi-
ological analysis, it seems advisable to continue and optimize the existing
biomonitoring activities. More generally, it is desirable to strengthen the par-
ticipation of public health officials in indentifying and adopting appropriate
policies on waste management in the region. Above all, immediate action is
essential to ensure that the most extreme instances of population exposure to
environmental contamination due to waste treatment are prevented.

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REFERENCES

1. VRIJHEID, M. 2000. Health effects of residence near hazardous waste landfill sites:
101–112.
in U.S. counties with hazardous waste sites and ground water pollution. Arch.
among persons living near a municipal solid waste landfill site in Montreal,
vicinanze di due discariche di rifiuti di Torino. In Valutazione del rischio sanitario
8. GREISSERT, E., I. LOTZ, H. BRAND & H. WEBER. 1991. Increased incidence of
leukemias in the vicinity of a previous industrial waste dump in North Rhine-


findings. In First European Conference Geographic Information Sciences in Public Health. Sheffield, U.K.


