Policy and practice

HAZARDOUS WASTE: A CHALLENGE FOR PUBLIC HEALTH

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ABSTRACT

Background: The disposal and management of hazardous waste are worldwide problems. Notwithstanding the difficulties evaluating epidemiological studies, some observations of their health impact appear to be, to some extent, reproducible.

Local context: The role of epidemiological studies in contributing to decision-making in public health is addressed, through describing an Italian context with illegal, hazardous waste dumps.

Approach: This case study, concerning the Italian "Land of Fires", provides a frame for integrating scientific, evidence-based public health actions and priorities for further research.

Relevant changes: Additional research on the adverse health effects among individuals living close to hazardous waste sites, and on the characterization of air contaminants near waste sites, is necessary. Furthermore, counteracting illegal and poor waste dumping, the environmental remediation of areas contaminated by waste, and prevention and health care actions targeted at local human populations are urgently required.

Lessons learnt: Cooperation on this topic between public health institutions of the WHO European Region Member States appears warranted.

Keywords: HAZARDOUS WASTE, CONTAMINATED SITES, PUBLIC HEALTH, POLICY

BACKGROUND

The disposal and management of hazardous waste are worldwide problems in terms of environmental pollution and its potential health impact on human populations living close to waste sites. Waste is part of the agenda of the European Environment and Health Process as well as one of the topics considered by the Sixth Ministerial Conference on Environment and Health of the World Health Organization (WHO) European Region *(1)*.

Waste storage, treatment and disposal are the main activities (31.5%) causing problems in the 1684 present or past Environmental Protection Agency National Priority List (NPL) sites in the United States, followed by contaminants released by manufacturing and industrial activities *(2)*. In 2011, based on data provided by 33 countries in Europe, the activities which contributed most to soil and groundwater contamination were waste disposal, including municipal and industrial waste (approximately 38% of the sites), followed by industrial and commercial activities *(3)*. Such data are more limited in middle and low income countries. In seven Asian countries, 679 areas were estimated to be contaminated by hazardous waste *(4)*. Recently, hazardous waste has been included among the top three major environmental risk factors for health effects in Africa, where non-communicable diseases, such as cancer, are on the rise *(5)*.

Assessing the health impacts of hazardous waste, especially through illegal or uncontrolled dumping

sites, has, to date, been the aim of only a few review papers *(6-8)*. The difficulties in detecting exposed populations, outcome selection, control of confounding variables and, especially, assessing exposure to complex and often heterogeneous cocktails of hazardous chemicals, represent the usual limitations associated with epidemiological investigations on this topic.

Notwithstanding these difficulties, some observations appear to be, to some extent, reproducible. These include the excess of some cancer sites, such as the stomach, liver, lung, bladder, and leukemia, congenital malformations, adverse reproductive effects and asthma, as illustrated in the recent WHO report on waste and human health, previously referred to in *(1)*. These observations were recorded in studies performed in different parts of the world, namely Europe, the United States and some low-income countries, with the latter including some investigations on the acute effects of illegal dumping of waste traded from industrialized countries.

The purpose of this paper is to examine one specific case study concerning the Campania Region in Italy, to which, since the late 1980s, hazardous waste has been illegally transferred from various parts of Italy and subsequently dumped or burned. The authors believe that similar issues are of wider interest, taking into account the spread of poor waste management practices in some areas at the global level, mainly concerning low socioeconomic status people. The role of epidemiological studies in providing estimates of the health impact of residential exposure to waste, thus contributing to the public health decision-making process in the last ten years, will be specifically addressed.

LOCAL CONTEXT

In the middle to late 1990s, the Italian national government declared an environmental emergency in the Campania Region due to waste management. Subsequently, in 1998, 77 municipalities in this region were included within the territory of the national priority contaminated site, "Litorale Domizio Flegreo e Agro Aversano".

Campania is located in southern Italy and its regional capital is Naples. For several decades, waste in Campania was poorly managed, mainly due to insufficient recycling, landfill exhaust, and the absence of incinerators. Given this context, criminal organizations set up an illegal system of delivering hazardous waste, produced mainly by industries located in Italy's northern regions, for dumping or burning in the countryside. This practice was concentrated in the two provinces of Naples and Caserta and was not ubiquitous throughout the region.

Some environmentalist organizations, taking into account the information being made available on the illegal traffic and dumping of industrial hazardous waste by crime organizations, denounced the possible health risk to the human populations living in these areas. In this context, researchers of the Italian National Institute of Public Health (Istituto Superiore di Sanità, or ISS) and Institute of Clinical Physiology of the Italian National Research Council (CNR), in collaboration with regional environmental and health agencies and an environmentalist organization, performed the first epidemiological investigation at the municipal level in the area. The study, performed in three municipalities with high concentrations of waste dumping sites, showed higher rates of mortality from specific diseases than the regional population average *(9)*. The results were published in the peer-reviewed journal of the Italian Association of Epidemiology and communicated to the population and local government during an *ad hoc* meeting. Afterwards, awareness increased among several stakeholders, including national and local associations and policy-makers, about the possible health impact of uncontrolled and illegal waste dumping and burning.

APPROACH

Given this context, a cycle of epidemiological studies was performed in the provinces of Naples and Caserta in the Campania Region.

Beginning in 2004, the WHO European Centre of Environment and Health and the Institute of Clinical Physiology of CNR, in strict cooperation with ISS, investigated cause-specific mortality and the prevalence of malformations in the 196 municipalities in the provinces of Naples and Caserta.

The first study *(10)* showed numerous clusters of municipalities with significant excesses of mortality

for neoplasms of the lung, liver, stomach, kidney and bladder, from 1994 to 2001; and of the prevalence of congenital anomalies in cardiovascular and urogenital systems and limbs, from 1996 to 2002. These clusters were concentrated in a sub-area where most of the hazardous dumping sites were located.

A municipal indicator of environmental pressure due to hazardous waste was provided for each of the 196 municipalities in the provinces of Naples and Caserta, on the basis of the characteristics of the dumped waste and sites *(11)*.

The association between the indicator of hazardous waste "pressure" and several health outcomes at the municipal level was tested in a subsequent correlation study *(12)*, which also took socioeconomic status into account. Significantly increasing trends were reported for all causes of deaths; all cancers; liver, lung and stomach cancer mortality; and for the prevalence of congenital malformations of the nervous system and uro-genital tract at birth. Even if a causal interpretation of the reported associations was not observed to be fully demonstrated, it was deemed necessary and urgent to foster the reduction of exposure to hazardous waste.

Further studies performed in cooperation with the Naples Health Authority Cancer Registry suggested a correlation between hazardous waste exposure and testis cancer *(13)*, while inconsistent findings were reported for the incidence of soft-tissue sarcomas *(14)*.

A human biomonitoring project named "SEBIOREC", focused on the absorption of chlorinated compounds and heavy metals in the population resident in the same area, was performed by ISS and the National Research Council, following a request from Campania regional health authorities *(15)*. Donors were recruited in three sub-areas characterized by elevated, moderate and low environmental pressures from uncontrolled waste dumping and burning, with the latter area serving as a reference. The analyses of blood and milk pool samples, both based on residential proximity, did not show anomalous concentrations of heavy metals (i.e. arsenic, cadmium, mercury and lead) or halogenated compounds; or the burden of Total Equivalent Toxicity of dioxins and dioxin-like compounds and non-dioxin-like polychlorobiphenyls. Some municipalities were flagged as possibly deserving attention for health-oriented interventions, on the basis of relatively higher biomarker values within their hematic samples.

Some biomonitoring studies performed on individual samples showed high levels of dioxin-like compounds in the milk of cows grown on farms in specific areas of Caserta Province *(16)* and in the milk of primiparous mothers participating in a human biomonitoring study in the provinces of Naples and Caserta *(17)*.

Additionally, *ad hoc* environmental studies were performed on some paradigmatic, illegal, urban and hazardous waste dumping sites. For example, one site, located in an area of about 59 000 square metres previously used as a quarry, contained approximately 1 million cubic metres of solid urban and hazardous waste. Arsenic, heavy metals and organic chemicals contaminated the surrounding soils, while mercury, fluorides, total hydrocarbons, 1,2-dichloropropane, trichloroethylene and tetrachloroethylene were detected in underground water. Emissions and depositions showed elevated levels of benzene *(18)*.

RELEVANT CHANGES

The publication of the findings of the epidemiological studies on waste and health in Campania in peer-reviewed journals, and the communication process with local stakeholders and the local population *(19)*, contributed to raising awareness on this issue. Besides being the object of scientific studies, the question was raised in the press, novels, movies and a TV series (e.g. see *Gomorrah* by Roberto Saviano).

In 2014, the Italian Parliament adopted an Act (No. 6 of 6 February 2014) that created a new regulation for 55 municipalities in the provinces of Naples and Caserta, identified as constituting the so-called "Land of Fires", which was characterized by the widespread malpractice of setting fire to urban solid and hazardous waste.

Most of the prescriptions under the "Land of Fires" Act concerned environmental clean-up based on extensive environmental monitoring, particularly aimed at detecting areas where the food chain had experienced contamination.

The same Act assigned ISS the task of providing up-to-date epidemiological findings on the municipalities included in the "Land of Fires". This study was promptly made available to the national Ministry of Health and Campania Region, and was subsequently published on the freely accessible ISS website, as required by law.

The epidemiological results found that resident populations in this area have a series of excesses in mortality, cancer incidence and hospitalization for several diseases with a multifactorial etiology. Exposure to environmental contaminants, that were potentially emitted or released by uncontrolled hazardous and urban waste dumping and burning, was among their ascertained or suspected risk factors. The authors pointed out some critical aspects regarding children's health, namely, the excesses of children hospitalized for all cancers in the first year of life, and for brain cancer in the first year of life and in the class aged 0 to 14 years. Analyses at the municipal level detected some locations where specific observations required further and urgent in-depth analysis *(20)*.

In this framework, ISS was also required to recommend health checks that were to be freely offered by the Campania Region to the population residing in the "Land of Fires". For this purpose, two principles were followed: screening at the population level must depend on the availability of tests with high sensitivity, specificity and predictive value; and offering tests without proven effectiveness is not recommended.

For the diseases characterized by an ascertained or suspected etiological role of agents emitted or released by waste dump sites, and occurring in excess in the study area (i.e. stomach, liver, lung, bladder, pancreas, larynx, and kidney cancers and non-Hodgkin lymphoma), the creation of a program of health care actions, based on national and international guidelines and using process and outcome indicators, was suggested.

Futhermore, the implementation of prevention and health care actions recommended by international and national health agencies was advised, namely: screening tests for breast and colon-rectum tumours, which currently have a very low level of respondence in the study area; the application of the tests for subjects aged 40 years or more, to identify those at risk of acute myocardial infarction; pharmacological treatments, defined by the Italian National Drugs Agency (AIFA), for cardiovascular diseases; and the application of guidelines for physiological pregnancy, offering folic acid and the surveillance of pediatric oncology referring to specialized centres, for the protection of maternal and child health *(20)*.

In the absence of *ad hoc* or even pilot studies on this issue, it is not easy, and could be arbitrary, to draw conclusions about the consequences of the aforementioned epidemiological studies on risk perception in the "Land of Fires". Nonetheless, some can be noted.

In the early 2000s, in the absence of any evidence-based approach, conflicting messages on the possible health effects of waste exposure made by public health authorities, some investigators and policy-makers raised puzzlement and the worry of the people. Meanwhile, environmental organizations and judicial authorities increased efforts to bring the real dimension of the problem to light.

Currently, the availability of epidemiological studies, together with the findings of human biomonitoring surveys and improvements made to mapping illegal hazardous waste dumping sites *(18)*, have contributed to creating a shared body of knowledge onto which robust state-of-the-art assessment and consequent evidence-based decision-making should be implemented. Even if no final evaluation of the health impact of uncontrolled waste dumping and burning is available, some evidence has accumulated and uncertainty has been reduced. To some extent, the current debate is less ideological and more factual, but much work has still to be done.

LESSONS LEARNT

The first lesson learnt concerns the public policies that should be adopted in contexts characterized by illegal hazardous waste management. These policies require strong measures to counteract the illegal trafficking of hazardous waste in terms of repression, by judiciary authorities, and prevention, by administrative authorities. Moreover, the implementation of the best practices in the management of hazardous waste is needed in the areas of industrialized countries and in

middle and low income countries where this issue is currently unregulated. Furthermore, it is necessary to implement a systematic mapping of dumping sites that is integrated with the environmental monitoring of soil, shallow and surface water, air and the food chain. Environmental remediation should be pursued according to scientifically-based priorities aimed at minimizing health risks. Communication plans directed at resident populations, policy-makers, local health and environmental authorities, civil society organizations, and health professionals must also be realized.

The second lesson concerns the need to conduct epidemiologic studies aimed at providing information on issues that are not yet sufficiently documented. In fact, there is an urgent need for additional research which documents the adverse health effects among individuals who live near hazardous waste sites. Most sites contain a mixtures of chemicals and each chemical may have a unique profile of human health effects. Because there is strong evidence that different chemicals affect the rates of many different diseases, it is important to investigate multiple disease endpoints, both developmental (e.g. birth defects, birth weight, fetal deaths, cognitive development and physical growth) as well as adult diseases (e.g. infections, cancer, diabetes, cardiovascular, liver and kidney diseases, and endocrine and reproductive effects). It is critical to be able to compare health between exposed and unexposed populations that are matched as much as possible with age, sex, socioeconomic status, race and ethnicity, and behavioral factors such as smoking and alcohol consumption. Given the vast number of possible chemical contaminants, it is not realistic to obtain chemical measurements of contaminants in the human body in most circumstances, although it is sometimes possible to monitor the serum or urinary concentrations of one or more toxicant. Studies that are realistic are often ecological, when investigating patterns of disease in populations living near waste sites as compared to those not living near such sites. While there are limitations with ecological studies, they have great value for developing hypotheses to improve studies at individual levels with better exposure assessment through the measurement of serum levels or the urinary metabolites of specific chemicals.

Individuals living near hazardous sites may be exposed to dangerous substances through the ingestion of food or water, inhalation of airborne contaminants or dermal absorption. While the contamination of garden vegetables, livestock or drinking water is a possible route of human exposure, the most important route is likely inhalation of contaminated air. In addition, significant research is needed to develop studies on animal exposure to the chemical mixtures associated with these sites and to have good controls. Studies of caged animals near waste and control sites need to be conducted, especially when inhalation is the major route of human exposure.

There is also a great need for analysing chemicals in air near waste sites. If air contains volatile or semi-volatile chemicals, they will be continuously inhaled by local residents and absorbed in their lungs. Such analyses will provide the exposure assessment that is much more difficult to obtain through the measurement of human bodily fluids.

A third lesson learnt concerns the transfer of the experience gained from the Italian "Land of Fires" case study to other countries within the WHO European region that might encounter similar problems. The issue of the uncontrolled or openly illegal management of hazardous waste was discussed during the WHO meetings on waste and health of November 2015 (that produced the aforementioned Report *(1)*) and October 2016. There, it was clarified that hazardous waste tends to move towards areas characterized by lower environmental health standards, constituting a factor for raising environmental inequity at the global level. This was the case within Italy, involving different regions, but it may also concern different countries within or beyond Europe. A strong European collaborative network of public health and research institutions, sharing a common view of the problem and adopting consistent approaches to solve it, may ensure the preservation of environmental quality and the prevention of adverse health effects.

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