

APPENDIX

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Health Studies Related to Landfill Gas Exposures

This appendix summarizes five studies that were undertaken to assess the potential health effects of landfill gas exposure over the long term:

1. Study of Reproductive Effects from Exposure to Landfill Gas, Montreal, Canada
2. Study of Cancer Incidences Surrounding a Municipal Solid Waste Landfill, Montreal, Canada
3. Study of Cancer Incidences Surrounding Municipal Solid Waste Landfills, New York State
4. A Panel Study of Respiratory Outcomes, Staten Island, New York
5. Risk of Congenital Anomalies near Hazardous Waste Landfill Sites in Europe: the EUROHAZCON Study

1. Study of Reproductive Effects from Exposure to Landfill Gas, Montreal, Canada

Goldberg MS, Goulet L, Riberdy H, and Bonvalot Y. Low birth weight and preterm births among infants born to women living near a municipal solid waste landfill site in Montreal, Quebec. Environ Res.: 69 (1):37-50. 1995.

Researchers in Montreal conducted a study of landfill gas emissions to evaluate potential reproductive impacts from living near a municipal solid waste landfill. The study design included comparing instances of low birth weight, very low birth weight, premature birth, and smallness for gestational age for populations living near the landfill and assumed to be exposed to landfill gases versus reference populations living beyond the area where exposure was assumed. Control or reference areas were selected based on sociodemographic factors. Potential exposures to landfill gas were defined by exposure zones around the landfill site. Sampling data, however, were not available to quantify exposures. Information was gathered from the Quebec birth registration file.

Researchers found that there were elevated instances of low birth weight and smallness for gestational age in the areas where exposure was assumed. No increase in instances of very low birth weight or premature birth was found. The researchers could not definitively conclude whether low birth weight and smallness for gestational age are associated with exposure to landfill gas. The effects of all potentially important confounding factors could not be addressed, and detailed environmental exposure assessments were not available. Researchers recommended that additional studies be conducted to support or refute their evidence.

2. Study of Cancer Incidences Surrounding a Municipal Solid Waste Landfill, Montreal, Canada

Goldberg MS, Al-Homsi N, Goulet L, and Riberdy H. Incidence of cancer among persons living near a municipal solid waste landfill site in Montreal, Quebec. *Archives of Environmental Health*. 50(6):416-424. Nov/Dec 1995.

Goldberg MS, Seimiatyck J, DeWar R, Desy M, and Riberdy H. Risks of Developing Cancer Relative to Living Near a Municipal Solid Waste Landfill in Montreal, Quebec, Canada. *Archives of Environmental Health*. 54(4):291-296. July/August 1999.

The Miron Quarry municipal solid waste landfill is located in a heavily populated area. Approximately 100,000 people live within 2 kilometers (1.5 miles). This landfill, which operated between 1968 and the late 1990s, is also the third largest landfill in North America. Because of its proximity to a large residential population, there has been concern that landfill gases released into the air may have impacted public health. Beginning in 1980, landfill gases were collected and flared; however, the collection system was inefficient and combustion was likely incomplete. Therefore, some landfill gases were still entering the ambient air. Sampling from the gas collection system detected 35 chemicals, including the recognized human carcinogens benzene and vinyl chloride and the suspected human carcinogens methylene chloride, chloroform, 1,2-dichloroethane, bromodichloromethane, tetrachloroethylene, 1,4-dichlorobenzene, 1,2-dibromoethane, and carbon tetrachloride.

Because of health concerns, researchers conducted a study to evaluate cancer incidences in populations living near the Miron Quarry landfill. This study was the first of its kind. The researchers established four exposure zones based on distance from the landfill boundary and prevailing wind direction. The researchers also selected four reference zones based on socioeconomic factors where people were not expected to have been exposed to the landfill gas. Researchers used the Quebec Tumor Registry, a population-based cancer registry, to evaluate whether cancer incidence among persons who lived near the site was higher than the incidence in the reference zones during the period 1981 to 1988.

A statistical analysis found that among men living in the exposure zone closest to the site, elevated risks were observed for cancers of the prostate, stomach, liver, and lungs. Among women, rates of stomach cancer and cervix uteri cancer were elevated, but breast cancer incidence was less than expected. The researchers concluded, however, that there are limits to these findings. Quebec residents who were treated outside of Quebec were not included in the tumor registry. To the researchers' knowledge, the reliability of the data retained in the registry has not been investigated. Although monitoring data for gas in the collection system were available, no data regarding contaminant concentrations in ambient air were available. The researchers, therefore, were unable to assess cancer incidence directly in relation to landfill gas concentrations. No information was available regarding residential history, specifically the duration of residence. The researchers also noted that the landfill began operation in 1968, and the study time encompassed 1981 to 1988. Therefore, the maximum latency period was only 20 years, considered a short latency period for solid tumors. Because of the lack of environmental data and other limiting factors, the researchers stated that they were unable to conclude whether the excess cancer risks found in this study represent true associations with exposure to landfill gas or other factors. The researchers recommended additional study.

An additional study was conducted to further evaluate the cancer incidence in the vicinity of the Miron Quarry landfill. Investigators used face-to-face interviews to obtain information about key risk factors. The main limitations of the study were the absence of complete lifetime residential histories, the relatively short period from the first exposure (1968) to cancer onset, and the use of distance measurements to define “exposure” in lieu of actual measurements of exposure. The results of the analyses suggest possible associations between living near the landfill and liver cancer, kidney cancer, pancreatic cancer, and non-Hodgkin’s lymphomas. The statistical evidence is not persuasive, however, according to investigators. This study did not show an excess of stomach cancer. The finding most consistent with the earlier study was the excess risk of liver cancers in high-exposure zones. Without actual exposure data, no strong conclusions can be drawn, but investigators controlled for other risk factors (e.g., alcohol consumption, hepatitis-B virus) and noted the presence of vinyl chloride (a recognized liver carcinogen) in the landfill gas collection system.

3. Study of Cancer Incidences Surrounding Municipal Solid Waste Landfills, New York State

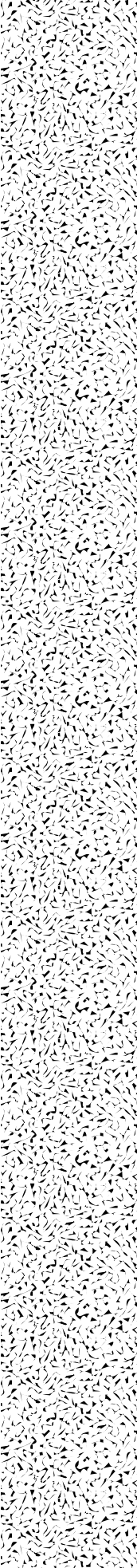
ATSDR. Agency for Toxic Substances and Disease Registry. U.S. Department of Health and Human Services. Investigation of cancer incidence and residence near 38 landfills with soil gas migration conditions, New York State, 1980-1989. Prepared by the New York State Department of Health, Division of Occupational Health and Environmental Epidemiology, Bureau of Environmental and Occupational Epidemiology. PB98-142144. June 1998.

Continuing public concern about cancer rates and exposure to toxic substances, specifically those in landfill gases, prompted the New York Department of Health (NYSDOH) to conduct a study of cancer incidence among people living near landfills.

From the hundreds of landfills located in New York State, NYSDOH selected 38 landfills for inclusion in this study. These landfills were selected because information indicated that gas production and movement could create conditions for possible exposures. Of these landfills, 30 began operation before 1970. These landfills were not lined or capped as they would be if constructed today because New York State and the federal governments did not begin regulating landfills until 1973 and 1976, respectively. Gas collection systems had been installed in 22 of the study landfills at the time of the NYSDOH study. By the end of the 1980s, only three of the study landfills were operating; currently none are active.

At each of the 38 landfills selected for study, NYSDOH identified potential exposure areas and reference areas where no exposure was expected. The potential exposure areas were identified as a ring around the landfill boundary where landfill gas was migrating according to sampling data. For most of the landfills, this area extended 250 feet from the landfill boundary. At four landfills, sampling data indicated that the area of potential exposure should extend 500 feet from the landfill boundary, and at one landfill the area extended 1,000 feet from the landfill boundary. The reference areas were identified as the area within the same zip code as the landfill, but beyond the ring that defined the potential exposure areas.

Data from the New York State Cancer Registry were used to identify leukemia; non-Hodgkin’s lymphoma; and liver, lung, kidney, bladder, and brain cancer cases diagnosed during the 10-year period between 1980 to 1989. Using death certificates files, NYSDOH also identified non-cancer deaths which occurred in the potential exposure areas and reference areas during the same 10-year period. The residential address for each cancer case and each non-cancer death was used to



pinpoint the resident locations in relation to the potential exposure areas and reference areas. To determine if higher than expected cancer cases were occurring within the potential exposure areas, NYSDOH compared the proportion of cancer cases to non-cancer deaths in the potential exposure areas to the proportion of cancer cases to non-cancer deaths in the reference areas. Of the 9,020 cancer cases identified, 49 were within the potential exposure areas. Of the 9,169 non-cancer deaths identified, 36 were within the potential exposure areas.

Using a statistical comparison of these results, this study found a statistically significant four-fold elevation of risk for bladder cancer and leukemia for women living in the areas of potential exposure. This means that the statistical tests show that it is very unlikely, but not impossible, that the higher-than-expected number of cases of these two types of cancer in the area of potential exposure occurred just by chance. For the other five cancers examined in females and the seven cancers examined in males, no statistically significant increase in cancer incidence was found.

These results should be viewed with consideration of the study's limitations, including the lack of exposure (type and duration of exposure) and possible confounding factors. It is possible that unidentified personal risk factors, such as smoking or occupation, could have played a role in the findings. In addition, no data were available to confirm that individuals were exposed to landfill gas or what the chemicals were in the landfill gas. Only a person's address at the time of diagnosis was used for mapping his or her location. The length of time people lived at their homes before being diagnosed with cancer was unknown; a person in the study could have recently moved. This is important because of the latency period between the beginning of the cancer's growth and its later appearance and diagnosis. For most cancers, the period of latency is thought to be between 10 and 20 years.

NYDOH concluded that this study does not prove that there is a relationship between living very close to the landfill and female bladder cancer and leukemia. But the study does suggest that there may be an increased risk for these cancers for women who lived within 250 feet of the landfills during the 1960s and 1970s, based on the reporting dates of cancer incidence and the expected latency period. Since the 1960s and 1970s, when individuals may have been exposed, cleanup efforts have changed the conditions at New York State landfills. As a result, this study does not provide information about health risks related to living near landfills today.

To further assess potential cancer effects from living near landfills, NYDOH is conducting additional review of medical records for leukemia and bladder cancer cases for people who lived in the area of potential exposure. A second study is planned using a different group of controls to see if the initial study findings can be verified. The initial study will be updated to include cancers diagnosed through 1994 and will include additional review of data that are relevant to past landfill conditions. Sampling will be conducted at selected landfills to assess current conditions.

4. A Panel Study of Respiratory Outcomes, Staten Island, New York

ATSDR. Agency for Toxic Substances and Disease Registry. A Panel Study of Acute Respiratory Outcomes, Staten Island, New York. Draft Final Report for Public Comment. August 20, 1999.

In the early 1990s, a community member living near the Fresh Kills Municipal Landfill in Staten Island, New York—one of the largest MSW landfills in North America—requested that ATSDR conduct a public health assessment to address health concerns about living near this landfill. Residents questioned if odors and gas emissions from the landfill might be the cause of asthma and other breathing illnesses in the area. To address these concerns, ATSDR conducted a health

study of the nearby communities. The study was undertaken to gain a better understanding of the possible health risks posed by the landfill to area residents. ATSDR designed the study to focus on asthma sufferers and assess how hydrogen sulfide concentrations, odors, and proximity of residence to the landfill might affect respiratory function.

A group of more than 150 community residents, ranging in age from 15 through 65 years, reported as having asthma volunteered to participate in the study. Over 80% of the study participants had lived on Staten Island for at least 5 years. For a 6-week period from July through September 1997, when annual landfill emissions tend to be at their peak, study participants completed a daily diary to record perceived odors, measures of respiratory symptoms, and daily activities. Participants also measured their lung function each morning and evening with a peak flow meter. During this same period, ATSDR conducted continuous air monitoring in the study area to assess ambient air concentrations of hydrogen sulfide (a common source of the rotten egg odor), ozone, and particulate matter. Pollen and fungi counts and meteorologic data, which are confounding factors that can influence study results, were also sampled. ATSDR also conducted a separate odor impact survey to provide an independent odor assessment.

ATSDR concluded that the measured levels of hydrogen sulfide and other parameters were not high enough to cause health problems. When study participants reported that they smelled rotten eggs or garbage, they also reported that they were more likely to wheeze or experience difficulties in breathing. A moderate decline in lung function was also documented on days when participants reported these odors. Results varied throughout the study group by factors such as the participant's age and how long he or she had suffered from asthma. Laboratory measurements of hydrogen sulfide, however, did not correlate increased hydrogen sulfide concentrations with increased respiratory symptoms or peak flow.

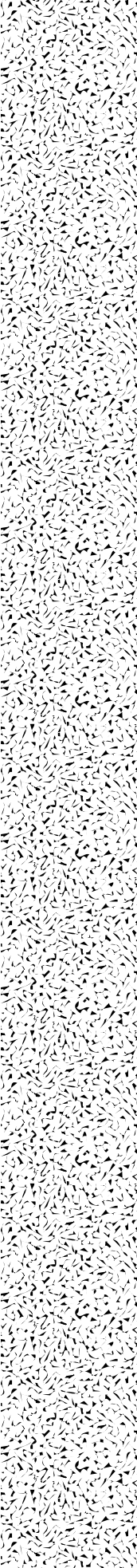
ATSDR concluded that the results of this study suggest that the perception of odors is associated with worsening of respiratory symptoms of some people in the study group. Future investigations of potential health effects associated with the landfill should consider odor issues.

5. Risk of Congenital Anomalies Near Hazardous Waste Landfill Sites in Europe: The EUROHAZCON Study

Dolk H, Vrijheid M, Armstrong B, Abramsky L, Bianchi F, Garne E, et al. Risk of congenital anomalies near hazardous waste landfill sites in Europe: the EUROHAZCON Study. Lancet. 1998; 352: 423-27.

In 1998, researchers in Europe published the results of a study conducted to assess the relationship between residence near a hazardous waste landfill and birth defects. Several research centers in Europe maintain regional-population based registers of congenital anomalies (birth defects). These registers also included data on live births, stillbirths, and pregnancy termination after prenatal diagnosis.

To assess the relationship between birth defects and residence near a hazardous waste landfill, the researchers identified 21 landfills in five countries (Belgium, Denmark, France, Italy, and the United Kingdom) that were located in areas covered by the registers. The landfill and an area within a 7-kilometer (km) radius was identified as the study area. The area within a 3-km radius of the landfill was designated as the "proximate" zone and the area between a 3- and 7-km radius of the landfill served as the control zone.



Researchers reviewed the congenital anomaly registers for a time period extending from when the register began to at least 5 years after operation of the nearby landfill began to identify study and control cases. Study cases in the proximate zone and control cases in the control zone were identified geographically by the mother's address or postcode at the time of birth. Once data were collected, researchers conducted statistical analyses to evaluate the expected number of birth defect occurrences and the actual number of birth defect occurrences in both the study and control areas.

The study concluded that there was a small, but significant, increased risk of birth defects to babies whose mothers lived within 3 km of a hazardous waste landfill. Neural-tube defects, malformations of the cardiac septa, and malformation of the great arteries and veins had an increased risk of occurrence. Researchers noted that socioeconomic status is a potential, but unlikely, confounding factor in this study. Another, potentially more important confounding factor is the presence of other industrial sites or toxic exposures near landfill sites. This study did not, however, measure actual chemical exposures of women residing near the landfill sites. Researchers felt that direct measure of exposures and birth defects would better establish a causal relationship. Researchers suggested that further study is needed.