Birth Weight Reduction Associated with Residence near a Hazardous Waste Landfill

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We examined the relationship between birth weight and mother's residence near a hazardous waste landfill. Twenty-five years of birth certificates (1961–1985) were collected for four towns. Births were grouped into five 5-year periods corresponding to hypothesized exposure periods (1971–1975 having the greatest potential for exposure). From 1971 to 1975, term births (37–44 weeks gestation) to parents living closest to the landfill (Area 1A) had a statistically significant lower average birth weight (192 g) and a statistically significant higher proportion of low birth weight [odds ratio (OR) = 5.1; 95% confidence interval (CI), 2.1–12.3] than the control population. Average term birth weights in Area 1A rebounded by about 332 g after 1975. Parallel results were found for all births (gestational age >27 weeks) in Area 1A during 1971–1975. Area 1A infants had twice the risk of prematurity (OR = 2.1; 95% CI, 1.0–4.4) during 1971–1975 compared to the control group. The results indicate a significant impact to infants born to residents living near the landfill during the period postulated as having the greatest potential for exposure. The magnitude of the effect is in the range of birth weight reduction due to cigarette smoking during pregnancy. *Key words*: environmental health, hazardous waste, low birth weight, Superfund. *Environ Health Perspect* 105:856–861 (1997)

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The Lipari Landfill is a 15-acre site located in Mantua Township, Gloucester County, New Jersey, and borders the towns of Pitman, Glassboro, and Harrison. The landfill is ranked number one on the EPA's National Priority List. In 1958 the site was first excavated as a source of sand and gravel, leaving an empty pit that was later backfilled with municipal refuse, household wastes, liquid and semisolid chemical wastes, and other industrial wastes. The landfill operated until 1971 and accepted an estimated 12,000 cubic yards of solid waste and 2.9 million gallons of liquid chemical waste. Liquid wastes were emptied from containers and dumped into the landfill from 1958 to 1969, and solid wastes were disposed of until May 1971 (*1*).

Hazardous waste deposited into the landfill included cleaning solvents, resins, paint and paint thinners, ester press cakes, phenol wastes, and amine wastes. According to the on-site Remedial Investigation/Feasibility Study (*1*), a major hazard identified in the landfill was bis(2-chloroethyl) ether. Other chemicals identified include benzene, toluene, methylene chloride, 1,2-dichloroethane, formaldehyde, phenol, chromium, nickel, mercury, lead, selenium, arsenic, and silver.

The landfill was the source of hazardous leachate, which migrated from the site into two nearby streams and a lake immediately adjacent to a neighborhood with homes, schools, and playgrounds. It has been estimated by the EPA that the heaviest period of dumping occurred in 1967 through 1969 (*1*). The heaviest migration of the pollution from the landfill is estimated to have occurred during the late 1960s to the mid-1970s. The primary pathways for community exposure were inhalation of volatilized chemicals emitted from the landfill and contaminated waters and, to a lesser extent, direct contact with contaminated soils and water. Drinking water was not considered to be a potential exposure pathway because most nearby residents were on a public water system with no evidence of contamination and the few private wells in the vicinity were either very deep or upgradient of the landfill. Operation of the landfill ended in 1971 because of residents' complaints regarding odors, respiratory problems, headaches, nausea, and dying vegetation.

Because of concerns of the impact of past exposure of nearby residents to toxic chemicals emanating from the landfill, the New Jersey Department of Health, in consultation with community leaders and activists, developed a study protocol to evaluate birth weights of children born in the area. Birth weights were selected because birth certificate information is an objective indicator of infant health and low birth weight is a significant determinant of infant morbidity and mortality (*2*).

Methods

Twenty-five years (1961–1985) of birth certificate information was collected from the New Jersey Department of Health's Center for Health Statistics for the four municipalities closest to the landfill (Mantua, Pitman, Glassboro, and Harrison). Because of the area's proximity to Philadelphia, birth certificates were requested and obtained from the Pennsylvania Vital Statistics Office for study-area children born in Pennsylvania hospitals.

Exposure categories were developed for each birth based on the distance of the mother's residence from the landfill as identified on the birth certificate. An irregular polygon approximating a circle or ring with a radius of 1.0 km was extended from the perimeter of the landfill (including the contaminated streams and lake) and formed the basis of the exposed area, called Area 1. The 1.0-km radius for the exposed area was employed at the request of a community advisory group providing input into the study design. The area extending beyond the 1.0 km boundary to the end of the four municipal limits formed the unexposed population sector or Area 2. The approximate populations of Area 1 and Area 2 during the study period were 6,600 and 30,000, respectively.

Because numerous volatile organic compounds (VOCs) were disposed of in the landfill and based on an earlier EPA environmental assessment of the site (*1*), the primary route of exposure for the majority of the exposed population was hypothesized to be via an air pathway. Consequently, Area 1 was further subdivided into two sectors: Area 1A (see Fig. 1), the only neighborhood adjacent to the landfill and lake (also in the direction of the prevailing wind and considered to have the greatest likelihood for air contaminant exposure), and Area 1B, the rest of Area 1 less Area 1A, which is generally further from the site. Area 1A is composed of approximately 600 residences (about 20% of the population of Area 1) located in Pitman and Glassboro.

Selection requirements for births in the study include the following: 1) the subject was a singleton live birth (no twins, triplets, etc.); 2) the street address on the birth certificate indicated that the mother lived in

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Area 1 or Area 2 at the time of birth of the subject (those with missing, incomplete, or undefinable addresses were excluded); 3) the birth occurred in 1961 through 1985; 4) information was available on sex and birth weight of the child and on mother's race; and 5) reported gestational ages were between 28 and 50 weeks and birth weights were between 500 and 7,000 g in order to exclude clearly inaccurate data.

Birth certificates that lacked information on birth weight or street address were not included in the study because residential proximity to the landfill and birth weight were factors of primary interest. Since sex and race are associated with birth weight, births lacking information on these potential confounders were also excluded. Because Area 1 births during the study period were approximately 99% white, the study was restricted to births among whites only.

Birth certificates were aggregated into five 5-year periods selected to represent periods when exposure to toxic waste at the site was likely to be 1) nonexistent or minimal (1961–1965); 2) increasing and moderate to heavy due to increased dumping (1966–1970); 3) heaviest due to runoff and air emissions into the neighboring community and contamination of the lake (1971–1975); 4) decreasing and moderate (1976–1980) since dumping had ended in 1971 and air exposures would be expected to decrease over time due to earlier volatilization of contaminants; and 5) minimal due to remedial work (1981–1985).

Information on the following potential risk factors for low birth weight was obtained from the birth certificate: sex; gestational age in weeks (based on last menstrual period); mother's race, age, and education; parity; previous fetal deaths (born dead after 20 weeks gestation in New Jersey and after 16 weeks in Pennsylvania); month prenatal care began; total number of prenatal visits; and father's age and education. These variables were not always available for all time periods or for both states (New Jersey and Pennsylvania). Race of the mother was not always reported on New Jersey birth certificates during the years 1962 and 1963, resulting in a loss of potential study subjects. No information on prenatal visits or on parental education was included in the New Jersey birth certificates for 1961–1967 or on the Pennsylvania birth certificates for 1961–1965 and 1971–1975; therefore, prenatal visits and parental education could not be evaluated for the 1961–1965 or 1966–1970 periods. However, since the total number of Pennsylvania births was relatively small during 1971–1975, these variables were included in the analysis during this time period. Apgar scores and previous miscarriages (fetal loss earlier than requirements for reporting) were not evaluated because they were only available on New Jersey and Pennsylvania birth certificates for the period 1981–1985.

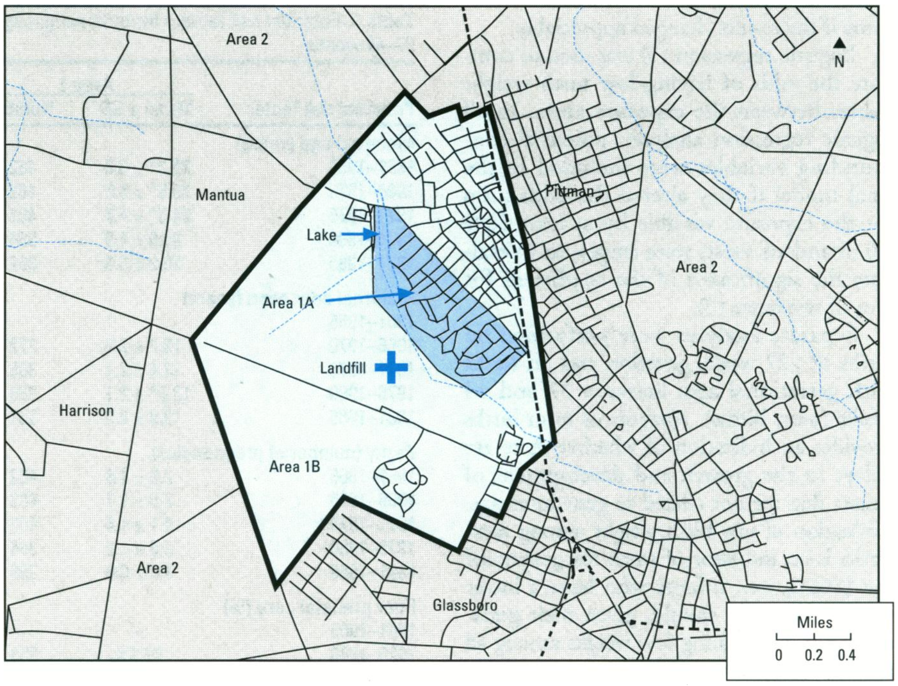

Figure 1. The location of Lipari Landfill in relation to Area 1A, Area 1B, and Area 2. Area 1 includes both Area 1A and Area 1B.

Information on other risk factors for low birth weight was not available on the birth certificate and could not be evaluated. These factors include maternal health, cigarette and alcohol consumption during pregnancy, parental occupational information, and parental socioeconomic status.

The distributions, means, and standard deviations of birth weights and risk factors from the birth certificate were generated and compared for Area 1 (or Area 1A) versus Area 2. The birth outcome variables analyzed included birth weight of the child in grams, proportion of low birth weight infants, and the proportion of preterm infants. Low birth weight is defined as <2,500 g and preterm is defined as gestational age <37 weeks.

Mother's residence at the time she gave birth was the exposure variable. An unadjusted analysis was performed comparing the birth outcomes for the two areas. Analyses were then performed to measure the effect of the exposure variable on average birth weight and on low birth weight proportion after the effects of other potential risk factors were taken into account. These other factors included the age, parity, prenatal care, education, and number of previous stillbirths of the mother and the sex of the child (*3*). (Paternal age and education were not included in the analysis because they were highly correlated with maternal age and education and because there was a high proportion of missing data for these variables.) The National Academy of Science's standard formula for prenatal visits, based on the total number of prenatal doctor visits, the gestational month the visits began, and the gestational age of the child at birth, was used to define the quality of prenatal care (*3*).

Descriptive analyses of average maternal age, parity, maternal education, and prenatal care are given separately for each time period studied. Comparisons of birth weight distribution and proportion of low birth weight between the two areas were evaluated by *t*-test and chi-square test (*4*), respectively. A result was considered statistically significant if a two-tailed *p*-value was <0.05 (*5*).

Multiple regression was used to analyze differences in average birth weight between the two areas (*4,6*). All linear regression models included the sex of the child and the mother's age, parity, prenatal care, number of previous stillbirths, educational level, and residential location at time of birth except for the periods prior to 1971, which did not have information on prenatal care or mother's education available. Regression diagnostics were performed to identify any study subjects who might strongly influence the results because they had extreme values for one (or more) of the risk factors and/or the birth weight (*7*). Analyses were performed with and without these subjects to determine if the results changed appreciably.

Logistic regression (*5*) was used to compare the odds of having low birth weight babies between the exposure areas. In all logistic regression analyses, potential confounding variables were included in the final model if they altered the odds ratio for the exposure variable by at least 10% (*8*). Standard t-tests were employed to evaluate the significance of the coefficient for area of residence (*5*).

Separate analyses were performed on births of >27 weeks gestation and on births with gestational ages between 37 and 44 weeks (term births). Analysis of term births provides an indication of whether there are delays in the growth and development of fetuses that are not related to gestational age. Evaluation of low birth weight among term births is an indicator of small for gestational age (SGA), i.e., infants who have a lower weight than they should, given their gestational age. (Evaluating low weight among all births combines two endpoints with possibly different etiologies—preterm birth and SGA.)

Analyses for all births and term births showed similar results. Therefore, we will focus on the results of the term birth analyses only.

Table 1. Potential risk factors for birth weight by area and 5-year period for white births of gestational age 37–44 weeks

	Area 1		Area 1A		Area 2	
Potential risk factor	Mean ± SD	Number	Mean ± SD	Number	Mean ± SD	Number
Maternal age (years)						
1961–1965	26.2* ± 5.6	462	28.0* ± 4.7	143	26.9 ± 5.8	1,599
1966–1970	25.6* ± 5.6	482	28.3* ± 5.9	105	26.3 ± 5.8	1,593
1971–1975	24.5* ± 4.7	402	27.4* ± 4.3	74	25.5 ± 5.1	1,251
1976–1980	26.0 ± 4.9	384	27.6* ± 4.7	69	25.7 ± 5.0	1,264
1981–1985	26.2 ± 5.3	362	28.5* ± 4.8	80	26.2 ± 4.9	1,131
Maternal education (years)						
1961–1965						
1966–1970	12.2 ± 2.2	272	13.1* ± 2.0	55	12.2 ± 1.8	882
1971–1975	12.4 ± 2.1	385	13.8* ± 2.1	70	12.5 ± 2.0	1,161
1976–1980	13.3* ± 2.1	369	14.3* ± 1.9	68	12.8 ± 2.1	1,235
1981–1985	12.9 ± 2.2	361	14.2* ± 2.0	79	13.1 ± 2.1	1,128
Parity (number of pregnancies)						
1961–1965	2.8 ± 1.8	462	2.8 ± 1.3	143	2.9 ± 1.7	1,598
1966–1970	2.5 ± 1.7	482	2.8 ± 1.7	105	2.7 ± 1.7	1,587
1971–1975	2.1 ± 1.4	402	2.4 ± 1.1	74	2.4 ± 1.7	1,246
1976–1980	2.0 ± 1.2	384	2.3 ± 1.1	69	2.0 ± 1.2	1,262
1981–1985	1.8 ± 0.9	359	1.9 ± 1.0	78	1.9 ± 1.1	1,123
Poor prenatal care (%)						
1961–1965	–	–	–	–	–	–
1966–1970	49.1%	269	48.2%	56	47.8%	857
1971–1975	53.1%	375	40.3%	67	53.0%	1,128
1976–1980	31.7%	363	24.2%	66	34.6%	1,201
1981–1985	22.8%	355	19.2%	78	26.1%	1,111

SD, standard deviation.
*Significantly different (p<0.05) compared to Area 2.

Table 2. Average birth weight by area and 5-year period for white births of gestational age 37–44 weeks

	Area 1		Area 1A		Area 2	
Period	Mean ± SD	Number	Mean ± SD	Number	Mean ± SD	Number
1961–1965	3,425.5 ± 496.8	462	3,523.3** ± 501.1	143	3,419.5 ± 518.9	1,600
1966–1970	3,424.7 ± 482.2	482	3,455.6 ± 487.1	105	3,420.1 ± 483.7	1,593
1971–1975	3,410.5* ± 498.0	402	3,334.7* ± 618.6	74	3,475.3 ± 499.7	1,251
1976–1980	3,548.2 ± 492.7	384	3,705.6** ± 560.5	69	3,497.3 ± 503.3	1,264
1981–1985	3,522.9 ± 510.4	362	3,627.8** ± 469.9	80	3,510.5 ± 494.2	1,132

SD, standard deviation.
*Birth weight mean is significantly lower (p<0.05) than Area 2.
**Birth weight mean significantly higher (p<0.05) than Area 2.

Results

A total of 11,579 singleton live births with adequate information on residential location and birth weight occurred in the study area over the 25-year period. Of these births, 85.1% (9,856) were white and nearly 5% (576) had no information on race. White births in Area 1 accounted for approximately 99% of all Area 1 births. The annual number of births in each area decreased over the entire study period.

Of the total eligible white births, 90.6% (8,932) were term births (gestational age 37–44 weeks). Among these births, 51.9% (4,640) were males and 23.4% (2,092) were born to mothers residing in Area 1. A total of 471 eligible white term births were in area 1A.

A summary of the known potential risk factors of the study population term births are listed in Table 1. In general, mothers in Area 1A were on average significantly older and more educated than those in Area 2 for every aggregate time period where data was available. Although the quality of prenatal care was generally increasing for all groups over time, Area 1A mothers generally had better prenatal care than Area 2 mothers from 1971 onward.

Table 2 presents the average birth weight by 5-year birth period for each area's term births. During the time period 1971–1975, Area 1 had an average birth weight 65 g less than Area 2, while Area 1A's average birth weight was 141 g less than Area 2. Area 1A had significantly higher average birth weights for every time period studied except 1966–1970 and 1971–1975. While Area 2 had consistently increasing average birth weight throughout the time periods, Area 1A's average birth weight decreased substantially after 1965 and through 1975 (189 g), corresponding with the period exposures that were suspected to be the highest. After 1975 the average birth weight for Area 1A rebounded by approximately 332 g (see Fig. 2). Area 1B average birth weights were similar to Area 2, indicating that the demonstrated decrease in average birth weight for Area 1 primarily occurred in the Area 1A infants.

Table 3 presents the low birth weight proportions by 5-year birth period. Of note, Area 1A term births had a significantly larger proportion of low birth weights for 1971–1975 when compared to Area 2 [odds ratio (OR) = 5.12; 95% confidence interval (CI), 2.14–2.27]. From 1976 onward, there were no low birth weight term infants born in Area 1A. The increased proportion of low birth weight detected in Area 1A appears to be responsible for the high proportion of low birth weights detected in all of Area 1. When Area 1B was evaluated separately, the proportion of low birth weight infants was found to be similar to Area 2 for each of the birth time periods.

Table 4 presents term birth summary multiple regression results for area of residence. Area of residence was statistically significantly associated with reduced average birth weight for children born in Area 1 and Area 1A for the 1971–1975 time period (a decrease of 74 g and 192 g, respectively).

For the time periods 1961–1965 and 1976–1980, Area 1A had a statistically significantly higher average birth weight for term births (99 and 166 g, respectively) than Area 2. Area of residence did not display any associations with higher average birth weight during any other time period evaluated. None of the regression analyses for Area 1B found an association between area of residence and birth weight.

In the logistic regression analyses (Table 5), the proportion of low birth weight infants was significantly elevated for Area 1A (OR = 5.12; CI, 2.14–12.27) for the time period 1971–1975. Area of residence was not associated with low birth weight during any other time period evaluated.

Similar results (but somewhat attenuated) were found for all births with gestational age over 27 weeks. For all births in Area 1A during the 1971–1975 period, a significant decrease in average birth weight (160 g) was detected in the multiple regression analysis while a significant increase in the proportion of low birth weight (OR = 3.32; CI, 1.49–7.37) was detected in the logistic regression analysis.

When all births were analyzed, Area 1A infants had twice the risk of being born preterm (OR = 2.10; CI, 1.01–4.36) during 1971–1975 compared to Area 2. No other time period displayed significant differences between the exposure areas.

Discussion

After taking into account risk factor information available on birth certificates, a substantially lower average birth weight and higher proportion of low birth weights were found in Area 1 compared to Area 2 during the period 1971–1975. Additionally, the residential association detected for Area 1 was primarily concentrated in the section designated Area 1A, the residential area nearest the landfill and polluted lake. When Area 1A births were removed from the 1971–1975 analysis, the remaining Area 1B birth outcome was similar to that of the Area 2 unexposed group.

The decrease in average birth weight for Area 1A was dramatic over the 10 years from the end of 1965 to the end of 1975, when average birth weight dropped 189 g. This time frame includes the documented period of heaviest dumping of hazardous chemicals in the landfill (*1*) and the postulated period of greatest potential for exposures to nearby residents. After 1975, Area 1A's average birth weight rebounded over 300 g and was substantially higher (163 g) than the control population.

The average decrease in birth weight in infants of gestational age >27 weeks and term births during 1971–1975 for Area 1A relative to Area 2 after controlling for the potential effect of confounders was 160 and 192 g, respectively. This effect is in the range of birth weight reduction found from cigarette smoking during pregnancy (150 g–290 g) (*9,10*). Perhaps the real impact in Area 1A was even greater than the 192 g decrease in average birth weight because Area 1A had significantly higher average birth weights prior to and after the 1971–1975 time period. This indicates that unmeasured risk factors, such as smoking, alcohol consumption, and occupational exposures, were most likely less prevalent among parents in Area 1A than in Area 2. Area 1A infants also showed a significant increased shift toward preterm delivery.

A potential weakness in this study, as well as in most environmental epidemiologic studies, is the possibility of exposure misclassification. The critical missing piece of information required to meaningfully evaluate health data is the actual personal exposure to chemicals emanating from the landfill during pregnancies over time, that is, who was exposed and who was not exposed and what the magnitude of the exposure

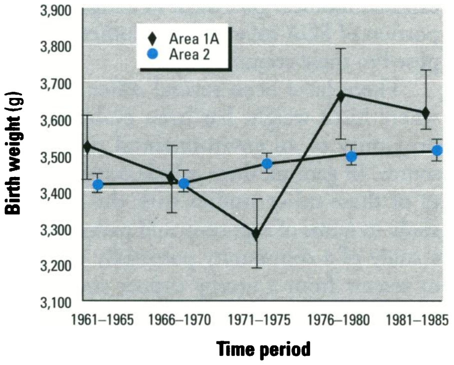

Figure 2. Average adjusted birth weight by 5-year time period for Area 1A and Area 2 from 1961 to 1985. Error bars indicate 95% confidence intervals.

Table 3. Low birth weight proportions, odds ratios (OR), and 95% confidence intervals (CI) by area and 5-year period for white births of gestational age 37–44 weeks[a]

Low birth weight by year	Area 1	Area 1A	Area 2
1961–1965			
Yes	14 (3.0%)	3 (2.1%)	58 (3.6%)
No	448	140	1,542
OR	0.83	0.57	
CI	0.46–1.50	0.18–1.84	
1966–1970			
Yes	14 (2.9%)	4 (3.8%)	43 (2.7%)
No	468	101	1,550
OR	1.08	1.43	
CI	0.59–1.99	0.50–4.06	
1971–1975			
Yes	15 (3.7%)	7 (9.5%)	25 (2.0%)
No	387	67	1,226
OR	1.90	5.12*	
CI	0.99–3.64	2.14–12.27	
1976–1980			
Yes	6 (1.6%)	0 (0.0%)	30 (2.4%)
No	378	69	1,234
OR	0.65		
CI	0.27–1.58		
1981–1985			
Yes	9 (2.5%)	0 (2.3%)	17 (1.5%)
No	353	80	1,115
OR	1.67		
CI	0.74–3.79		

[a] Values for Yes are number and percent; values for No are number only. *Significantly higher (p<0.05) than Area 2.

Table 4. Multiple regression analysis: area of residence summary for white births of gestational age 37–44 weeks[a]

	Area 1			Area 1A		
Period	Average change (g)	CI	*p*-value	Average change (g)	CI	*p*-value
1961–1965	11.5	-41.2–64.2	0.6797	98.6	10.8–186.4	0.0279
1966–1970	2.0	-43.4– 53.8	0.8329	13.2	-80.7–107.1	0.7830
1971–1975	-74.2	-120.8–-27.5	0.0112	-192.0	-285.9–-98.1	0.0023
1976–1980	33.9	-23.1–90.9	0.2440	166.4	43.5–289.3	0.0080
1981–1985	9.3	-50.1–68.7	0.7576	99.5	-15.0–214.0	0.0888

CI, 95% confidence interval.

[a] Other variables controlled for in the models include child's sex, mother's age and educational level, previous fetal deaths, first born, and prenatal care.

Table 5. Logistic regression analysis: area of residence summary for white births of gestational age 37–44 weeks

	Area 1			Area 1A		
Period	Adjusted OR	CI	*p*-value	Adjusted OR	CI	*p*-value
1961–1965	0.83	0.46–1.50	0.5403	0.57	0.18–1.84	0.3479
1966–1970	1.07	0.58–1.97	0.8352	1.43	0.53–3.84	0.5042
1971–1975	1.78	0.90–3.51	0.0955	5.12	2.14–12.27	0.0002
1976–1980[a]	0.76	0.31–1.86	0.5468			
1981–1985[a]	1.67	0.74–3.78	0.2173			

Abbreviations: OR, odds ratio; CI, 95% confidence interval.

[a] No low birth weight babies were born in Area 1A during these time periods.

was. Because personal exposure information did not exist, residential distance from the landfill was used as a surrogate measure for potential past exposure. The results of this study indicate that the Area 1 designation (1-km radius from the landfill) was too large and resulted in exposure misclassification, attenuating the results. The smaller residential subdivision of Area 1A, the neighborhood immediately adjacent to the landfill, is the better exposure surrogate and provides the strongest association between residential location and birth weight.

Information on other potential risk factors for low birth weight and length of residence were not available on the birth certificate and could not be evaluated. Other potenial risk factors include maternal health, cigarette and alcohol consumption during pregnancy, parental occupational information, and parental socioeconomic status (SES). Since these unmeasured risk factors cannot be controlled for in the analysis, incorrect results may have occurred as a result of an uneven distribution of these other risk factors in the population. However, because Area 1A appeared to have a higher SES (indicated by better prenatal care and a higher level of maternal education), if there was confounding from SES and lifestyle factors the bias would likely be towards the null. Furthermore, it appears that unmeasured risk factors (alcohol, tobacco, etc.) were not playing a role since Area 1A had higher average birth weights than Area 2 during the other time periods.

The EPA has identified numerous volatile organic chemical contaminants off-site including benzene, bis(2-chloroethyl) ether, methylene chloride, 1,2-dichloroethane, ethylbenzene, 4-methyl-2-pentanone, toluene, and xylene. Numerous metals (arsenic, chromium, lead, mercury, nickel, and zinc) were also found in off-site soil and leachate.

There are few studies available on the relationship between most the compounds found off-site and their impact on birth weight. Positive associations with low birth weight have been reported for two of the metals (cadmium and lead) in animals and humans (*11–14*). However, the real public health threat to residents living near the contamination was likely due to the VOCs because of their high evaporative qualities and, therefore, their enhanced capability for exposing more people in the community. Positive associations with low birth weight and VOCs have been reported for benzene and xylene in animals (*15,16*). In another study of rats exposed to xylene, no relationship was found (*17*).

Two occupational studies have identified associations between chemical exposures and low birth weight: working mothers exposed to polychlorinated biphenyls (*18*) and paternal exposure to auto body solvents (*19*). However, two other studies did not detect an occupational effect on low birth weights: female veterinarians exposed to several known reproductive hazards (*20*) and women working in dry cleaning shops (*21*).

Several environmental studies have detected associations between organic chemical contamination similar to that found in Lipari and birth outcomes. In one study, children born to homeowners in the Love Canal, New York, neighborhood had an average decrease in birth weight of 50 g and a higher prevalence of low birth weight (OR = 3.0) when compared to unexposed children (*22*). In studies of drinking water contaminated with trihalomethane (*23,24*), triazine herbicides (*25*), carbon tetrachloride (*24*), or trichloroethylene (*26*), exposed mothers gave birth to a higher proportion of SGA infants than mothers unexposed to these contaminants.

There have been several other studies where birth weight has been evaluated in proximity to an environmental pollutant source. In general, there is little comparability of these other studies with the current study in terms of exposures and pathways. In a study of a community potentially exposed to arsenic from a nearby copper smelter in northern Sweden, investigators found a statistically significant decline in average birth weight of 68 g (*27*). However, investigations of communities living near a toxic waste site (*28*), two different lead smelters (*29,30*), dioxin-contaminated soil (*31*), and a toxic waste landfill (*32*) did not find significant declines in average birth weight or an elevated prevalence of low birth weight infants. These studies generally had far fewer study subjects than did the Lipari study and thus had less power to detect small differences.

Two other studies evaluated communities exposed to environmental pollution using census tract codes as the surrogate measure of exposure. In the first study, industrial pollution from a plant could not be correlated with low birth weights in Monroe County, New York (*33*). In the second, environmental contamination in the San Francisco Bay area (*34*) did not detect differences in census tract average birth weight. These last two studies were far less specific about defining the exposure surrogate (census tract) and probably suffer more from exposure misclassification than the current study.

Although there is a lack of appropriate toxicity data for many of the compounds contaminating the community, there is evidence from studies with similar VOC contaminants that provides a reasonable biological plausibility for a potential relationship between exposures to these contaminants and low birth weight in the community.

In summation, the results of this 25-year analysis of birth weights near the Lipari Landfill indicate that the population living immediately adjacent (Area 1A) was substantially impacted between 1971 and 1975. This time frame matches the hypothesized period of greatest likely community exposure to pollution from the landfill.

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