Low birth weight is an important predictor of infant morbidity and mortality. About 75% of early neonatal mortality in the United States and Canada is associated with low birth weight. This condition is also related to increased infant and childhood morbidity because low-birth-weight infants are 5–10 times as likely to die in the first year of life (Kramer 1987).

Recent studies have shown that low birth weight increases risk of several chronic adult diseases, including cardiovascular diseases (Barker 1999; Rich-Edwards et al. 1997), hypertension (Law et al. 2001), renal failure (Lackland et al. 2000), and type 2 diabetes (Forsen et al. 2000; Rich-Edwards et al. 1999).

Conventionally, low-birth-weight infants are defined as those born weighing < 2,500 g. This low weight could be caused by shortened gestation (< 37 weeks) and/or inadequate fetal growth. Infants born weighing < 1,500 g are considered very low-birth-weight infants. Very low birth weight is usually a reflection of a more serious problem with pregnancy and thus has a different etiology (Kramer 1987), although there are some common risk factors. Several factors have been proven to be associated with increased risk of giving birth to low-birth-weight babies: mother’s age, race, nutritional status and weight before pregnancy, socioeconomic status and educational level, and mother’s smoking status. Premature birth is by far the most common cause of low birth weight. Birth weight and gestational age are usually positively correlated (Kramer 1987). African-American women are twice as likely as white women to deliver a low-birth-weight infant (Goldenberg et al. 1997; Luke et al. 1993). Lack of education and low-income status are also associated with low birth weight (Bruce and Tchabo 1989; Olsen and Frische 1994; Williams 1998). The effect of maternal age on risk of having a low-birth-weight baby is U-shaped: Women at the youngest (≤ 18 years) and oldest (> 39 years old) ends of the childbearing age spectrum are at greatest risk of having a low-birth-weight infant (Abel et al. 2002; Aldous and Edmonson 1993; Goldenberg et al. 1997; Herceg et al. 1994). Cigarette smoking affects birth weight by causing intrauterine growth retardation (Kramer 1987). Female infants are more likely to be of low birth weight than are male infants (Herceg et al. 1994; Goldenberg et al. 1997). Other risk factors include poor gestational nutrition (Bruce and Tchado 1989; Haste et al. 1990), primiparity (Herceg et al. 1994), single motherhood (Holt et al. 1997), and mother’s short stature (Goldenberg et al. 1997; Herceg et al. 1994).

Exposure to environmental contaminants also contributes to the increased risk of having a low-birth-weight baby. Numerous studies that looked at the relationship between exposure to environmental hazards and reproductive outcomes used residence in proximity to hazardous waste landfill sites as a surrogate for exposure. A statistically significant association between the mother’s residence near hazardous waste sites and risk of having low-birth-weight births was found in some (Berry and Bove 1997; Elliott et al. 2001; Goldberg et al. 1995; Goldman et al. 1985; Vianna and Polan 1984) but not all studies (Baker et al. 1988; Khraza et al. 1997; Shaw et al. 1992). Most of these studies did not consider the chemical composition of the waste within the sites. Because most waste sites contain multiple chemical components, it is usually not possible to determine which chemicals are responsible for the observed health effects.

A key to understanding which contaminant(s) might cause these effects comes from the observation that low birth weight occurs more commonly among women who consume large amounts of fish contaminated with organochlorine compounds, including polychlorinated biphenyls (PCBs), persistent pesticides, and dioxins/furans (Fein et al. 1984; Rylander et al. 1998, 2000; Vartiainen et al. 1998). Fein et al. (1984) noted that PCB-exposed infants averaged 190 g less in weight and 4.9 days less in gestational age, and Taylor et al. (1984, 1989) also reported an increase of low-birth-weight babies and shortened gestational age among women occupationally exposed to PCBs. Rylander et al. (1995, 1996) and Hertz-Picciotto et al. (2000) found that in PCB-exposed populations, low birth weight is more pronounced in male infants than in female infants. Vartiainen et al. (1998) reported that low birth weight was more pronounced in boys than in girls prenatally exposed to dioxins and furans.

We have examined the effect of maternal residence in a zip code that contains or abuts a PCB-contaminated site on the birth weight of the baby. We used birth registry data without personal identifiers from the New York State Vital Statistics (New York State Department of Health 1994–2000) to test the hypothesis that living in a zip code that contains or abuts a PCB-contaminated site is a risk factor for giving birth to a male infant of low birth weight. These observations support the hypothesis that living in a zip code near a PCB-contaminated site poses a risk of exposure and giving birth to a male infant of low birth weight.
giving birth to a low-/very low-birth-weight infant. Although zip code of residence is a very inexact indicator of exposure, some studies have shown that residential proximity to contaminated sites increases risk of several different diseases (Carpenter et al. 2001; Elliott et al. 2001; Gilbertson and Brophy 2001).

Materials and Methods
The New York State Department of Environmental Conservation has identified 865 hazardous waste sites in the state, and for each lists the chemicals of major concern and the geographical location, including zip code, census track, and geographic longitude and latitude. Additional information is available for those waste sites listed on the U.S. Environmental Protection Agency (2003) National Priority List website. After scanning the list of the chemicals under each of the waste sites for the key words PCBs, PCB, Aroclor, and Pyranol, we have identified 128 zip codes in New York containing PCB-contaminated sites. In this study we excluded New York City, which reduced the PCB-contaminated zip codes to 117. We added all zip codes that directly abut bodies of water known to be contaminated with PCBs, including a major portion of the Hudson River and the six Areas of Concern in New York State (areas along the Great Lakes that have exceptional levels of contamination), as identified by the International Joint Commission. These are the Niagara River, Buffalo River, 18 Mile Greek, Oswego River, the Rochester Embayment and Genesee River, and the St. Lawrence River near Massena (Carpenter et al. 2001). The final number of zip codes identified to contain or abut PCB-contaminated sites was 187. Of these, 78 abut the Hudson River; the others were distributed throughout the state.

Data on outcomes and potential confounders/effect modifiers were derived from birth certificates collected and stored in New York State Department of Health Vital Statistics files for the years 1994–2000. To estimate socioeconomic status, we used the estimated mean per capita income for 1997 (midpoint between the beginning and the end of the study) in the zip code of the mother’s residence. This information was obtained from the New York State Department of Health, which in turn uses data produced by Claritas Inc. (San Diego, CA).

Inclusion criteria. We analyzed all births recorded in New York State hospitals from years 1994 through 2000. There were 1,871,594 births recorded during this time span. We excluded all births to New York City residents (885,685) and to out-of-state residents (3,324), and all plural births (35,144). Observations where data on baby’s sex were missing and births where the recorded baby’s birth weight was < 500 g or > 7,500 g (these values must be a result of miscoding) were also excluded (2,364). These exclusions produced a final sample size of 945,077 births.

Statistical methods. We performed bivariate analysis to look at the distribution of potential confounders between exposed (defined as residence in a PCB zip code) and unexposed groups (defined as residence in a zip code that doesn’t have PCBs). Then two separate multiple logistic models were fitted for two outcomes: low birth weight and very low birth weight. Low birth weight was defined as infants weighing between 1,500 and 2,500 g at birth, and very low birth weight was defined as infants weighing < 1,500 g. Finally, the model for probability of having a low-birth-weight baby was stratified by sex of the baby.

Potential confounders and effect modifiers. Variables that have been reported to be independent risk factors for low birth weight/very low birth weight were considered potential confounders/effect modifiers in our regression models. The most important risk factor for the outcomes of interest is short gestational age. We input the number of completed weeks of gestation as a continuous variable in both models. The rest of the variables were categorized before being included in the model, and all are adjusted for gestational age. Mother’s age was stratified into three groups: ≤ 18 years or younger, 19–39 years old, and ≥ 40 years. Because paternal age has also been identified by some researchers (Abel et al. 2002) as a risk factor, a variable indicating father’s age was included into the model and was classified as ≤ 18 years and ≥ 19 years. The mothers were grouped by race into white, African American, and other. Mother’s education was classified as less than or up through high school or having some postsecondary education. We used the lowest 10th percentile of distribution of mother’s prepregnancy weight and mother’s height in the study sample to define the cutoff point for low maternal weight before pregnancy and maternal short stature. They were found to be 110 lb for maternal weight and 61 inches for maternal height. We estimated parent’s socioeconomic status on the basis of two variables: mean per capita income in the zip code of the mother’s residence, and the primary payer for birth. The mean per capita income was classified as < $15,000 and ≥ $15,000. The primary payers for birth were categorized as Medicaid/self-paid and other, which is expected to indicate parents of lower and higher socioeconomic status, respectively, because “other” is assumed to mean coverage by health insurance.

The information on mother’s smoking was obtained from the birth certificate and had two categories: yes/no. Single motherhood was defined as absence of any information on the father in the birth certificate.

Results
Among the total of 945,077 births, the PCB zip code group constituted 24.5% (231,583) and the non-PCB group was 75.5% (713,494) of the study sample. The mean birth weight in the PCB group was 3,386.7 g, whereas in the non-PCB group it was 3,408.3 g. The difference of 21.6 g was statistically significant, with a p-value < 0.0001. There was no significant difference in rates of very low-birth-weight infants between the two groups. The low-birth-weight rates were 5.7% and 5.0% and very low-birth-weight rates were 0.94% and 0.85% in the PCB group and non-PCB groups, respectively. The yearly distribution of low-birth-weight and very low-birth-weight rates showed a slight upward trend and followed the same pattern among the PCB and non-PCB groups (Figure 1). The upward trend is consistent with national statistics (Centers for Disease Control and Prevention 1994).

Table 1 presents the distribution of potential confounders among the PCB and non-PCB groups. There was no difference in the sex ratio between the PCB and non-PCB sites. Several variables do have a different pattern of distribution between these two groups. The PCB-contaminated zip codes have a higher percentage of African-American population (13.4 vs. 9.6%), teenage mothers (6.9 vs. 4.6%), and teenage fathers (1.7 vs. 1%) and a higher percentage of people with mean per capita annual income < $15,000 (28.5 vs. 18.9%) compared with the non-PCB group. There was also a larger proportion of women for whom Medicaid is the primary payer (32.4 vs. 24.5%).
In addition, women in the PCB zip codes were less likely to have postsecondary education (49.6 vs. 56.4%) and more likely to smoke (18.7 vs. 14.2%) and to be single mothers (16.9 vs. 11.6%).

The logistic regression models for both low and very low birth weight had 15 terms, including intercept. Overall, the fit of the model was good with concordance of 87% for the low-birth-weight model and 95% for the very low-birth-weight model. Table 2 shows the estimated odds ratios (ORs) for giving birth to an infant with low birth weight, with 95% confidence interval (CI) for each variable, calculated on the basis of the estimates of β-coefficients and standard errors given by the model. The OR for weeks of gestation is not included in Table 2, because this variable was modeled as a continuous variable, and all other variables are adjusted for gestational age. However, gestational age was found to be a very significant risk factor for the outcome of interest. The OR for gestational age given by the model was 0.6, which means that each additional week of gestation lowers the risk of having a low-birth-weight baby by 1.7 times. Other risk factors for having a low-birth-weight baby in order from the strongest to the weakest are maternal smoking (OR = 2.08; 95% CI, 2.02–2.14), maternal weight before pregnancy <110 lbs (OR = 1.66; 95% CI, 1.61–1.71), African-American race of the mother (OR = 1.63; 95% CI, 1.58–1.68), female sex of the baby (OR = 1.43; 95% CI, 1.40–1.46), maternal age ≥ 39 years (OR = 1.38; 95% CI, 1.30–1.47), maternal height <61 inches (OR = 1.29; 95% CI, 1.25–1.33), and female sex of the baby (OR = 1.22; 95% CI, 1.15–1.30). Interestingly, mother’s age ≤ 18 years, low mother’s educational level, and Medicaid or nonwhite race of the mother (OR = 1.29; 95% CI, 1.22–1.37), Medicaid or self-paid (OR = 1.03; 95% CI, 0.99–1.07) or for non-white race of the mother or single motherhood. Several variables that were predictors of low birth weight remain strong risk factors for very low birth weight, including African-American race of the mother (OR = 1.60; 95% CI, 1.48–1.74), maternal height < 61 inches (OR = 1.59; 95% CI, 1.746–1.72), maternal weight < 110 lbs (OR = 1.39; 95% CI, 1.28–1.51), maternal smoking (OR = 1.25; 95% CI, 1.15–1.35), and female sex of the baby (OR = 1.22; 95% CI, 1.15–1.30).

Table 1. Distribution of potential confounders between exposed and unexposed groups.

| Variable | PCB-contaminated sites | PCB-free sites |
|----------|------------------------|---------------|
| No. | Percent | No. | Percent |
| Sex of babies | | | |
| Male | 118,909 | 51.3 | 365,000 | 51.2 |
| Female | 112,674 | 48.7 | 348,494 | 48.8 |
| Race | | | |
| White | 192,191 | 83.5 | 618,065 | 87.0 |
| African American | 30,955 | 13.4 | 68,492 | 9.6 |
| Other | 7,091 | 3.1 | 23,698 | 3.3 |
| Length of gestation (weeks) | | | |
| < 37 | 20,080 | 9.0 | 56,919 | 8.2 |
| ≥ 37 | 204,193 | 91.0 | 634,062 | 91.8 |
| Mother's age (years) | | | |
| ≤ 18 | 16,009 | 6.9 | 33,042 | 4.6 |
| 19–39 | 210,214 | 90.9 | 658,534 | 92.6 |
| ≥ 40 | 4,987 | 2.2 | 19,511 | 2.7 |
| Father's age (years) | | | |
| ≤ 18 | 3,178 | 1.7 | 6,516 | 1.0 |
| ≥ 19 | 188,484 | 98.3 | 621,591 | 99.0 |
| Mother's education | | | |
| No education | 308 | 0.1 | 618 | 0.1 |
| High school only | 114,267 | 50.5 | 305,323 | 43.5 |
| Postsecondary education | 112,543 | 49.6 | 396,023 | 56.4 |
| Mother's weight before pregnancy (lbs) | | | |
| < 110 | 16,666 | 7.7 | 49,737 | 7.5 |
| ≥ 110 | 200,225 | 92.3 | 612,750 | 92.5 |
| Mother's height (inches) | | | |
| < 61 | 17,043 | 7.9 | 46,342 | 7.3 |
| ≥ 61 | 198,866 | 92.1 | 587,274 | 92.7 |
| Average annual per capita income in the ZIP code of residence | | | |
| $0–15,000 | 60,058 | 28.5 | 134,493 | 18.9 |
| $15,000–34,999 | 161,124 | 69.6 | 532,262 | 73.3 |
| ≥ $35,000 | 4,401 | 1.9 | 55,718 | 7.8 |
| Primary payer for birth | | | |
| Medicaid | 72,965 | 32.4 | 167,970 | 24.5 |
| Self-paid | 3,881 | 1.7 | 13,599 | 2.0 |
| Other | 148,517 | 65.9 | 505,170 | 73.6 |
| Mother's smoking | | | |
| Yes | 42,899 | 18.7 | 99,502 | 14.2 |
| No | 186,540 | 81.3 | 505,170 | 85.8 |
| Single motherhood | | | |
| Yes | 39,222 | 16.9 | 82,471 | 11.6 |
| No | 192,361 | 83.1 | 631,023 | 88.4 |

Table 2. Estimated ORs (95% CIs) for risk of having low-birth-weight babies.

| Variables | OR (95% CI) |
|-----------|-------------|
| PCB | 1.24 (1.02–1.50) |
| Female sex of the baby | 1.43 (1.40–1.46) |
| African-American race of the mother | 1.63 (1.58–1.68) |
| Nonwhite race of the mother | 1.29 (1.22–1.37) |
| Mother’s age ≤ 18 years | 1.08 (1.03–1.13) |
| Mother’s age > 39 years | 1.38 (1.30–1.47) |
| Father’s age ≤ 18 years | 1.01 (0.92–1.12) |
| Mother’s educational level less than or equal to high school grades | 1.06 (1.04–1.09) |
| Parents annual per capita income < $15,000 | 1.03 (1.00–1.06) |
| Medicaid/self-paid births | 1.12 (1.08–1.14) |
| Maternal weight before pregnancy < 110 lbs | 1.66 (1.61–1.71) |
| Maternal height < 61 inches | 1.29 (1.25–1.33) |
| Single motherhood | 1.04 (0.95–1.14) |
| Maternal smoking | 2.08 (2.02–2.14) |

*All variables are adjusted for gestational age (in weeks).
self-payment as the primary payer for births seem to exert a slight protective effect against the risk of having a very low-birth-weight baby.

**Discussion**

Our results show that maternal residence in a zip code that contains or abuts a PCB-contaminated hazardous waste site results in a statistically significant 6% increased risk of giving birth to a male infant of low birth weight, after adjustment for other known risk factors. There was also a 3% increased risk of low birth weight for female infants, a value that almost reached statistical significance. These results suggest that simply living near a PCB-contaminated site poses a risk of exposure and of health impact, probably secondary to airborne spread of the PCBs. Although many PCB-contaminated sites also have other types of contaminants present, the disproportionate impact on male infants supports the conclusion that it is the PCBs that are responsible. A selective effect of PCB or dioxin/furan exposure on male infants has previously been reported in several other studies (Rylander et al. 1995, 1996; Varhiainen et al. 1998; Hertz-Picciotto et al. 2000).

**Limitations.** The main limitation of this study is the exposure assessment. The exposure was measured on a group level that cannot correctly represent the true level of individual exposure. Very little is known about the extent to which residents living near a waste site are exposed to PCBs (Steehr-Green et al. 1988). In general, the use of surrogate measures such as residence close to a waste site can lead to non-differential misclassification of exposure and decrease the sensitivity of the study to find a true effect (Vrijheid 2000). Moreover, exposure to PCBs from landfills or contaminated bodies of water, if such exposure exists, would be expected to be at very low concentrations. Associations with such low-level environmental exposures in the general population are by their nature hard to establish. Low-dose exposures are generally expected to generate small increases in relative risk that will be difficult to distinguish from noise introduced by confounding factors and biases.

Another potential source of exposure misclassification involves the assumption that the zip code at the time of birth reflects the residence where a woman lived before and during the critical period of her pregnancy. If a woman moved during pregnancy, then the zip code of her latest residency does not represent her exposure status. It appears that as many as 25% of women change residence between conception and the end of the first trimester (Khoury et al. 1988; Shaw and Malcoe 1991; Shaw et al. 1992). This type of misclassification error is also nondifferential with respect to outcome and tends to reduce the magnitude of the estimated effects (Copeland et al. 1977; Shaw et al. 1992).

Information on exposure and confounders derived from birth certificates is not always accurate and complete. Almost all study variables have some percentage of missing data. For some variables this percentage was relatively low (0.5% for race, 0.3% for mother’s age, and 1.7% for mother’s education and smoking). For other variables, the percentage of missing data was higher (3.2% for gestational age, 6.9% for maternal prepregnancy weight, and 10% for maternal height). If the data are randomly missing, it does not distort the effect estimates but could affect the standard error. We also cannot rule out some percentage of data miscoding.

With respect to potential confounders, we were limited to those that are present on the birth certificate. Several other variables in the birth certificate, such as maternal alcohol and drug use and mother’s comorbid conditions, were not included in our analysis because these variables had a high percentage of missing and miscoding data. Although we cannot completely rule out a contribution of these and possibly other unknown confounders, the fact that the relationship between low birth weight and PCB sites was stronger for male than for female infants supports the conclusion that PCB exposure was the critical factor.

No evidence indicates that other confounders would selectively affect male infant birth weight.

Overall, our results confirm previous observations on a number of risk factors for giving birth to an infant with low/very low birth weight.

**PCBs and low birth weight.** We have found that infants born to mothers who reside in PCB-contaminated zip codes give birth to infants who are on average 21.6 g lighter than those born to mothers who do not live in PCB-contaminated zip codes. This value should be compared with the reports of Fein et al. (1984), who found that mothers who are contaminated Lake Michigan fish had infants 160–190 g lighter than those of controls, and of Taylor et al. (1984), who reported that women occupationally exposed to PCBs have infants 153 g lighter than those of controls. After adjustment for most known confounders, we find that maternal residence in proximity to waste sites contaminated by PCBs increases by 6% the risk of having a low-birth-weight male baby, whereas the risk of having a low-birth-weight female infant narrowly misses being significant, and there is no elevated risk of having a very low-birth-weight baby of either sex. Even though the added risk of giving birth to low-birth-weight male babies by women residing in proximity to PCB-contaminated zip codes is small, the observation is consistent with the hypothesis that living next to a PCB-contaminated site constitutes a risk of exposure and of adverse health effects. The sex-specific effect is important support for the conclusion that the risk is due to PCB exposure, because most other confounders are not known to exhibit selective effects on male infants, and we have controlled for the added general risk of low birth weight in female infants.

Several points are worth noting. We have no direct exposure assessment other than zip code of residence. Zip codes are of irregular shape, and residence in a zip code near a PCB site is certainly not the optimal indicator of exposure. Previous studies of this type (Shaw et al. 1992; Sosniak et al. 1994) found that merging a large population database with environmental data is an innovative but not very efficient method of assessing the risks of low birth weight related to the environment. On the other hand, the benefits of such investigations are that they are economical, they may be useful for identifying large risks not previously known, and they may be used as hypothesis-generating studies (Shaw et al. 1992). Use of birth records for a large geographic area such as New York State over several years provides sufficient power to detect relationships that would otherwise not be apparent. Furthermore, the inadequacy of the exposure assessment should obscure the relationship, which suggests that the true relationship between PCB exposure was not significant.

**Table 3. Estimated ORs (95% CIs) for risk of having very low-birth-weight babies.**

| Variables                                    | OR (95% CI)         |
|----------------------------------------------|---------------------|
| PCB                                          | 0.95 (0.89–1.02)    |
| Female sex of the baby                       | 1.22 (1.15–1.30)    |
| African-American race of the mother          | 1.60 (1.48–1.74)    |
| Nonwhite race of the mother                  | 0.98 (0.81–1.17)    |
| Mother’s age ≥ 18 years                      | 0.81 (0.71–0.93)    |
| Mother’s age ≥ 30 years                      | 1.16 (0.98–1.37)    |
| Father’s age ≥ 18 years                      | 0.94 (0.73–1.21)    |
| Mother’s educational level less than or equal to high school grades | 0.98 (0.80–1.09)    |
| Parents annual per capita income < $15,000   | 1.08 (1.00–1.17)    |
| Medicaid/self-paid births                    | 0.88 (0.81–0.95)    |
| Maternal weight before pregnancy < 110 lbs   | 1.39 (1.28–1.51)    |
| Maternal height ≤ 61 inches                  | 1.95 (1.46–1.72)    |
| Single motherhood                            | 0.79 (0.66–1.10)    |
| Maternal smoking                             | 1.22 (1.15–1.35)    |

*All variables are adjusted for gestational age (in weeks).*
and low birth weight of male infants (and probably female infants as well) is actually greater than we have demonstrated. To identify the risk of maternal residence in selected zip codes, more detailed studies measuring the actual serum level of PCBs in women living in these zip codes are needed.

If living in a PCB-contaminated zip code indeed poses a risk of low birth weight in male infants, there is a question of the route of exposure to the mother. Consumption of PCB-contaminated fish is the best-documented route of exposure (Fein et al. 1984; Jacobson JL et al. 1998; Jacobson SW et al. 1985; U.S. Department of Health and Human Services 2000), but sport fishers are not defined by the zip code in which they live. The most likely route of exposure is airborne (Currado and Harrad 1998), either through inhalation of volatile PCBs or PCBs bound to particulates or through ingestion of PCB-contaminated particulates with foodstuffs. Inhalation as a route of exposure has not received much attention, but there is considerable evidence that PCBs volatilize, especially from contaminated bodies of water (Chiarenzelli et al. 2000) and wet sediments (Bushart et al. 1998; Chiarenzelli et al. 1996). Volatile PCBs can be absorbed through inhalation (Casey et al. 1999). PCBs are widely distributed in the food chain (U.S. Department of Health and Human Services 2000), and even remote places will have measurable PCBs in the air (Lohmann et al. 2001). Therefore, there is no exposed population, and our results reflect only the effects of gradients of exposure. This fact also suggests that the risks of low birth weight that we have demonstrated are underestimations of the actual risk.

We did not find as strong a relationship between residence in a PCB-contaminated zip code and gestational age as others have reported (Fein et al. 1984; Taylor et al. 1984, 1989), who have suggested that gestational age is the major cause of low birth weight after PCB exposure. The reason for this is not clear, but it most likely reflects a lack of accuracy in the reporting of gestational age (from last menstrual period) in the vital statistics database. Animal studies have demonstrated that PCBs stimulate contraction of pregnant rat uterine muscle (Bac et al. 1999a, 1999b), which is likely the mechanism by which PCBs cause a shortened gestational age. It is interesting that this is a property of lower chlorinated, non–dioxin-like congeners, not the dioxin-like congeners (Tsai et al. 1996). Such congeners are more volatile and less persistent, but still may have health effects.

A separate issue raised by the present study is the inequity of locating hazardous waste sites and hazardous materials. The analysis of distribution of potential risk factors for giving birth to a low-birth-weight/very low-birth-weight baby indicates that the PCB group has a higher risk not only because of proximity to waste sites but also because of race and income level (Table 1). This means that hazardous waste sites and the locations of hazardous materials are either disproportionately situated near minority communities, especially African-American communities and low-income communities, or that such places are unattractive to those who can afford to choose to live elsewhere.

These studies have confirmed several known risk factors for low birth weight and have also found 6% increased risk associated with living near a PCB-contaminated site and giving birth to a male infant of low birth weight. Because low birth weight is itself a risk factor for infant morbidity and mortality and a number of chronic diseases in adulthood, even a small increased risk has important public health implications. Furthermore, because zip code of residence is an inexact exposure assessment, it is likely that our results significantly underestimate the true risk from PCB exposure. Perhaps the most significant conclusion from these observations is that they provide additional support for the hypothesis that simply living near a PCB-contaminated site is a risk of exposure and of adverse health effects. The fact that the relationship was found only for males is consistent with this effect being secondary to PCB exposure, because most other confounders are not known to have a sex-specific effect.

References

Abel EL, Kruger M, Burd L. 2002. Effects of maternal and paternal age on Caucasian and Native American preterm births and birth weights. Am J Perinatol 19:49–54.
Aldous MB, Edmonson MB. 1993. Maternal age at first birth and risk of low birthweight and preterm delivery in Washington State. J Am Med Assoc. 270:2574–2577.
ATSDR. 2000. Toxicological Profile for Polychlorinated Biphenyls (Update). Contract No. 205-1999-00024. Atlanta, GA:Agency for Toxic Substances and Disease Registry.
Bae J, Peters-Golden M, Loehr-Carusus R. 1999a. Stimulation of pregnant rat uterine contraction by the polychlorinated biphenyl (PCB) mixture Aroclor 1242 may be mediated by arachidonic acid release through activation of phospholipase A2 enzymes. J Pharmacol Exp Ther 289:1112–1120.
Bae J, Stuenkel EL, Loehr-Carusus R. 1999b. Stimulation of uterine contraction by the PCB mixture Aroclor 1242 may involve increased (Ca2+)2 through voltage-operated calcium channels. Toxicol Appl Pharmacol 155:261–272.
Baker D, Greenland S, Mendlein J, Hanson P. 1988. A health study of two communities near the Stingy festive waste disposal site. Arch Environ Health 43:325–334.
Barker DP, 1999. In utero programming of cardiovascular disease. Theobalaria 16:23–58.
Berry M, Bove F. 1987. Birth weight reduction associated with residence near a hazardous waste landfill. Environ Health Perspect 105:856–861.
Bove F, Tchabo JG. 1988. Nutrition intervention program in a prenatal clinic. Obstet Gynecol 73:310–312.
Bushart SP, Bush B, Barnard EL, Bott A. 1988. Volatilization of extensively dechlorinated polychlorinated biphenyls from historically contaminated sediments. Environ Toxicol Chem 17:1927–1933.
Carpenter DP, Shen Y, Nuygen T, Le L, Linnerin L. 2001. Incidence of endocrine disease among residents of New York Areas of Concern. Environ Health Perspect 109:849–850.
Casey AC, Berger DF, Lombardo JP, Hunt A, Quimby F. 1999. Aroclor 1242 inhalation and ingestion by Sprague-Dawley rats. J Toxicol Environ Health 56:311–342.
Fein GG, Jacobson JL, Jacobson SW, Schwartz PM, Dowler JK. 1984. Prenatal exposure to polychlorinated biphenyls: effects on birth size and gestational age. J Pediatr 105:315–320.
Forset T, Eriksson J, Tuomilehto J, Reunanen A, Osmond C, Barker D. 2000. The fetal and childhood growth of persons who develop type 2 diabetes. Ann Intern Med 132:176–182.
Gilbertson M, Brophy J. 2001. Community health profile of Windsor, Ontario: Canada. In: The Great Lakes Area of Concern. Environ Health Perspect 109:827–843.
Goldenberg GS, Goulet L, Riberdy H, Bonvayt V. 1995. Low birth weight and preterm births among infants born to women living near a municipal solid waste landfill site in Montreal, Quebec. Environ Res 69:37–50.
Goldenberg RL, Cliver SP, Neegens Y, Copper RL, Dubard M, Davis RG, et al. 1997. The relationship between maternal characteristics and fetal and neonatal anthropometric measurements in women delivering at term: a summary. Acta Obstet Gynecol Scand 76(suppl8):1–13.
Goldman LR, Paigen B, Maganint MM, Highland JH. 1985. Low birth weight, prematurity, and birth defects in children living in the hazardous waste site, Love Canal. Hazard Waste Hazard Mater 2:209–223.
Haste PM, Brooke DG, Anderson HR, Bland JM, Shaw A, Griffin J, et al. 1990. Nutrient intakes during pregnancy: observations on the influence of smoking and social class. Am J Clin Nutr 51:29–36.
Herceg A, Simpson JM, Thompson JF. 1994. Risk factors and outcomes associated with low birthweight delivery in the Australian Capital Territory 1989–90, National Centre for Epidemiology and Population Health, Australian National University. J Paed Child Health 30:331–335.
Hertz-Picciotto I, Keller J, Williams J, Teplin S, Charles MJ. 2000. Fetal and early childhood growth in relation to prenatal PCB and organochlorine pesticide exposures. Organochlorine Compounds 48:163–186.
Hol WJ, Danoff NL, Mueller BA, Swanson MW. 1997. The association of change in maternal marital status with birth and adverse pregnancy outcomes in the second birth. Paediatr Perinatal Epidemiol 1:31–40.
Jacobson JL, Jacobson SW, Humphrey HE. 1990. Effects of in utero exposure to polychlorinated biphenyls and related contaminants on cognitive functioning in young children. J Pediatr 116:28–36.
Jacobson SW, Fein GG, Jacobson JL, Schwartz PM, Dowler JK. 1985. The effects of intrauterine PCB exposure on visual recognition memory. Child Dev 56:255–260.
Kloster M, Vorhahm J, Smith SM, Loehr-C, Armstrong R, et al. 1997. A community-based study of adverse pregnancy outcomes near a large hazardous waste landfill in California. Toxicol Ind Health 13:299–310.
Khoury MJ, Stewart W, Fries P, Langan MM, Highland JH. 1985. Low birth weight, prematurity and birth defects in children living in the hazardous waste site, Love Canal. Hazard Waste Hazard Mater 2:209–223.
Kloster M, Vorhahm J, Smith SM, Loehr-C, Armstrong R, et al. 1997. A community-based study of adverse pregnancy outcomes near a large hazardous waste landfill in California. Toxicol Ind Health 13:299–310.
Law CM, Egger P, Dada O, Delgado H, Kyberg E, Lavin P, et al. 2001. Body size at birth and blood pressure among children in developing countries. Int J Epidemiol 30:57–59.

Lohmann R, Ockenden WA, Shears J, Jones KC. 2001. Atmospheric distribution of polychlorinated dibenzo-p-dioxins, dibenzofurans (PCDD/Fs), and non-ortho biphenyls (PCBs) along a north-south Atlantic transect. Environ Sci Technol 35:4046–4053.

Luke B, Williams C, Minogue J, Keith L. 1993. The changing pattern of infant mortality in the US: the role of prenatal factors and their obstetrical implications. Int J Gynaecol Obstet 40:199–212.

New York State Department of Health. 1994–2000. Vital Statistics, Bureau of Production Systems Management. Albany, NY: New York State Department of Health.

Olsen J, Frische G. 1994. Low birth weight, stillbirth and congenital malformations. Social differences. Ugeskr Laeger 156:5519–5523.

Rich-Edwards JW, Colditz GA, Stamper MJ, Willett WC, Gillman MW. 1999. Birthweight and the risk for type 2 diabetes mellitus in adult women. Am J Epidemiol 149:5519–5523.

Rylander L, Stromberg U, Dyemark E, Ostman C, Nilsson-Ehle P, Hagmar L. 1998. Polychlorinated biphenyls in blood plasma among Swedish female fish consumers in relation to low birth weight. Am J Epidemiol 147:493–502.

Rylander L, Stromberg U, Hagmar L. 1995. Decreased birthweight among infants born to women with a high dietary intake of fish contaminated with persistent organochlorine compounds. Scand J Work Environ Health 21:368–375.

———. 1996. Dietary intake of fish contaminated with persistent organochlorine compounds in relation to low birthweight. Scand J Work Environ Health 22:260–266.

———. 2000. Lowered birth weight among infants born to women with a high intake of fish contaminated with persistent organochlorine compounds. Chemosphere 40:1255–1262.

Shaw GM, Maceo LH. 1991. Residential mobility during pregnancy for mothers of infant with cardiac anomalies and controls. Arch Environ Health 46:310–312.

Shaw GM, Schulman J, Cummins SK, Harris JA. 1992. Congenital malformations and birthweight in areas with potential environmental contamination. Arch Environ Health 47:757–760.

Stehr-Green PA, Burse VW, Welty E. 1988. Human exposure to polychlorinated biphenyls at toxic waste sites: investigation in the United States. Arch Environ Health 43:430–424.

Taylor PR, Lawrence CE, Hwang HL, Paulson AS. 1984. Polychlorinated biphenyls: influence on birthweight and gestation. Am J Public Health 74:1153–1154.

Taylor PR, Steima JM, Lawrence CE. 1989. The relation of polychlorinated biphenyls to birth weight and gestational age in the offspring of occupationally exposed mothers. Am J Epidemiol 129:395–406.

Tsai M-L, Webb CR, Loh-Caruso R. 1996. Congener-specific effects of PCBs on contractions of pregnant rat uteri. Reprod Toxicol 10:21–28.

Vartiainen T, Jaakkola JJK, Saarikoski S, Tuomisto J. 1998. Birth weight and sex of children and the correlation to the body burden of PCDDs/PCDFs and PCBs of the mother. Environ Health Perspect 106:61–66.

Vartiainen T, Jaakkola JJK, Saarikoski S, Tuomisto J. 1998. Birth weight and sex of children and the correlation to the body burden of PCDDs/PCDFs and PCBs of the mother. Environ Health Perspect 106:61–66.

Vrijheid M. 2000. Health effects of residence near hazardous waste landfill sites: a review of epidemiologic literature. Environ Health Perspect 108:101–112.

Williams MD. 1998. Lower socioeconomic status and increased mortality: early childhood roots and the potential for successful interventions. J Am Med Assoc 279:1745–1746.