# Hazardous Waste Sites, Industrial Facilities, and Adverse Pregnancy Outcomes in Dallas, Denton, and Tarrant Counties, 1997 - 2000

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Introduction

There is ongoing public concern regarding the potential relation between residential proximity to hazardous waste sites or industrial facilities and adverse birth outcomes. In the past, public health researchers had to rely on self-reports of residential proximity to these sites, especially when looking at large numbers of people. The advent of geographic information systems (GIS) has significantly increased the ability to examine the relation between living near such sites and adverse birth outcomes including congenital malformations.

With the use of GIS, several studies found an association between living near hazardous waste sites and all congenital malformations combined (Geschwind et al., 1992), chromosomal anomalies (Vrijheid et al., 2002; Orr et al., 2002), neural tube defects (Geshwind et al., 1992; Croen et al., 1997; Dolk et al., 1998; Orr et al., 2002) and heart/circulatory defects (Croen et al., 1997; Dolk et al., 1998; Yauck et al., 2004). On the other hand, no relation was noted between maternal residential proximity to waste sites in Texas and 1996 - 2000 births with neural tube defects (Suarez et al., 2007), oral clefts (Brender et al., 2006a), or chromosomal anomalies with the exception of Klinefelter variants (Brender et al., 2008). Malik et al. (2004) noted a slight increase risk for offspring with congenital heart disease among Dallas residents who lived within one mile of a hazardous waste site at delivery.

Compared with hazardous waste sites, less research has been conducted on the relation between maternal residential proximity to industrial facilities and birth defects. In New York State, Marshall et al. (1997) noted a slightly elevated risk of central nervous system defects among births to women who lived near industrial facilities (required to report as part of the Toxic Release Inventory [TRI]) that emitted solvents or metals into the air. Among 1996 – 2000 Texas births, Suarez et al. (2007) also found a maternal residence within a mile of a TRI facility with solvent emissions to be modestly associated with neural tube defects. A positive association was seen as well between living near facilities with emissions of polycyclic aromatic hydrocarbons (PAHs) and these defects in offspring. In this Texas birth population, a maternal residence within a mile of a TRI facility was most strongly associated with birth defects to offspring of older (≥ 35 years) women including isolated oral clefts (odds ratio [OR] 2.4, 95% confidence interval [CI] 1.3, 4.2) (Brender et al., 2006a); neural tube defects (OR 2.7, 95% CI 1.4, 5.0) (Suarez et al., 2007); and chromosomal anomalies (women ≥ 40 years, OR 4.8, 95% CI 1.2, 42.8) (Brender et al., 2008). Among older women (≥ 38 years) residing in Milwaukee, Wisconsin, a maternal address at delivery within 1.32 miles of one or more trichloroethylene-emitting sites (industries or waste sites) was associated with a three-fold increase of congenital heart disease among offspring (Yauck et al., 2004).

In contrast, Bhopal et al. (1999) found no evidence that living close to steel and petrochemical industries (in the United Kingdom) increased risk for adverse birth outcomes including low birth weight, still births, or fetal abnormalities (major congenital anomalies). Wulff et al. (1996) also did not detect an overall increased risk of congenital malformations in offspring of women living near a smelter in Northern Sweden; however, these women were more likely to have births with chromosomal anomalies (OR 2.6, 95% CI 0.90, 6.7).

As part of Contract No. 2008-024788, we examined the relation between living near hazardous waste sites and industrial facilities that reported air emissions of chemicals and selected adverse pregnancy outcomes in three North Texas counties including Dallas, Denton, and Tarrant counties. Specific objectives of this project included the following:

1. To examine the relation between maternal residential proximity to state and National Priority List (NPL) hazardous waste sites and births with selected birth defects (neural tube defects, isolated oral clefts, conotruncal heart defects, and chromosomal anomalies) for the combined three-county area and separately for each county.
2. To examine the relation between maternal residential proximity to industries reporting air releases of chemicals (under the Toxic Release Inventory [TRI]) and births with selected birth defects (as indicated under objective 1) for the combined three-county area and separately for each county.
3. To examine the relation between maternal residential proximity to state and National Priority List (NPL) hazardous waste sites and the percent of preterm and low birth weight births for the combined three-county area and separately for each county.
4. To examine the relation between maternal residential proximity to industries reporting air releases of chemicals and the percent of preterm and low birth weight births for the combined three-county area and separately for each county.
5. To explore the relation between maternal characteristics (race/ethnicity, age, education, prenatal care, and Medicaid status) and residential proximity to hazardous waste sites and industrial facilities in the three-county area.

Methods

The data for this study were taken from a statewide Texas study that linked locations of various environmental entities to residences at delivery of mothers who gave birth to offspring with selected birth defects and comparison mothers of births without major birth defects (Brender et al., 2006). Birth defect data for births occurring 1996–2000 were obtained from the Texas Birth Defects Registry (TBDR) at the Texas Department of State Health Services (DSHS). During this period, birth defect data were available for 1997 through 2000 for Public Health Region 3 which included the three county-area of interest (Dallas, Denton, and Tarrant counties). The Registry uses the Centers for Disease Control modification of the British Paediatric Association (BPA) codes for birth defects, a modification of the International Classification of Diseases 9$^{th}$ revision (ICD-9) codes. Only cases in which the defect was diagnosed prenatally or within one year after delivery are included. Birth defects selected for this study included neural tube defects (BPA codes 740.000 – 742.090); conotruncal heart defects (BPA codes 745.000 – 745.010; 745.100 – 745.190; 745.200 – 745.210; 747.215; 747.230; 747.250; 746.000 – 746.090 with 745.480 or 745.490, then scanned to exclude muscular ventricular septal defects; 746.995 with 745.480 or 745.490, then scanned to exclude muscular ventricular septal defects; 747.310, 746.840); oral clefts (BPA codes 749.000 – 749.220); and all chromosomal malformations (BPA codes 758.000 – 758.990).

Comparison births were randomly selected and frequency matched to case births by year of birth (1997 – 2000 for the three-county area and 1996 – 2000 for applicable Public Health Regions other than Public Health Region 3) and public health region of maternal residence as recorded on the birth certificate (11 regions in Texas). Prior to selection of this random sample, we removed all births that had been identified by the Birth Defect Registry as having a birth defect. Case births with the congenital malformation of interest were linked to their respective birth and fetal death records, and these data were merged with the comparison birth file to form the complete data set for case and control births. Maternal addresses of cases were taken from vital records unless missing and then addresses from medical records were used. The only addresses available for controls were from those on vital records. Maternal addresses were geocoded with the geocoding tool ArcGIS 8.3 Centrus GeoCoder for ArcGIS plug-in with its accompanying reference street database (Zhan et al., 2005) and completed without knowledge of case or control status. The Texas Department of State Health Services, Texas State University, and Texas A&M University Institutional Review Boards approved the original study protocol.

Comparison births without major birth defects served as the population source for preterm births and low birth weight births. In these analyses, preterm birth was defined as a gestation of less than 37 weeks and low birth weight was defined as less than 2500 grams. Comparison births were respectively those with a gestation of 37 weeks or more and a birth weight of at least 2500 grams. In these analyses, births with major congenital malformations were excluded.

*Environmental Data*

Environmental data were obtained from three sources. Data regarding National Priority List (NPL) superfund sites were downloaded from the ATSDR online Hazardous Substances Release/Health Effects Database (HazDat) (Agency for Toxic Substances and Disease Registry, 2005), including information about site characteristics and contaminants present by environmental media and maximum concentrations found. The Texas Commission on Environmental Quality (TCEQ) online superfund database (Texas Commission on Environmental Quality, 2005) provided information regarding site status (active/deleted) and geographic coordinates (point locations). Because the ATSDR HazDat database did not contain information on state superfund sites, we abstracted environmental data for these waste sites from paper and microfilmed files stored at TCEQ in Austin, Texas. Downloaded NPL and abstracted state superfund data were merged into one file that contained site and chemical-specific information for hazardous waste sites in Texas.

Land area of hazardous waste sites in Texas ranged from less than 2 to 760 acres. To account for varying land area and reduce misclassification of proximity that would have been introduced by using point locations, Dr. Ben Zhan and his staff digitized the boundaries of these sites from Digital Orthophoto Quarter Quads (DOQQ) images with a 1-meter resolution. These images were obtained from the Texas Natural Resources Information System (TNRIS).

Data regarding Texas industries with air emissions of chemicals were obtained from the United States Environmental Protection Agency (EPA) Toxic Release Inventory (TRI) program (U.S. Environmental Protection Agency, 2005). Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) mandates reports from certain businesses each year on the amounts of EPCRA Section 313 chemicals that these facilities release into the environment. A company is required to report as part of the TRI if it is included in a covered standard industrial code (SIC), has 10 or more employees, and it manufactures, imports, processes, or otherwise uses any of the 650+ EPCRA Section 313 chemicals in amounts greater than the threshold quantities specified. These databases contain information on each reporting facility for location (address, latitude and longitude), year of report, chemicals released (name, CAS number, amount released in pounds, environmental media), and type of industry (SIC code). These industries were further classified by whether they were a petroleum refinery (SIC Major Group 29: Petroleum Refining and Related Industries), primary metals or smelter facility (SIC Major Group 33: Primary Metal Industries), or a chemical industry (SIC Major Group 28: Chemicals and Allied Products).

Dr. Zhan and his staff examined the company-reported locational information and found several errors such as addresses in Texas assigned geographic coordinates outside of the state. Therefore, street addresses of the actual locations of industrial facilities were geocoded by the original study team to increase the degree of positional accuracy and reduce misclassification of distances between maternal residences and these facilities.

Site contaminants at hazardous waste sites and air releases from industries were further classified by whether heavy metals, polycyclic aromatic hydrocarbons, or solvents were involved. Solvents were also specified by structural categories (e.g. alcohols, aromatic hydrocarbons, alkyl halides) based on Sullivan's classification of these compounds (Sullivan, 2003).

*Data Linkage and Analysis*

All related databases were combined to create a comprehensive geographic information system (GIS) within the ArcGIS environment. We also developed a query tool—called GIS-EpiLink—that provided functions to support a variety of queries to link environmental data and cases and controls based on different combinations of chemicals, type of birth defects, and the distance between a maternal residence location and a hazardous waste site or industrial facility (Zhan et al., 2006). Different queries were performed between industrial facilities and hazardous waste site databases and the maternal residential files to identify women who had birth addresses within 10 miles of these sites or facilities. Actual distances within 10 miles were incorporated into the maternal residential files. This large buffer area with distances in miles as output was chosen to allow for flexibility in developing smaller buffer zones of various sizes and to allow for comparisons with other published studies. Maternal addresses were related to locations of those hazardous waste sites that were still active (undergoing clean up) during year of the index birth (1996 – 2000 birth defects cases and birth certificate controls). Locations of industrial facilities were related by year to the corresponding year(s) of maternal addresses during the year of the index birth.

In all analyses with sufficient numbers of cases and comparison, separate analyses were performed for each of the three counties, the three counties combined, Public Health Region 3, and public health regions other than 3 combined. Odds ratios and 95% confidence intervals were computed with SPSS (version 15.0 Chicago, Illinois). Because of small numbers of potentially exposed birth defect cases, preterm births, and low birth weight births in the three counties of interest, we combined state and NPL hazardous waste sites into one group and examined the relation between living less than one mile and less than two miles from these sites and adverse pregnancy outcomes.

For the industrial facility analyses, we had sufficient numbers of cases and controls to examine the relation between types of facilities (petrochemical, primary metals/smelter, and chemical industry) and emissions (heavy metals, polycyclic aromatic hydrocarbons, solvents) within one mile of maternal residences and the selected pregnancy outcomes. Because both maternal race/ethnicity and education have been found to be associated with living near hazardous waste sites and industrial facilities in Texas (Brender et al., 2006b), we adjusted for these variables (maternal education [< 12, 12+ years]; maternal race/ethnicity [non-Hispanic white, Hispanic white, African American, other]) for all crude odds ratios that exceeded 1.0 and had respective 95% confidence intervals that excluded 1.0. Because of the sparse numbers of case- and control-mothers who lived near these sites and facilities, exact logistic regression was used to obtain these odds ratios adjusted for maternal race/ethnicity and education. Formulas for the unadjusted odds ratios, 95% confidence limits, and logistic regression (general format) are shown in Appendix A.

We also examined the relation between maternal characteristics of the study population and an address at delivery within one mile of a hazardous waste site or industrial facility. We examined maternal age (five categories ranging from less than 20 years to 35 years or older); maternal race/ethnicity (non-Hispanic white, African American, Hispanic, other); maternal education (0-8, 9-11, 12, 13-15, 16+ years), Medicaid status (on Medicaid or not), and prenatal care (yes/no). Odds ratios (OR) and 95% confidence intervals (CI) for living within one mile of one or more industrial sites or hazardous waste sites were calculated for each of the maternal characteristics. Logistic regression (SPSS 15.0, Chicago, Illinois) was used to obtain odds ratios adjusted for race/ethnicity and education. We also adjusted some estimates for maternal smoking (yes/no) and occupational exposure to solvents (yes, no, homemaker, unknown occupational status).

Results

Table 1 shows the number of cases and controls available for study in Dallas, Denton, and Tarrant counties for the study period 1997 – 2000. By county, the case- and control-mothers were similar with respect to race/ethnicity and education; however, case-mothers were more likely than control-mothers to be 35 years or older. This age difference can be attributed to the inclusion of case-mothers who gave birth to babies with chromosomal anomalies. A high proportion of the maternal addresses at delivery were geocoded in these counties ranging from 97% to 99%.

In the three counties combined, few women lived within one or two miles of a hazardous waste site (Table 2). Although the odds ratios were elevated for several birth defects in relation to residential proximity to these sites, most of these associations were consistent with the null (95% confidence intervals included 1.0). Women who gave birth to babies with isolated oral clefts were 5.7 times more likely (95% CI 1.3, 25.8) than control-mothers to live within one mile of a state or NPL superfund site. Adjustment for maternal race/ethnicity, education, and smoking had minimal effect on the risk estimate (adjusted OR 6.0). In Public Health Region 3 that contains Dallas, Denton, and Tarrant counties, mothers who gave birth to offspring with Down syndrome were more likely to live within one mile of a waste site than comparison mothers (OR 4.8, 95% CI 1.1, 21.5). With adjustment for maternal race/ethnicity, education, and age (categorized as < 35 years or 35 or more years), the odds ratio increased to 5.9 with an exact 95% confidence interval of 0.98, 41.6.

Mothers who gave birth to babies with NTDs were more likely to live within a mile of industrial facilities with reported air emissions of chemicals (Table 3) including primary metal/smelter and chemical manufacturing facilities (Table 4). With adjustment for maternal race/ethnicity, education, and smoking, living within one mile of an industrial facility in the three-county area was associated with neural tube defects in offspring (OR 1.9, 95% CI 1.3, 2.8), including anencephaly (OR 2.4, 95% CI 1.3, 4.6) and spina bifida (OR 1.8, 95% CI 1.1, 2.9). Positive associations were seen between living within one mile of facilities with emissions of heavy metals, PAHs, or solvents and NTDS. However, the odds ratio for NTDs in relation to living in close proximity to PAH emissions was consistent with the null due to sparse numbers of case- and control-mothers having this residential characteristic (Table 5). The risk estimates (in which the 95% CIs excluded 1.0) did not change appreciably with adjustment for maternal race/ethnicity or education except for that associated with a maternal residence within one mile of a primary metal/smelter facility and anencephalic births. With adjustment for maternal race/ethnicity and education, this odds ratio increased from 4.8 (Table 4) to 6.8 (95% CI 1.1, 29.1).

With adjustment for maternal race/ethnicity, education, and occupations with a likelihood of solvent exposure, mothers of offspring with neural tube defects were 1.7 times more likely (95% CI 1.1, 2.6) than comparison women to live within one mile of industrial facilities with reported emissions of solvents in the three counties of interest. Spina bifida in offspring also remained associated (OR 1.8, 95% CI 1.1, 3.0) with a maternal residence near such facilities with adjustment for these maternal characteristics. We did not conduct these additional analyses with anencephaly because 53% of these cases were fetal deaths, and computerized occupational information was not available from the Texas State Department of Health Services on fetal deaths. When we restricted our analyses to women listed as homemakers on the live birth certificate and examined the relation between maternal residential proximity to any industrial facility and neural tube defects, this residential characteristic remained associated with neural tube defects (OR 1.8, 95% CI 1.1, 3.0) including spina bifida (OR 1.8, 95% CI 1.0, 3.4).

When we examined the three counties separately, we found little evidence of an association between a maternal residence near waste sites and the selected birth defects of interest (Table 6). Among Tarrant county residents, women who gave birth to babies with non-Down chromosomal anomalies were 4 times more likely (95% CI 1.3, 12.4) to live within two miles of a hazardous waste sites. This association, based on 6 "exposed" cases and 7 "exposed" controls, was essentially unchanged with adjustment for maternal race/ethnicity and education. Several positive associations were noted between living within a mile of a hazardous waste site in Tarrant county and birth defects in offspring, but the confidence limits were very wide because of the sparse numbers of case- and control-mothers with this residential characteristic.

Considering each county separately, NTDs in offspring were associated with living within a mile of an industrial facility in Dallas, Denton, and Tarrant counties (Table 7), particularly chemical manufacturing facilities in Dallas and Denton counties (Table 8). Some risk estimates were confounded by maternal race/ethnicity and education. With adjustment for these variables, the odds ratio between living within a mile of an industrial facility in Denton county and NTDs increased (OR 6.9, 95% CI 0.69, 92.3) but decreased in Tarrant county (OR 1.9, 95% CI 0.95, 3.8). The 95% confidence intervals for both adjusted ORs were consistent with unity. Living within a mile of facilities with emissions of heavy metals in Dallas or Tarrant counties or solvents in the three counties was associated with NTDs in offspring (Table 9). Adjustment for maternal race/ethnicity and education changed some of the risk estimates by more than 10%, but these residential characteristics remained positively associated with NTDs in the adjusted odds ratios. Living within one mile of an industrial facility with solvent emissions was also associated with chromosomal anomalies in offspring to Tarrant county residents, but this relation was not seen among births to Dallas and Denton county residents.

With the three counties combined, very few control-women who had either preterm or low birth weight births lived in close proximity to waste sites (Table 10). Furthermore, living in close proximity to industrial facilities was only weakly associated with these pregnancy outcomes (Table 11), and the 95% confidence intervals around all odds ratios were consistent with unity. In the three-county area, low birth weight was associated with a maternal residence within a mile of a petrochemical facility (Table 12), but this association was based on small numbers of "exposed" cases and controls and confounded by maternal race/ethnicity and education (adjusted OR 6.4, 95% CI 0.58, 41.6).

Numbers of women, who lived within one mile of a waste site, were too sparse to explore any meaningful associations between this residential characteristic and preterm or low birth weight births (Table 14). In the separate county analyses, three noteworthy associations were found between a maternal residence within a mile of an industrial facility and low birth weight births. Women who lived near industrial facilities in Tarrant County were more likely to have births with low birth weight (Table 15), especially if these facilities had reported solvent emissions (Table 17). In contrast, this pregnancy outcome was more likely among women who lived near petrochemical facilities in Dallas (Table 16). None of the odds ratios changed appreciably with adjustment for maternal race/ethnicity and education.

For the three counties combined, numbers of women were too sparse to explore maternal characteristics related to living within one mile of a hazardous waste site. We noted several maternal characteristics associated with living in close proximity to industrial facilities in these counties including Hispanic ethnicity (relative to non-Hispanic Whites) and low levels of education (relative to 16 years or more of education) in the three counties combined (Table 18) and for Dallas and Tarrant counties (Denton county had insufficient numbers of women to conduct these analyses) (Table 19). Associations with maternal age were close to the null (1.0) with adjustment for maternal race/ethnicity and education. In contrast with other areas of Texas, African American women in the three-county area were only slightly more likely than non-Hispanic white women to live within a mile of industrial facilities. In Tarrant County, they were slightly less likely to live in close proximity to industries.

## Discussion

Overall, we found no convincing evidence that residents who lived in close proximity to state or NPL superfund sites in Dallas, Denton, or Tarrant counties were more likely to have the adverse pregnancy outcomes studied (low birth weight, preterm birth, or selected congenital malformations [neural tube defects, oral clefts, conotruncal heart defects, and chromosomal anomalies]). In all three counties, however, a maternal residence within a mile of one or more industrial facilities with reported air emissions of chemicals was associated with neural tube defects in offspring; this positive association was noted for both anencephaly and spina bifida. These associations were the strongest with residential proximity near facilities with reported emissions of heavy metals or solvents. Interestingly, associations between industrial facilities and NTDs were much weaker or nonexistent in public health regions other than Public Health Region 3.

Several studies conducted in other areas have found central nervous system defects and specifically NTDs in offspring associated with a maternal residence near waste sites and industrial facilities. In New York, Geschwind et al., (1992) found a modest relation between living within one mile of a waste site and nervous system defects (OR 1.4), although a later study in the same state (Marshall et al., 1997) found no such relation (OR 1.0). In California, women who lived within a mile of an NPL superfund site were slightly more likely to have offspring with NTDs (OR 1.4), but no effects were observed for living with one mile of "any waste site" (Croen et al., 1997).

Also among California residents, Orr et al. (2002) examined the relation between maternal address at delivery in a census tract with one or more NPL sites and birth defects. Associations were noted between this residential characteristic and NTDs (OR 1.5) including anencephaly (OR 1.9) and spina bifida (OR 1.3).

Compared with studies of waste sites, far fewer studies have been published regarding the relation between residential proximity to industrial sources of pollution and congenital malformations. Marshall et al. (1997) found women in New York State slightly more likely to give birth to offspring with central nervous system defects if they lived within a mile of a TRI site with reported emissions of solvents (OR 1.3) or metals (OR 1.4). The associations found in the New York study were less strong than those found in the present study.

About one-third of the industrial solvents tested have been teratogenic in laboratory studies of animals, with the inhalation and dermal routes of exposure having the strongest potential to induce malformations (Schardein, 2000). Several heavy metals such as arsenic, cadmium, and lead are neurotoxins, and the results of animal studies have suggested that these chemicals can induce central nervous system defects (Morrissey and Mottet, 1983; Ferm and Hanlon, 1986; Carpenter, 1987; Kultima et al., 2006; Sobtka and Rahwan, 1995). Changes in the expression of several genes with arsenic exposure might induce problems with morphogenesis, oxidative phosporylation, redox response, and regulation of I-kappaB kinase/NF-kappaB cascade leading to neural tube defects (Wlodarczyk et al., 2006). Cengiz et al. (2004) found whole-blood lead levels were significantly higher in women with a second-trimester termination due to fetal neural tube defects than second-trimester control women with normal fetal outcomes.

This study was limited by the numbers of low birth weight and preterm births available to examine the association of these outcomes with a maternal residence near waste sites and industrial facilities. Taking sample size into consideration, the only notable associations found were low birth weight births to residents in Tarrant County in relation to maternal residential proximity to TRI facilities, especially those with reported solvent emissions. Maternal exposures to environmental air pollution have been associated with both preterm birth (Tsai et al., 2003; Yang et al, 2004) and low birth weight (Lin et al, 2001; Dugandzie et al., 2006; Mannes et al., 2005) in other studies.

In the three-county area, mothers who were of Hispanic ethnicity or less educated were more likely to live within a mile of industrial facilities; these maternal characteristics were related to each other. Unlike the rest of Texas, however, African American women in the study counties were not more likely than non-Hispanic white women to live near such facilities at delivery. Perlin et al. (2001) found that African American children five years or younger were more likely than white children to live in close proximity to industrial sources of air pollution in three study areas located in West Virginia, Louisiana, and Maryland. In a study of air pollution during pregnancy, higher proportions of Hispanic, African-American, and Asian/Pacific Islander mothers than white mothers lived in areas with higher levels of ozone, particulate matter, sulfur dioxide, nitrogen dioxide, and carbon monoxide (Woodruff et al., 2003). With adjustment for maternal age, parity, marital status, and race/ethnicity, women with lower education attainment, however, were not more likely to live in areas of higher levels of air pollution than more educated women. In the present study, although adjustment for maternal race/ethnicity reduced the association between low maternal educational attainment and proximity to industrial facilities, women with less than nine years of education were

2.8 times more likely to live within a mile of such facilities relative to women with 16 years or more of education.

In this study, we used maternal address at delivery to determine residential proximity to waste sites and industrial facilities. We did not have information regarding maternal addresses shortly before conception or during the first trimester which would have been relevant respectively to the morphogenesis of chromosomal anomalies and structural defects such as neural tube defects, conotruncal heart defects, and oral clefts. In a study of Texas participants of the National Birth Defects Prevention Study, Canfield et al. (2006) found that 33% of case and 31% of control mothers changed residence between conception and delivery. Therefore, use of maternal address at delivery is likely to introduce nondifferential exposure misclassification and lead to risk estimates closer to the null.

The approach of using distances from waste site boundaries and industrial facility street addresses as proxies for potential exposure has limitations. Such an approach can introduce misclassification of exposure, and overlap of exposures may also occur in some instances, e.g. exposure to emissions of both solvents and heavy metals. Furthermore, prevailing wind direction was not considered, an important potentiating and mitigating factor of exposure to waste site and industrial emissions. It is unlikely that the degree of misclassification of exposures varied much between case- and control-mothers given the similar and high percentages of maternal addresses geocoded; the same data sources used for addresses; and blinding of investigators to case-control status during all geocoding, data linkages, and assignment of potential exposures. Any misclassification of potential exposures would most likely be nondifferential with respect to case-control status and therefore would underestimate actual associations.

In this study, we did not have any information on women's use of folic acid and other vitamins because this information is not collected on the live birth and fetal death records. Folic acid has been shown reduce risk for neural tube defects (Locksmith & Duff, 1998; Lumley et al., 2001) and other types of birth defects (Botto et al., 2004). In a study of Texas National Birth Defects Prevention Study participants during 1997 – 2001, comparison women who denied using folic acid within one month before or after conception were 1.5 times more likely (95% CI 0.72, 3.3) to live near industrial facilities than women who reported taking these supplements, although the moderately elevated odds ratio was consistent with unity (1.0) because of the small number of women available for study (Brender et al., 2006b). That particular study population was located in other regions of Texas and not in the study region of this report. Although folic acid use is not recorded on birth and fetal death records, maternal education and race/ethnicity have been shown to influence the intake of folic acid during the periconceptional period (Sen S et al., 2001; de Jon-Van den Berg et al., 2005). Adjustment for these maternal characteristics might partly account for folic acid use. In the present study, we adjusted all significantly elevated (95% confidence limits excluding 1.0) odds ratios for both maternal race/ethnicity and education.

In conclusion, we found that Dallas, Denton, and Tarrant county residents were more likely to give birth to babies with neural tube defects during the study period of 1997 – 2000 if they lived near industrial facilities with reported air emissions of chemicals. This finding should be interpreted with caution because we had no information regarding folic acid and vitamin intake that are known to reduce risk of NTDs (Locksmith & Duff, 1998; Lumley et al., 2001). Nevertheless, the methods used in this study provide an objective and efficient approach to confirm the presence of reported perceived excesses of health problems among persons who live near waste sites and industrial facilities. One should not conclude, however, that any confirmed excesses are due to this residential characteristic. To answer this type of question regarding birth defects, women with and without malformed offspring would need to be interviewed about other exposures during pregnancy in a carefully designed epidemiologic study instead of relying solely on limited information regarding risk factors from existing records such as birth and fetal death certificates.

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Appendix A. Formulas for Case-Control Analyses

1. Odds ratio (OR) = ad/bc (see table below).

| Characteristic present | Case-mothers | Control-mothers |
|---|---|---|
| Yes | a | b |
| No | c | d |

2. 95% confidence interval for OR = $e^{\ln OR \pm 1.96 * SE_{\ln OR}}$

   Where $SE_{\ln OR}$ = square root (1/a + 1/b + 1/c + 1/d)

3. Logistic regression – statistical model of an individual's risk (probability of birth defect *y* in offspring in this study) as a function of a potential risk factor *x*:

   i. $P(y \mid x) = 1/(1 + e^{-\alpha-\beta x})$ where *e* is the (natural) exponential function. In multiple logistic model, the term $\beta x$ is replaced by a linear term that can involve several risk factors or characteristics of interest, e.g., $\beta x_1 + \beta x_2 + \beta x_3 \ldots \beta x_k$ (Last, 1995)

Table 1. Characteristics of Birth Defect Case and Comparison Births in Dallas, Denton, and Tarrant Counties, 1997 – 2000

| Characteristic | Dallas County (n = 1477) | | Denton County (n = 214) | | Tarrant County (n = 834) | |
|---|---|---|---|---|---|---|
| | Cases N (%) | Controls N (%) | Cases N (%) | Controls N (%) | Cases N (%) | Controls N (%) |
| Maternal age (years) | | | | | | |
| < 20 | 98 (12.4) | 104 (15.2) | 7 (6.5) | 10 (9.4) | 39 (8.4) | 35 (9.5) |
| 20 - 24 | 176 (22.3) | 194 (28.4) | 17 (15.7) | 21 (19.8) | 113 (24.3) | 103 (28.0) |
| 25 - 29 | 203 (25.7) | 187 (27.3) | 27 (25.0) | 36 (34.0) | 134 (28.8) | 113 (30.7) |
| 30 - 34 | 148 (18.7) | 130 (19.0) | 30 (27.8) | 24 (22.6) | 96 (20.6) | 80 (21.7) |
| 35+ | 166 (21.0) | 69 (10.1) | 27 (25.0) | 15 (14.2) | 83 (17.8) | 37 (10.0) |
| Maternal Race/Ethnicity | | | | | | |
| White, non-Hispanic | 256 (32.3) | 218 (31.9) | 86 (79.6) | 78 (73.6) | 250 (53.6) | 201 (54.6) |
| African-American | 122 (15.4) | 137 (20.0) | 2 ( 1.9) | 5 (4.7) | 50 (10.7) | 58 (15.8) |
| White, Hispanic | 375 (47.3) | 301 (44.0) | 14 (13.0) | 17 (16.0) | 143 (30.7) | 90 (24.5) |
| Other | 40 (5.0) | 28 (4.1) | 6 (5.6) | 6 (5.7) | 23 (4.9) | 19 (5.2) |
| Maternal education (years) | | | | | | |
| 0-8 | 129 (17.0) | 98 (14.5) | 3 (3.0) | 5 (4.8) | 34 (7.4) | 25 (6.9) |
| 9-11 | 161 (21.2) | 164 (24.3) | 10 (9.9) | 12 (11.5) | 87 (18.8) | 60 (16.5) |
| 12 | 204 (26.8) | 195 (28.8) | 23 (22.8) | 28 (26.9) | 133 (28.8) | 128 (35.2) |
| 13-15 | 121 (15.9) | 107 (15.8) | 21 (20.8) | 16 (15.4) | 103 (22.3) | 71 (19.5) |
| 16+ | 146 (19.2) | 112 (16.6) | 44 (43.6) | 43 (41.3) | 105 (22.7) | 80 (22.0) |
| Birth Defects (number) | | | | | | |
| Neural tube defects | 94 | – | 18 | – | 57 | – |
| Isolated oral clefts | 160 | – | 21 | – | 88 | – |
| Conotruncal heart defects | 162 | – | 22 | – | 118 | – |
| Chromosomal anomalies | 341 | – | 43 | – | 185 | – |
| Maternal address geocoded | 784 (98.9) | 663 (96.9) | 104 (96.3) | 103 (97.2) | 459 (98.5) | 361 (98.1) |

Table 2. Relation Between Maternal Residential Proximity to Hazardous Wastes Sites and Selected Birth Defects by Area of Residence

| Residential characteristic | Case-control status | Dallas, Denton, Tarrant counties | | Texas Public Health Region 3 | | Texas – Other Public Health Regions | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of waste site (Referent groups are women who lived more than 1 mile from these sites at delivery) | Controls | 3 (0.3) | – | 3 (0.2) | – | 114 (3.9) | – |
| | Neural tube defects | 1 (0.6) | 2.3 (0.24, 22.2) | 1 (0.5) | 2.3 (0.24, 22.7) | 19 (4.2) | 1.1 (0.66, 1.8) |
| | Isolated oral clefts | 4 (1.5) | **5.7 (1.3, 25.8)** | 4 (1.1) | **5.6 (1.2, 25.0)** | 22 (2.9) | 0.73 (0.46, 1.2) |
| | Conotruncal heart defects | 2 (0.7) | 2.5 (0.42, 15.3) | 2 (0.5) | 2.5 (0.42, 15.1) | 28 (3.3) | 0.83 (0.55, 1.3) |
| | Chromosomal anomalies | 4 (0.7) | 2.7 (0.59, 11.9) | 5 (0.7) | 3.5 (0.82, 14.5) | 49 (3.5) | 0.89 (0.64, 1.3) |
| | Down syndrome | 3 (0.9) | 3.4 (0.68, 17.0) | 4 (1.0) | **4.8 (1.1, 21.5)** | 30 (3.7) | 0.96 (0.63, 1.4) |
| | Non-Down chromosomal anomalies | 1 (0.4) | 1.6 (0.17, 15.5) | 1 (0.3) | 1.6 (0.17, 15.8) | 19 (3.2) | 0.81 (0.50, 1.3) |
| Within 2 miles of waste site (Referent groups are women who lived more than 2 miles from these sites at delivery) | Controls | 24 (2.1) | – | 24 (1.7) | – | 332 (11.4) | – |
| | Neural tube defects | 4 (2.4) | 1.1 (0.39, 3.4) | 4 (1.9) | 1.2 (0.40, 3.4) | 51 (11.4) | 1.0 (0.73, 1.4) |
| | Isolated oral clefts | 8 (3.0) | 1.4 (0.64, 3.2) | 8 (2.3) | 1.4 (0.62, 3.1) | 65 (8.5) | 0.73 (0.55, 0.96) |
| | Conotruncal heart defects | 5 (1.7) | 0.79 (0.30, 2.1) | 5 (1.3) | 0.78 (0.30, 2.1) | 86 (10.0) | 0.87 (0.68, 1.1) |
| | Chromosomal anomalies | 15 (2.6) | 1.3 (0.65, 2.4) | 17 (2.4) | 1.5 (0.79, 2.8) | 142 (10.2) | 0.88 (0.72, 1.1) |
| | Down syndrome | 6 (1.8) | 0.84 (0.34, 2.1) | 8 (2.0) | 1.2 (0.53, 2.7) | 83 (10.4) | 0.90 (0.70, 1.2) |
| | Non-Down chromosomal anomalies | 9 (3.8) | 1.8 (0.84, 4.0) | 9 (3.0) | 1.9 (0.86, 4.0) | 59 (9.9) | 0.86 (0.64, 1.1) |

Table 3. Relation Between Maternal Residential Proximity to Industrial Facilities with Air Emissions of Chemicals and Selected Birth Defects by Area of Residence

| Residential characteristic | Case-control status | Dallas, Denton, Tarrant counties | | Texas Public Health Region 3 | | Texas – Other Public Health Regions | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of industrial facility (Referent groups are women who lived more than 1 mile from these facilities at delivery) | Controls | 227 (20.1) | – | 263 (18.1) | – | 345 (11.8) | – |
| | Neural tube defects | 56 (34.1) | **2.1 (1.4, 2.9)** | 64 (30.8) | **2.0 (1.5, 2.8)** | 51 (11.4) | 0.95 (0.70, 1.3) |
| | Anencephaly | 19 (38.0) | **2.4 (1.3, 4.4)** | 19 (34.5) | **2.4 (1.3, 4.2)** | 14 (11.3) | 0.95 (0.54, 1.7) |
| | Spina bifida | 31 (33.3) | **2.0 (1.3, 3.1)** | 38 (29.9) | **1.9 (1.3, 2.9)** | 32 (11.6) | 0.97 (0.66, 1.4) |
| | Isolated oral clefts | 52 (19.6) | 0.97 (0.69, 1.4) | 66 (18.8) | 1.0 (0.78, 1.4) | 92 (12.1) | 1.0 (0.80, 1.3) |
| | Conotruncal heart defects | 59 (19.9) | 0.98 (0.71, 1.4) | 69 (17.8) | 0.98 (0.73, 1.3) | 114 (13.3) | 1.1 (0.91, 1.4) |
| | Chromosomal anomalies | 127 (22.4) | 1.1 (0.89, 1.5) | 144 (20.4) | 1.2 (0.93, 1.5) | 168 (12.0) | 1.0 (0.84, 1.2) |
| | Down syndrome | 77 (23.1) | 1.2 (0.89, 1.6) | 88 (21.6) | 1.2 (0.95, 1.6) | 92 (11.5) | 0.97 (0.76, 1.2) |
| | Non-Down chromosomal anomalies | 50 (21.3) | 1.1 (0.76, 1.5) | 56 (18.7) | 1.0 (0.76, 1.4) | 76 (12.8) | 1.1 (0.84, 1.4) |
| Within 2 miles of industrial facility (Referent groups are women who lived more than 2 miles from these facilities at delivery) | Controls | 616 (54.7) | – | 707 (48.6) | – | 1101 (37.8) | – |
| | Neural tube defects | 102 (62.2) | 1.4 (0.98, 1.9) | 118 (56.7) | **1.4 (1.0, 1.9)** | 161 (35.9) | 0.92 (0.75, 1.1) |
| | Anencephaly | 34 (68.0) | 1.8 (0.96, 3.2) | 34 (61.8) | 1.7 (0.98, 3.0) | 39 (31.5) | 0.76 (0.51, 1.1) |
| | Spina bifida | 56 (60.2) | 1.3 (0.82, 1.9) | 70 (55.1) | 1.3 (0.90, 1.9) | 97 (35.0) | 0.89 (0.69, 1.1) |
| | Isolated oral clefts | 150 (56.6) | 1.1 (0.83, 1.4) | 182 (51.9) | 1.1 (0.90, 1.4) | 284 (37.3) | 0.98 (0.83, 1.2) |
| | Conotruncal heart defects | 157 (52.9) | 0.93 (0.72, 1.2) | 183 (47.3) | 0.95 (0.76, 1.2) | 320 (37.3) | 0.98 (0.84, 1.1) |
| | Chromosomal anomalies | 322 (56.7) | 1.1 (0.89, 1.3) | 357 (50.6) | 1.1 (0.90, 1.3) | 538 (38.6) | 1.0 (0.91, 1.2) |
| | Down syndrome | 192 (57.7) | 1.1 (0.88, 1.4) | 213 (52.3) | 1.2 (0.93, 1.4) | 312 (39.0) | 1.1 (0.90, 1.2) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Non-Down chromosomal anomalies | 130 (55.3) | 1.0 (0.77, 1.4) | 144 (48.2) | 0.98 (0.77, 1.3) | 226 (38.0) | 1.0 (0.84, 1.2) |

Table 4. Relation Between Maternal Residential Proximity to Specific Types of Industrial Facilities and Selected Birth Defects by Area of Residence

| Residential and industrial facility characteristic | Case-Control status | Dallas, Denton, Tarrant counties | | Texas Public Health Region 3 | | Texas – Other Public Health Regions | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of petrochemical facility (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Controls | 7 (0.8) | | 8 (0.7) | | 20 (0.8) | |
| | Neural tube defects | 1 (0.9) | 1.2 (0.15, 9.8) | 1 (0.7) | 1.0 (0.13, 8.3) | 7 (1.7) | 2.3 (0.95, 5.4) |
| | Anencephaly | 1 (3.1) | 4.1 (0.50, 34.7) | 1 (2.7) | 4.1 (0.50, 33.9) | 2 (1.8) | 2.3 (0.54, 10.1) |
| | Spina bifida | 0 (0.0) | – | 0 (0.0) | – | 4 (1.6) | 2.1 (0.71, 6.2) |
| | Isolated oral clefts | 0 (0.0) | – | 1 (0.3) | 0.52 (0.07, 4.2) | 9 (1.3) | 1.7 (0.78, 3.8) |
| | Conotruncal heart defects | 0 (0.0) | – | 0 (0.0) | – | 7 (0.9) | 1.2 (0.51, 2.9) |
| | Chromosomal anomalies | 3 (0.7) | 0.88 (0.23, 3.4) | 3 (0.5) | 0.80 (0.21, 3.0) | 20 (0.8) | 0.94 (0.43, 2.1) |
| | Down syndrome | 3 (1.2) | 1.5 (0.39, 5.9) | 3 (0.9) | 1.4 (0.37, 5.3) | 5 (0.7) | 0.91 (0.34, 2.4) |
| Within 1 mile of primary metals/smelter facility (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Controls | 18 (2.0) | – | 35 (2.9) | – | 31 (1.2) | – |
| | Neural tube defects | 4 (3.6) | 1.9 (0.62, 5.6) | 6 (4.0) | 1.4 (0.59, 3.4) | 1 (0.3) | 0.21 (0.03, 1.5) |
| | Anencephaly | 3 (8.8) | **4.8 (1.4, 17.3)** | 3 (7.7) | 2.8 (0.83, 9.7) | 0 (0.0) | – |
| | Spina bifida | 1 (1.6) | 0.81 (0.11, 6.1) | 3 (3.3) | 1.1 (0.35, 3.8) | 1 (0.4) | 0.34 (0.05, 2.5) |
| | Isolated oral clefts | 5 (2.3) | 1.2 (0.43, 3.2) | 11 (3.7) | 1.3 (0.66, 2.6) | 10 (1.5) | 1.2 (0.60, 2.5) |
| | Conotruncal heart defects | 5 (2.1) | 1.1 (0.39, 2.9) | 8 (2.5) | 0.86 (0.39, 1.9) | 9 (1.2) | 1.0 (0.48, 2.1) |
| | Chromosomal anomalies | 5 (1.1) | 0.57 (0.21, 1.5) | 13 (2.3) | 0.79 (0.41, 1.5) | 15 (1.2) | 1.0 (0.55, 1.9) |
| | Down syndrome | 2 (0.8) | 0.39 (0.09, 1.7) | 8 (2.4) | 0.85 (0.39, 1.9) | 9 (1.3) | 1.1 (0.50, 2.2) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Within 1 mile of chemical industry (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Controls | 86 (8.7) | – | 92 (7.2) | – | 70 (2.7) | – |
| | Neural tube defects | 20 (15.6) | **1.9 (1.1, 3.3)** | 20 (12.2) | **1.8 (1.1, 3.0)** | 14 (3.4) | 1.3 (0.72, 2.3) |
| | Anencephaly | 5 (13.9) | 1.7 (0.64, 4.5) | 5 (12.2) | 1.8 (0.69, 4.7) | 5 (4.3) | 1.7 (0.66, 4.2) |
| | Spina bifida | 14 (18.4) | **2.4 (1.3, 4.4)** | 14 (13.6) | **2.0 (1.1, 3.7)** | 9 (3.5) | 1.3 (0.67, 2.7) |
| | Isolated oral clefts | 19 (8.2) | 0.93 (0.56, 1.6) | 20 (6.6) | 0.91 (0.55, 1.5) | 25 (3.6) | 1.4 (0.86, 2.2) |
| | Conotruncal heart defects | 16 (6.3) | 0.70 (0.41, 1.2) | 19 (5.6) | 0.77 (0.47, 1.3) | 19 (2.5) | 0.94 (0.56, 1.6) |
| | Chromosomal anomalies | 41 (8.5) | 0.97 (0.66, 1.4) | 48 (7.9) | 1.1 (0.77, 1.6) | 28 (2.2) | 0.84 (0.54, 1.3) |
| | Down syndrome | 27 (9.5) | 1.1 (0.70, 1.7) | 30 (8.6) | 1.2 (0.79, 1.9) | 15 (2.1) | 0.78 (0.44, 1.4) |

Table 5. Relation Between Maternal Residential Proximity to Specific Types of Industrial Emissions and Selected Birth Defects by Area of Residence

| Residential and industrial facility characteristic | Case-Control status | Dallas, Denton, Tarrant counties | | Texas Public Health Region 3 | | Texas – Other Public Health Regions | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of facility with air emissions of heavy metals (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Controls | 95 (9.5) | – | 119 (9.1) | – | 158 (5.8) | – |
| | Neural tube defects | 26 (19.4) | **2.3 (1.4, 3.7)** | 28 (16.3) | **1.9 (1.2, 3.0)** | 24 (5.7) | 0.98 (0.63, 1.5) |
| | Anencephaly | 10 (24.4) | **3.1 (1.5, 6.4)** | 10 (21.7) | **2.8 (1.3, 5.7)** | 5 (4.3) | 0.74 (0.30, 1.8) |
| | Spina bifida | 14 (18.4) | **2.1 (1.2, 4.0)** | 16 (15.2) | **1.8 (1.0, 3.2)** | 16 (6.1) | 1.1 (0.63, 1.8) |
| | Isolated oral clefts | 24 (10.1) | 1.1 (0.67, 1.7) | 32 (10.1) | 1.1 (0.75, 1.7) | 36 (5.1) | 0.88 (0.60, 1.3) |
| | Conotruncal heart defects | 20 (7.8) | 0.80 (0.48, 1.3) | 25 (7.3) | 0.79 (0.50, 1.2) | 50 (6.3) | 1.1 (0.79, 1.5) |
| | Chromosomal anomalies | 52 (10.5) | 1.1 (0.78, 1.6) | 63 (10.1) | 1.1 (0.81, 1.5) | 77 (5.9) | 1.0 (0.77, 1.4) |
| | Down syndrome | 32 (11.1) | 1.2 (0.78, 1.8) | 38 (10.6) | 1.2 (0.81, 1.8) | 40 (5.3) | 0.92 (0.64, 1.3) |
| Within 1 mile of facility with air emissions of polycyclic aromatic hydrocarbons (Referent groups are women who lived a mile or more from any industrial facility with reported air | Controls | 11 (1.2) | – | 11 (0.9) | – | 40 (1.5) | – |
| | Neural tube defects | 3 (2.7) | 2.3 (0.62, 8.3) | 3 (2.0) | 2.3 (0.62, 8.2) | 11 (2.7) | 1.8 (0.90, 3.5) |
| | Anencephaly | 0 (0.0) | – | 0 (0.0) | – | 2 (1.8) | 1.2 (0.28, 4.9) |
| | Spina bifida | 2 (3.1) | 2.6 (0.57, 12.2) | 2 (2.2) | 2.4 (0.53, 11.1) | 8 (3.2) | 2.1 (0.97, 4.5) |
| | Isolated oral clefts | 3 (1.4) | 1.2 (0.32, 4.2) | 3 (1.0) | 1.1 (0.32, 4.1) | 14 (2.0) | 1.3 (0.73, 2.5) |
| | Conotruncal heart defects | 3 (1.2) | 1.0 (0.29, 3.7) | 3 (0.9) | 1.0 (0.28, 3.7) | 11 (1.5) | 0.95 (0.49, 1.9) |
| | Chromosomal anomalies | 5 (1.1) | 0.93 (0.32, 2.7) | 5 (0.9) | 0.96 (0.33, 2.8) | 13 (1.0) | 0.68 (0.36, 1.3) |
| | Down syndrome | 1 (0.4) | 0.32 (0.04, 2.5) | 1 (0.3) | 0.34 (0.04, 2.6) | 7 (1.0) | 0.63 (0.28, 1.4) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| emissions of chemicals) | | | | | | | |
| Within 1 mile of facility with air emissions of solvents (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Controls | 151 (14.4) | – | 169 (12.4) | – | 206 (7.4) | – |
| | Neural tube defects | 38 (26.0) | **2.1 (1.4, 3.2)** | 42 (22.6) | **2.1 (1.4, 3.0)** | 32 (7.4) | 1.0 (0.68, 1.5) |
| | Anencephaly | 12 (27.9) | **2.3 (1.2, 4.6)** | 12 (25.0) | **2.4 (1.2, 4.6)** | 6 (5.2) | 0.68 (0.30, 1.6) |
| | Spina bifida | 23 (27.1) | **2.2 (1.3, 3.7)** | 27 (23.3) | **2.1 (1.4, 3.4)** | 23 (8.6) | 1.2 (0.75, 1.8) |
| | Isolated oral clefts | 28 (11.6) | 0.78 (0.51, 1.2) | 31 (9.8) | 0.77 (0.51, 1.1) | 61 (8.4) | 1.1 (0.84, 1.5) |
| | Conotruncal heart defects | 40 (14.4) | 1.0 (0.69, 1.5) | 45 (12.4) | 1.0 (0.70, 1.4) | 66 (8.2) | 1.1 (0.83, 1.5) |
| | Chromosomal anomalies | 89 (16.8) | 1.2 (0.90, 1.6) | 98 (14.8) | 1.2 (0.94, 1.6) | 88 (6.7) | 0.89 (0.69, 1.2) |
| | Down syndrome | 57 (18.2) | 1.3 (0.95, 1.9) | 62 (16.3) | 1.4 (1.0, 1.9) | 48 (6.3) | 0.84 (0.61, 1.2) |

Table 6. Relation Between Maternal Residential Proximity to Hazardous Wastes Sites and Selected Birth Defects by Area of Residence

| Residential characteristic | Case-control status | Dallas County | | Denton County | | Tarrant County | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of waste site (Referent groups are women who lived more than 1 mile from these sites at delivery) | Controls | 2 (0.3) | – | – | – | 1 (0.3) | -- |
| | Neural tube defects | – | – | – | – | 1 (1.9) | 6.9 (0.43, 112.4) |
| | Isolated oral clefts | 2 (1.3) | 4.2 (0.59, 30.1) | – | – | 2 (2.3) | 8.6 (0.77, 95.6) |
| | Conotruncal heart defects | 1 (0.6) | 2.1 (0.19, 23.2) | – | – | 1 (0.9) | 3.1 (0.19, 50.0) |
| | Chromosomal anomalies | 1 (0.3) | 0.98 (0.09, 10.8) | – | – | 3 (1.6) | 5.9 (0.61, 57.4) |
| | Down syndrome | 1 (0.5) | 1.7 (0.15, 18.5) | – | – | 2 (1.9) | 7.1 (0.63, 78.6) |
| | Non-Down chromosomal anomalies | – | – | – | – | 1 (1.2) | 4.5 (0.28, 72.7) |
| Within 2 miles of waste site (Referent groups are women who lived more than 2 miles from these sites at delivery) | Controls | 17 (2.6) | -- | – | – | 7 (1.9) | -- |
| | Neural tube defects | 3 (3.2) | 1.3 (0.36, 4.4) | – | – | 1 (1.9) | 1.0 (0.12, 8.1) |
| | Isolated oral clefts | 4 (2.5) | 1.0 (0.33, 3.0) | – | – | 4 (4.7) | 2.5 (0.71, 8.6) |
| | Conotruncal heart defects | 4 (2.5) | 0.98 (0.33, 3.0) | – | – | 1 (0.9) | 0.4 (0.05, 3.6) |
| | Chromosomal anomalies | 7 (2.1) | 0.80 (0.33, 2.0) | | | 8 (4.3) | 2.3 (0.82, 6.4) |
| | Down syndrome | 4 (2.0) | 0.78 (0.26, 2.3) | – | – | 2 (1.9) | 1.0 (0.20, 4.8) |
| | Non-Down chromosomal anomalies | 3 (2.1) | 0.83 (0.24, 2.9) | – | – | 6 (7.4) | **4.0 (1.3, 12.4)** |

Table 7. Relation Between Maternal Residential Proximity to Industrial Facilities with Air Emissions of Chemicals and Selected Birth Defects by Area of Residence

| Residential characteristic | Case-control status | Dallas county | | Denton county | | Tarrant county | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of industrial facility (Referent groups are women who lived more than 1 mile from these facilities at delivery) | Controls | 159 (24.0) | -- | 4 (3.9) | -- | 64 (17.7) | -- |
| | Neural tube defects | 35 (37.2) | **1.9 (1.2,3.0)** | 3 (17.6) | **5.3 (1.1,26.2)** | 18 (34.0) | **2.4 (1.3,4.5)** |
| | Anencephaly | 11 (39.3) | 2.1 (0.94,4.5) | 1 (50.0) | **24.8 (1.3,471.2)** | 7 (35.0) | 2.5 (0.96,6.5) |
| | Spina bifida | 20 (39.2) | **2.0 (1.1,3.7)** | 2 (15.4) | 4.5 (0.74,27.4) | 9 (31.0) | 2.1 (0.91,4.8) |
| | Isolated oral clefts | 30 (18.9) | 0.74 (0.48,1.14) | 2 (10.0) | 2.8 (0.47,16.1) | 20 (23.3) | 1.4 (0.8, 2.5) |
| | Conotruncal heart defects | 36 (22.6) | 0.93 (0.61,1.4) | 1 (4.8) | 1.2 (0.13,11.7) | 22 (18.9) | 1.1 (0.62,1.8) |
| | Chromosomal anomalies | 83 (24.4) | 1.0 (0.76,1.4) | 1 (2.3) | 0.59 (0.06,5.4) | 43 (23.2) | 1.4 (0.91,2.2) |
| | Down syndrome | 51 (25.6) | 1.1 (0.76,1.6) | 1 (3.3) | 0.85 (0.09,7.9) | 25 (24.0) | 1.5 (0.87,2.3) |
| | Non-Down chromosomal anomalies | 32 (22.7) | 0.93 (0.6,1.4) | -- | -- | 18 (22.2) | 1.3 (0.74,2.4) |
| Within 2 miles of industrial facility (Referent groups are women who lived more than 2 miles from these facilities at delivery) | Controls | 412 (62.1) | -- | 18 (17.5) | -- | 186 (51.5) | -- |
| | Neural tube defects | 62 (66.0) | 1.2 (0.75,1.9) | 3 (17.6) | 1.0 (0.26, 3.9) | 37 (69.8) | **2.2 (1.2, 4.1)** |
| | Anencephaly | 18 (64.3) | 1.1 (0.50,2.4) | 1 (50.0) | 4.7 (0.28,79.1) | 15 (75.0) | 2.8 (1.0,7.9) |
| | Spina bifida | 36 (70.6) | 1.5 (0.79,2.7) | 2 (15.4) | 0.86 (0.18,4.2) | 18 (62.1) | 1.5 (0.71,3.4) |
| | Isolated oral clefts | 100 (62.9) | 1.0 (0.72,1.5) | 5 (23.0) | 1.6 (0.51, 4.9) | 45 (52.3) | 1.0 (0.65, 1.7) |
| | Conotruncal heart defects | 93 (58.5) | 0.86 (0.60,1.2) | 6 (28.6) | 1.9 (0.60,5.5) | 58 (49.6) | 0.93 (0.61,1.4) |
| | Chromosomal anomalies | 213 (62.6) | 1.0 (0.78,1.3) | 11 (25.6) | 1.6 (0.89,3.8) | 98 (53.0) | 1.1 (0.74,1.5) |
| | Down syndrome | 127 (63.8) | 1.1 (0.77,1.5) | 9 (30.0) | 2.0 (0.80,5.1) | 56 (53.8) | 1.1 (0.71,1.7) |
| | Non-Down | 86 (61.0) | 0.95 (0.66,1.4) | 2 (15.4) | 0.86 (0.18,4.2) | 42 (51.9) | 1.0 (0.63,1.6) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | chromosomal anomalies | | | | | | |

Table 8. Relation Between Maternal Residential Proximity to Specific Types of Industrial Facilities and Selected Birth Defects by Area of Residence

| Residential and industrial facility characteristic | Case-Control status | Dallas county | | Denton county | | Tarrant county | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of petrochemical facility (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Controls | 7 (1.4) | -- | -- | -- | -- | -- |
| | Neural tube defects | 1 (1.7) | 1.22 (0.15,10.1) | -- | -- | -- | -- |
| | Anencephaly | 1 (5.6) | 4.2 (0.49,36.4) | -- | -- | -- | -- |
| | Spina bifida | -- | -- | -- | -- | -- | -- |
| | Isolated oral clefts | 0 (0.0) | -- | 0 (0.0) | -- | 0 (0.0) | -- |
| | Conotruncal heart defects | 0 (0.0) | -- | 0 (0.0) | -- | 0 (0.0) | -- |
| | Chromosomal anomalies | 3 (1.2) | 0.84 (0.22,3.3) | 0 (0.0) | -- | 0 (0.0) | -- |
| | Down syndrome | 3 (2.0) | 1.5 (0.37,5.7) | 0 (0.0) | -- | 0 (0.0) | -- |
| Within 1 mile of primary metals/smelter facility (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Controls | 17 (5.3) | -- | 0 (0.0) | -- | 1 (0.3) | -- |
| | Neural tube defects | 2 (3.3) | 1.0 (0.23,4.5) | 1 (6.7) | -- | 1 (2.8) | 8.5 (0.52,138.7) |
| | Anencephaly | 2 (10.5) | 3.5 (0.75,16.3) | 1 (50.0) | -- | 0 (0.0) | -- |
| | Spina bifida | 0 (0.0) | -- | 0 (0.0) | -- | 1 (4.8) | 14.9 (0.90,246.3) |
| | Isolated oral clefts | 5 (3.7) | 1.1 (0.42,3.2) | 0 (0.0) | -- | 0 (0.0) | -- |
| | Conotruncal heart defects | 4 (3.1) | 0.96 (0.32,2.9) | 0 (0.0) | -- | 1 (1.0) | 3.1 (0.19,50.5) |
| | Chromosomal anomalies | 5 (1.9) | 0.58 (0.21,1.6) | 0 (0.0) | -- | 0 (0.0) | -- |
| | Down syndrome | 2 (1.3) | 0.40 (0.09,1.8) | 0 (0.0) | -- | 0( 0.0) | -- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Within 1 mile of chemical industry (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Controls | 69 (12.0) | -- | 1(1.0) | -- | 16 (5.1) | -- |
| | Neural tube defects | 16 (21.3) | **2.0 (1.1,3.6)** | 2 (12.5) | **14.1 (1.2,166.3)** | 2 (5.4) | 1.1 (0.23,4.8) |
| | Anencephaly | 4 (19.0) | 1.7 (0.56,5.3) | 1 (50.0) | **99.0 (3.3,2967.8)** | 0 (0.0) | -- |
| | Spina bifida | 11 (26.2) | **2.6 (1.2,5.4)** | 1 (8.3) | 9.0 (0.53,154.2) | 2 (9.1) | 1.9 (0.40,8.6) |
| | Isolated oral clefts | 11 (7.9) | 0.62 (0.32,1.2) | 1 (5.3) | 5.5 (0.33,92.0) | 7 (9.6) | 2.0 (0.78,5.0) |
| | Conotruncal heart defects | 13 (9.6) | 0.77 (0.41,1.4) | 1 (4.8) | 5.0 (0.30,82.5) | 2 (2.1) | 0.39 (0.09,1.7) |
| | Chromosomal anomalies | 32 (11.1) | 0.91 (0.58,1.4) | 1 (2.3) | 2.4 (0.14,38.6) | 8 (5.3) | 1.0 (0.44,2.5) |
| | Down syndrome | 19 (11.4) | 0.94 (0.55,1.6) | 1 (3.3) | 3.4 (0.21,56.3) | 7 (8.1) | 1.6 (0.65,4.1) |

Table 9. Relation Between Maternal Residential Proximity to Specific Types of Industrial Emissions and Selected Birth Defects by Area of Residence

| Residential and industrial facility characteristic | Case-Control status | Dallas county | | Denton county | | Tarrant county | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of facility with air emissions of heavy metals (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Controls | 60 (0.6) | -- | 0 (0.0) | -- | 35 (10.5) | -- |
| | Neural tube defects | 14 (19.2) | **2.0 (1.1,3.8)** | 1 (6.7) | **--** | 11 (23.9) | **2.7 (1.2,5.7)** |
| | Isolated oral clefts | 10 (7.2) | 0.65 (0.323,1.3) | 0 (0.0) | -- | 14 (17.5) | 1.8 (0.92,3.5) |
| | Conotruncal heart defects | 10 (7.5) | 0.68 (0.34,1.4) | 1 (4.80) | -- | 9 (8.7) | 0.80 (0.37,1.7) |
| | Chromosomal anomalies | 27 (9.5) | 0.88 (0.55,1.4) | 0 (0.0) | -- | 25 (15.0) | 1.5 (0.86,2.6) |
| | Down syndrome | 18 (10.8) | 1.0 (0.59,1.8) | 0 (0.0) | -- | 14 (15.1) | 1.5 (0.77,2.9) |
| Within 1 mile of facility with air emissions of polycyclic aromatic hydrocarbons (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of | Controls | 5 (1.0) | -- | 1 (1.0) | -- | 5 (1.7) | **--** |
| | Neural tube defects | 2 (3.3) | 3.4 (0.65,18.0) | 1 (6.7) | 7.1 (0.42,119.6) | 0 (0.0) | -- |
| | Isolated oral clefts | 1 (0.8) | 0.78 (0.09,6.7) | 0 (0.0) | -- | 2 (2.9) | 1.8 (0.34,9.5) |
| | Conotruncal heart defects | 1 (0.8) | 0.82 (0.10,7.1) | 0 (0.0) | -- | 2 (2.1) | 1.3 (0.24,6.6) |
| | Chromosomal anomalies | 1 (0.4) | 0.40 (0.05,3.4) | 0 (0.0) | -- | 4 (2.7) | 1.7 (0.44,6.3) |
| | Down syndrome | 0 (0.0) | -- | 0 (0.0) | -- | 1 (0.3) | 0.75 (0.09,6.5) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| chemicals) | | | | | | | |
| Within 1 mile of facility with air emissions of solvents (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Controls | 111 (18.0) | **--** | 4 (3.9) | -- | 36 (10.8) | -- |
| | Neural tube defects | 26 (30.6) | **2.0 (1.2,3.3)** | 3 (17.6) | **5.3 (1.1,26.2)** | 9 (20.5) | 2.1 (0.94,4.8) |
| | Isolated oral clefts | 18 (12.2) | 0.63 (0.37,1.1) | 0 (0.0) | -- | 10 (13.2) | 1.3 (0.59,2.6) |
| | Conotruncal heart defects | 26 17.4) | 0.96 (0.6,1.5) | 1 (4.8) | 1.2 (0.13,11.7) | 13 (12.0) | 1.1 (0.58,2.2) |
| | Chromosomal anomalies | 58 (18.4) | 1.0 (0.72,1.5) | 0 (0.0) | -- | 31 (17.9) | **1.8 (1.1,3.0)** |
| | Down syndrome | 40 (21.3) | 1.2 (0.82,1.8) | 0 (0.0) | -- | 17 (17.7) | 1.8 (0.95,3.3) |

Table 10. Relation Between Maternal Residential Proximity to Hazardous Wastes Sites and Low Birth Weight and Preterm Birth by Area of Residence

| Residential characteristic | Case-control status* | Dallas, Denton, Tarrant counties | | Texas Public Health Region 3 | | Texas – Other Public Health Regions | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of waste site (Referent groups are women who lived more than 1 mile from these sites at delivery) | Normal birth weight | 3 (0.3) | – | 3 (0.2) | – | 102 (3.7) | – |
| | Low birth weight | 0 (0.0) | – | 0 (0.0) | – | 12 (7.3) | **2.0 (1.1, 3.8)** |
| | Term birth | 3 (0.3) | – | 3 (0.2) | – | 88 (3.6) | – |
| | Preterm birth | 0 (0.0) | – | 0 (0.0) | – | 11 (4.7) | 1.3 (0.69, 2.5) |
| Within 2 miles of waste site (Referent groups are women who lived more than 2 miles from these sites at delivery) | Normal birth weight | 22 (2.1) | – | 22 (1.6) | – | 306 (11.1) | – |
| | Low Birth Weight | 2 (3.1) | 1.5 (0.35, 6.5) | 2 (2.6) | 1.6 (0.37, 7.0) | 26 (15.9) | 1.5 (0.97, 2.3) |
| | Term birth | 18 (2.0) | – | 18 (1.5) | – | 272 (11.1) | – |
| | Preterm birth | 2 (2.4) | 1.2 (0.28, 5.4) | 2 (1.9) | 1.3 (0.29, 5.5) | 32 (13.6) | 1.3 (0.85, 1.9) |

* Cases and controls are live births without any major birth defects.

Table 11. Relation Between Maternal Residential Proximity to Industrial Facilities with Air Emissions of Chemicals and Low Birth Weight and Preterm Birth by Area of Residence

| Residential characteristic | Case-control status* | Dallas, Denton, Tarrant counties | | Texas Public Health Region 3 | | Texas – Other Public Health Regions | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of industrial facility (Referent groups are women who lived more than 1 mile from these facilities at delivery) | Normal birth weight | 208 (19.6) | – | 242 (17.6) | – | 314 (11.4) | – |
| | Low birth weight | 19 (29.2) | 1.7 (0.97, 3.0) | 21 (26.9) | **1.7 (1.0, 2.9)** | 30 (18.3) | **1.7 (1.1, 2.6)** |
| | Term birth | 182 (19.8) | – | 215 (17.9) | – | 284 (11.6) | – |
| | Preterm birth | 21 (25.3) | 1.4 (0.82, 2.3) | 24 (22.6) | 1.3 (0.83, 2.2) | 33 (14.0) | 1.2 (0.84, 1.8) |
| Within 2 miles of industrial facility (Referent groups are women who lived more than 2 miles from these facilities at delivery) | Normal birth weight | 575 (54.1) | – | 662 (48.1) | – | 1024 (37.3) | – |
| | Low Birth Weight | 41 (63.1) | 1.4 (0.86, 2.4) | 45 (57.7) | 1.5 (0.93, 2.3) | 76 (46.3) | **1.5 (1.1, 2.0)** |
| | Term birth | 498 (54.1) | – | 579 (48.1) | – | 921 (37.5) | – |
| | Preterm birth | 50 (60.2) | 1.3 (0.81, 2.0) | 57 (53.8) | 1.3 (0.84, 1.9) | 98 (41.5) | 1.2 (0.90, 1.6) |

* Cases and controls are live births without any major birth defects.

Table 12. Relation Between Maternal Residential Proximity to Specific Types of Industrial Facilities and Low Birth Weight and Preterm Birth by Area of Residence

| Residential and industrial facility characteristic | Case-Control status* | Dallas, Denton, Tarrant counties | | Texas Public Health Region 3 | | Texas – Other Public Health Regions | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of petrochemical facility (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Normal birth weight | 5 (0.6) | – | 6 (0.5) | – | 18 (0.7) | – |
| | Low birth weight | 2 (4.2) | **7.4 (1.4, 39.3)** | 2 (3.4) | **6.6 (1.3, 33.6)** | 2 (1.5) | 2.0 (0.46, 8.8) |
| | Term birth | 6 (0.8) | – | 7 (0.7) | – | 16 (0.7) | – |
| | Preterm birth | 0 (0.0) | – | 0 (0.0) | – | 2 (1.0) | 1.3 (0.31, 5.9) |
| Within 1 mile of primary metals/smelter facility (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Normal birth weight | 17 (2.0) | – | 33 (2.8) | – | 29 (1.2) | – |
| | Low birth weight | 1 (2.1) | 1.1 (0.14, 8.4) | 2 (3.4) | 1.2 (0.28, 5.2) | 2 (1.5) | 1.3 (0.30, 5.3) |
| | Term birth | 13 (1.7) | – | 29 (2.9) | – | 26 (1.2) | – |
| | Preterm birth | 3 (4.6) | 2.8 (0.76, 9.9) | 4 (4.7) | 1.7 (0.57, 4.8) | 4 (1.9) | 1.6 (0.57, 4.8) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Within 1 mile of chemical industry (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Normal birth weight | 78 (8.4) | – | 84 (6.9) | – | 65 (2.6) | – |
| | Low birth weight | 8 (14.8) | 1.9 (0.87, 4.2) | 8 (12.3) | 1.9 (0.88, 4.1) | 4 (2.9) | 1.1 (0.40, 3.1) |
| | Term birth | 73 (9.0) | – | 78 (7.3) | – | 58 (2.6) | – |
| | Preterm birth | 4 (6.1) | 0.65 (0.23, 1.8) | 5 (5.7) | 0.77 (0.30, 2.0) | 7 (3.3) | 1.3 (0.58, 2.9) |

*Cases and controls are live births without any major birth defects.

Table 13. Relation Between Maternal Residential Proximity to Specific Types of Industrial Emissions and Low Birth Weight and Preterm Birth by Area of Residence

| Residential and industrial facility characteristic | Case-Control status* | Dallas, Denton, Tarrant counties | | Texas Public Health Region 3 | | Texas – Other Public Health Regions | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of facility with air emissions of heavy metals (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Normal birth weight | 87 (9.2) | – | 110 (8.8) | – | 142 (5.5) | – |
| | Low birth weight | 8 (14.8) | 1.7 (0.78, 3.7) | 9 (13.6) | 1.6 (0.79, 3.4) | 16 (10.7) | 2.0 (1.2, 3.5) |
| | Term birth | 77 (9.4) | – | 100 (9.2) | – | 126 (5.5) | – |
| | Preterm birth | 6 (8.8) | 0.93 (0.39, 2.2) | 7 (7.9) | 0.84 (0.38, 1.9) | 17 (7.7) | 1.4 (0.85, 2.4) |
| Within 1 mile of facility with air emissions of polycyclic aromatic hydrocarbons (Referent groups are women who lived a mile or more from any industrial facility with reported air | Normal birth weight | 11 (1.3) | – | 11 (1.0) | – | 36 (1.5) | – |
| | Low birth weight | 0 (0.0) | – | 0 (0.0) | – | 4 (2.9) | 2.0 (0.71, 5.8) |
| | Term birth | 11 (1.5) | – | 11 (1.1) | – | 31 (1.4) | – |
| | Preterm birth | 0 (0.0) | – | 0 (0.0) | – | 8 (3.8) | **2.8 (1.3, 6.1)** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| emissions of chemicals) | | | | | | | |
| Within 1 mile of facility with air emissions of solvents (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Normal birth weight | 138 (13.9) | – | 155 (12.0) | – | 187 (7.1) | – |
| | Low birth weight | 13 (22.0) | 1.7 (0.92, 3.3) | 14 (19.7) | 1.8 (0.98, 3.3) | 18 (11.8) | **1.7 (1.0, 2.9)** |
| | Term birth | 123 (14.3) | – | 138 (12.3) | – | 165 (7.1) | – |
| | Preterm birth | 12 (16.2) | 1.2 (0.61, 2.2) | 15 (15.5) | 1.3 (0.73, 2.3) | 24 (10.6) | 1.6 (0.99, 2.4) |

*Cases and controls are live births without any major birth defects.

Table 14. Relation Between Maternal Residential Proximity to Hazardous Wastes Sites and Low Birth Weight and Preterm Birth by Area of Residence

| Residential characteristic | Case-control status* | Dallas County | | Denton County | | Tarrant County | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of waste site (Referent groups are women who lived more than 1 mile from these sites at delivery) | Normal birth weight | 2(0.3) | – | 0 (0.0) | – | 1 (0.3) | – |
| | Low birth weight | 0 (0.0) | – | 0 (0.0) | – | 0 (0.0) | -- |
| | Term birth | 2 (0.4) | – | 0 (0.0) | – | 1 (0.0) | – |
| | Preterm birth | 0 (0.0) | – | 0 (0.0) | – | 0 (0.0) | -- |
| Within 2 miles of waste site (Referent groups are women who lived more than 2 miles from these sites at delivery) | Normal birth weight | 16 (2.6) | -- | 0 (0.0) | – | 6 (1.8) | -- |
| | Low Birth Weight | 1 (2.5) | 0.97 (0.13, 7.5) | 0 (0.0) | -- | 1 (4.5) | 2.6 (0.30, 23.0) |
| | Term birth | 12 (2.3) | – | 0 (0.0) | – | 6 (1.9) | – |
| | Preterm birth | 1 (2.3) | 1.0 (0.13, 7.9) | 0 (0.0) | -- | 1 (3.0) | 1.6 (0.19, 13.8) |

* Cases and controls are live births without any major birth defects.

Table 15. Relation Between Maternal Residential Proximity to Industrial Facilities with Air Emissions of Chemicals and Low Birth Weight and Preterm Birth by Area of Residence

| Residential characteristic | Case-control status* | Dallas County | | Denton County | | Tarrant County | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of industrial facility (Referent groups are women who lived more than 1 mile from these facilities at delivery) | Normal birth weight | 149 (23.9) | – | 4 (4.0) | – | 55 (16.2) | – |
| | Low birth weight | 10 (25.0) | 1.1 (0.51, 2.2) | 0 (0.0) | -- | 9 (40.9) | **3.6 (1.5, 8.8)** |
| | Term birth | 126 (24.4) | – | 4 (4.4) | – | 52 (16.5) | – |
| | Preterm birth | 13 (30.2) | 1.3 (0.68, 2.7) | 0 (0.0) | -- | 8 (24.2) | 1.6 (0.69, 3.8) |
| Within 2 miles of industrial facility (Referent groups are women who lived more than 2 miles from these facilities at delivery) | Normal birth weight | 388 (62.3) | – | 16 (16.0) | – | 171 (50.4) | – |
| | Low Birth Weight | 24 (60.0) | 0.91 (0.47, 1.7) | 2 (66.7) | 10.5 (0.90, 122.8) | 15 (68.2) | 2.1 (0.84, 5.3) |
| | Term birth | 326 (63.2) | – | 15 (16.7) | – | 157 (49.8) | – |
| | Preterm birth | 29 (67.4) | 1.2 (0.62, 2.3) | 2 (28.6) | 2.0 (0.35, 11.3) | 19 (57.6) | 1.4 (0.66, 2.8) |

* Cases and controls are live births without any major birth defects.

Table 16. Relation Between Maternal Residential Proximity to Specific Types of Industrial Facilities and Low Birth Weight and Preterm Birth by Area of Residence

| Residential and industrial facility characteristic | Case-Control status* | Dallas County | | Denton County | | Tarrant County | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of petrochemical facility (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Normal birth weight | 5 (1.0) | — | 0 (0.0) | — | 0 (0.0) | — |
| | Low birth weight | 2 (6.3) | **6.3 (1.2, 33.9)** | 0 (0.0) | -- | 0 (0.0) | -- |
| | Term birth | 6 (1.5) | — | 0 (0.0) | — | 0 (0.0) | — |
| | Preterm birth | 0 (0.0) | — | 0 (0.0) | — | 0 (0.0) | -- |
| Within 1 mile of primary metals/smelter facility (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Normal birth weight | 16 (3.3) | — | 0 (0.0) | — | 1 (0.4) | — |
| | Low birth weight | 1 (3.23) | 0.99 (0.13, 7.7) | 0 (0.0) | -- | 0 (0.0) | -- |
| | Term birth | 12 (3.0) | — | 0 (0.0) | — | 1 (0.4) | — |
| | Preterm birth | 3 (9.1) | 3.3 (0.87, 12.1) | 0 (0.0) | -- | 0 (0.0) | -- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Within 1 mile of chemical industry (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Normal birth weight | 63 (11.7) | – | 1 (1.0) | – | 14 (4.7) | – |
| | Low birth weight | 6 (16.7) | 1.5 (0.60, 3.8) | 0 (0.0) | -- | 2 (13.3) | 3.1 (0.64, 15.2) |
| | Term birth | 57 (12.8) | – | 1 (1.1) | – | 15 (5.4) | – |
| | Preterm birth | 3 (9.1) | 0.68 (0.20, 2.3) | 0 (0.0) | -- | 1 (3.8) | 0.70 (0.09, 5.5) |

*Cases and controls are live births without any major birth defects.

Table 17. Relation Between Maternal Residential Proximity to Specific Types of Industrial Emissions and Low Birth Weight and Preterm Birth by Area of Residence

| Residential and industrial facility characteristic | Case-Control status* | Dallas County | | Denton County | | Tarrant County | |
|---|---|---|---|---|---|---|---|
| | | N (%) | OR (95% CI) | N (%) | OR (95% CI) | N (%) | OR (95% CI) |
| Within 1 mile of facility with air emissions of heavy metals (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Normal birth weight | 55 (10.4) | – | 0 (0.0) | – | 32 (10.1) | – |
| | Low birth weight | 5 (14.3) | 1.4 (0.54, 3.9) | 0 (0.0) | -- | 3 (18.3) | 2.0 (0.55, 7.6) |
| | Term birth | 46 (10.6) | – | 0 (0.0) | – | 31 (10.5) | – |
| | Preterm birth | 3 (9.1) | 0.85 (0.25, 2.9) | 0 (0.0) | -- | 3 (10.7) | 1.0 (0.29, 3.6) |
| Within 1 mile of facility with air emissions of polycyclic aromatic hydrocarbons (Referent groups are women who lived a mile or more from any industrial facility with reported air | Normal birth weight | 5 (1.0) | – | 1 (1.0) | – | 5 (1.7) | – |
| | Low birth weight | 0 (0.0) | – | 0 (0.0) | – | 0 (0.0) | -- |
| | Term birth | 5 (1.3) | – | 1 (1.1) | – | 5 (1.9) | – |
| | Preterm birth | 0 (0.0) | – | 0 (0.0) | – | 0 (0.0) | -- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| emissions of chemicals) | | | | | | | |
| Within 1 mile of facility with air emissions of solvents (Referent groups are women who lived a mile or more from any industrial facility with reported air emissions of chemicals) | Normal birth weight | 104 (18.0) | – | 4 (4.0) | – | 30 (9.6) | – |
| | Low birth weight | 7 (18.9) | 1.1 (0.46, 2.5) | 0 (0.0) | -- | 6 (31.6) | **4.4 (1.5, 12.3)** |
| | Term birth | 90 (18.8) | – | 4 (4.4) | – | 4 (13.8) | – |
| | Preterm birth | 8 (21.1) | 1.2 (0.51, 2.6) | 0 (0.0) | -- | 4 (13.8) | 1.5 (0.47, 4.5) |

*Cases and controls are live births without any major birth defects.

Table 18–Maternal characteristics by residential proximity to industrial facilities with air emissions to chemicals

| Maternal characteristic | Maternal Residence Within One Mile of Industrial Facility | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Dallas, Denton, Tarrant counties | | | Texas Public Health Region 3 | | | Texas – Other Public Health Regions | | |
| | N (%) | OR (95% CI) | Adjusted* OR (95% CI) | N (%) | OR (95% CI) | Adjusted* OR (95% CI) | N (%) | OR (95% CI) | Adjusted* OR (95% CI) |
| Age (years) | | | | | | | | | |
| < 20 | 74 (25.8) | 1.1 (0.80, 1.6) | 0.92 (0.65, 1.3) | 92 (25.3) | 1.2 (0.90, 1.7) | 1.0 (0.72, 1.4) | 147 (13.2) | 1.1 (0.89, 1.4) | 1.0 (0.80, 1.3) |
| 20-24 | 144 (23.6) | 1.0 (Referent) | 1.0 (Referent) | 167 (21.7) | 1.0 (Referent) | 1.0 (Referent) | 206 (12.0) | 1.0 (Referent) | 1.0 (Referent) |
| 25-29 | 147 (21.6) | 0.89 (0.69, 1.2) | 1.1 (0.80, 1.4) | 167 (18.9) | 0.84 (0.66, 1.1) | 1.1 (0.84, 1.4) | 194 (12.4) | 1.0 (0.84, 1.3) | 1.2 (0.98, 1.5) |
| 30-34 | 87 (17.4) | **0.69 (0.51, 0.92)** | 0.86 (0.61, 1.2) | 101 (15.6) | **0.67 (0.51, 0.88)** | 0.89 (0.65, 1.2) | 127 (10.7) | 0.88 (0.69, 1.1) | 1.2 (0.93, 1.5) |
| 35+ | 80 (20.4) | 0.83 (0.60,1.1) | 1.1 (0.75, 1.5) | 91 (17.7) | 0.77 (0.58, 1.0) | 1.1 (0.80, 1.5) | 121 (12.1) | 1.0 (0.79, 1.3) | 1.3 (0.97, 1.6) |
| Race/ethnicity | | | | | | | | | |
| Non-Hispanic white | 140 (13.1) | 1.0 (Referent) | 1.0 (Referent) | 187 (11.8) | 1.0 (Referent) | 1.0 (Referent) | 159 (7.4) | 1.0 (Referent) | 1.0 (Referent) |
| African American | 58 (15.9) | 1.3 (0.89, 1.8) | 1.2 (0.82, 1.6) | 70 (17.8) | **1.6 (1.2, 2.2)** | 1.4 (1.1, 2.0) | 88 (15.9) | **2.4 (1.8, 3.2)** | **2.1 (1.6, 2.8)** |
| Hispanic | 315 (34.1) | **3.4 (2.7, 4.3)** | **2.3 (1.8, 3.1)** | 341 (32.7) | **3.6 (3.0, 4.5)** | **2.4 (1.9, 3.1)** | 534 (14.4) | **2.1 (1.8, 2.6)** | **1.7 (1.4, 2.1)** |
| Other | 22 (18.0) | 1.5 (0.86,2.4) | 1.4 (0.82, 2.3) | 23 (14.8) | 1.3 (0.79, 2.1) | 1.3 (0.79, 2.1) | 14 (8.1) | 1.1 (0.60, 2.0) | 1.2 (0.67, 2.2) |
| Education (years) | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 – 8 | 124 (42.6) | **5.6 (3.9, 8.2)** | **2.8 (1.5, 5.1)** | 134 (41.1) | **6.7 (4.7, 9.4)** | **3.9 (2.2, 6.9)** | 124 (15.6) | **2.9 (2.1, 4.1)** | **2.1 (1.4, 3.2)** |
| 9 – 11 | 129 (26.8) | **2.8 (2.0, 3.9)** | 1.5 (0.95, 2.3) | 147 (25.6) | **3.3 (2.4, 4.5)** | **1.8 (1.2, 2.6)** | 234 (15.0) | **2.8 (2.1, 3.8)** | **2.2 (1.5, 3.0)** |
| 12 | 150 (21.6) | **2.1 (1.5, 2.9)** | **1.7 (1.2, 2.5)** | 181 (19.8) | **2.4 (1.7, 3.2)** | **2.0 (1.4, 2.7)** | 245 (12.2) | **2.2 (1.6, 3.0)** | **1.9 (1.4, 2.5)** |
| 13 – 15 | 60 (14.1) | 1.2 (0.83, 1.9) | 1.1 (0.76, 1.7) | 74 (13.2) | **1.5 (1.0, 2.1)** | 1.3 (0.94, 1.9) | 108 (10.0) | **1.8 (1.3, 2.5)** | **1.6 (1.1, 2.2)** |
| 16+ | 61 (11.6) | 1.0 (Referent) | 1.0 (Referent) | 70 (9.5) | 1.0 (Referent) | 1.0 (Referent) | 60 (6.0) | 1.0 (Referent) | 1.0 (Referent) |
| Medicaid status | | | | | | | | | |
| On Medicaid | 74 (21.0) | 0.98 (0.74,1.3) | 0.98 (0.73, 1.3) | 103 (21.0) | 1.1 (0.89, 1.4) | 1.2 (0.95, 1.6) | 204 (11.8) | 0.96 (0.81, 1.1) | **0.79 (0.66, 0.94)** |
| Not on Medicaid | 437 (21.3) | 1.0 (Referent) | 1.0 (Referent) | 492 (19.0) | 1.0 (Referent) | 1.0 (Referent) | 578 (12.2) | 1.0 (Referent) | 1.0 (Referent) |
| Prenatal care | | | | | | | | | |
| None | 6 (16.7) | 0.72 (0.30,1.7) | 0.70 (0.29, 1.7) | 8 (18.6) | 0.94 (0.43, 2.0) | 0.84 (0.38, 1.9) | 18 (12.9) | 1.1 (0.65, 1.8) | 0.97 (0.59, 1.6) |
| Yes | 529 (21.7) | 1.0 (Referent) | 1.0 (Referent) | 613 (19.5) | 1.0 (Referent) | 1.0 (Referent) | 777 (12.1) | 1.0 (Referent) | 1.0 (Referent) |

* Adjusted for maternal race/ethnicity and education

Table 19–Maternal characteristics by residential proximity to industrial facilities with air emissions to chemicals

| Maternal characteristic | Maternal Residence Within One Mile of Industrial Facility | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Dallas county | | | Denton county | | | Tarrant county | | |
| | N (%) | OR (95% CI) | Adjusted OR (95% CI) | N (%) | OR (95% CI) | Adjusted OR (95% CI) | N (%) | OR (95% CI) | Adjusted* OR (95% CI) |
| Age (years) | | | | | | | | | |
| < 20 | 57 (28.8) | 1.1 (0.74,1.6) | 0.92 (0.61,1.4) | 0 (0.0) | -- | -- | 17 (23.3) | 1.2 (0.65,2.3) | 1.2 (0.59,2.5) |
| 20-24 | 98 (27.0) | 1.0 (Referent) | -- | 4 (10.8) | -- | -- | 42 (19.9) | 1.0 (Referent) | -- |
| 25-29 | 89 (23.4) | 0.82 (0.59,1.1) | 1.0 (0.71,1.5) | 4 (6.7) | -- | -- | 54 (22.2) | 1.2 (0.74,1.8) | 1.2 (0.73,2.0) |
| 30-34 | 53 (19.6) | **0.66 (0.45,0.96)** | 0.86 (0.56,1.3) | 2 (3.8) | -- | -- | 32 (18.2) | 0.89 (0.54,1.5) | 0.96 (0.53,1.7) |
| 35+ | 56 (24.0) | 0.86 (0.59,1.3) | 1.1 (0.71,1.7) | 1 (2.4) | -- | -- | 23 (19.5) | 0.97 (0.55,1.7) | 1.4 (0.72,2.7) |
| Race/ethnicity | | | | | | | | | |
| Non-Hispanic white | 63 (13.6) | 1.0 (Referent) | -- | 5 (3.2) | -- | -- | 72 (16.2) | 1.0 (Referent) | -- |
| African American | 44 (17.4) | 1.3 (0.89,2.0) | 1.24 (0.81,1.9) | 0 (0.0) | -- | -- | 14 (13.5) | 0.81 (0.44,1.5) | 0.81 (0.43,1.5) |
| Hispanic | 233 (35.1) | **3.4 (2.5,4.7)** | **2.3 (1.6,3.3)** | 6 (19.4) | -- | -- | 76 (33.2) | **2.6 (1.8,3.7)** | **2.1 (1.3,3.4)** |
| Other | 15(22.1) | 1.8 (0.96,3.4) | 1.7 (0.87,3.4) | 0 (0.0) | -- | -- | 7 (16.7) | 1.0 (0.44,2.4) | 1.0 (0.43,2.5) |
| Education (years) | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 – 8 | 100 (44.4) | **6.5 (4.0,10.4)** | **3.9 (1.9,8.3)** | 3 (37.5) | -- | -- | 21 (36.2) | **2.8 (1.4,5.4)** | 1.1 (0.28,3.9) |
| 9 – 11 | 90 (28.5) | **3.2 (2.0,5.1)** | 1.7 (0.96,3.0) | 1 (5.0) | -- | -- | 38 (26.2) | 1.7 (1.0,3.0) | 1.2 (0.58, 2.6) |
| 12 | 93 (23.7) | **2.5 (1.6,4.0)** | **2.2 (1.4,3.6)** | 3 (6.3) | -- | -- | 54 (21.2) | 1.3 (0.81,2.1) | 1.1 (0.66,1.9) |
| 13 – 15 | 34 (15.5) | 1.5 (0.87,2.5) | 1.3 (0.79,2.4) | 2 (5.6) | -- | -- | 24 (14.0) | 0.80 (0.45,1.4) | 0.76 (0.42,1.4) |
| 16+ | 28 (11.0) | 1.0 (Referent) | -- | 2 (2.3) | -- | -- | 31 (16.9) | 1.0 (Referent) | -- |
| Medicaid status | | | | | | | | | |
| On Medicaid | 37 (21.4) | 0.84 (0.57,1.2) | 0.89 (0.59,1.3) | 0 (0.0) | -- | -- | 37 (22.4) | 1.2 (0.77,1.8) | 1.2 (0.75,1.9) |
| Not on Medicaid | 303 (24.6) | 1.0 (Referent) | -- | 9 (4.8) | -- | -- | 125 (19.9) | 1.0 (Referent) | -- |
| Prenatal care | | | | | | | | | |
| None | 4 (25.0) | 1.0 (0.33,3.2) | 1.2 (0.38,3.9) | 0 (0.0) | -- | -- | 2 (11.8) | 0.51 (0.12,12.2) | 0.41 (0.09,1.9) |
| Yes | 351 (24.5) | 1.0 (Referent) | -- | 11 (5.4) | -- | -- | 167 (20.8) | 1.0 (Referent) | -- |

* Adjusted for maternal race/ethnicity and education