Birth Defects

The term "birth defects" covers a range of structural and chromosomal abnormalities that occur while the baby is developing in the mother's body.[1,2] A birth defect may affect how the body looks, works, or both. Some birth defects can be detected before birth, others can be detected when the baby is born, and others may not be detected until some time has passed after birth.

Birth defects are the leading cause of infant death in the first year of life, accounting for about 20% of infant deaths in 2005.[3] Infants who do survive with a birth defect often have lifelong disabilities, such as intellectual disability, heart problems, or difficulty in performing everyday activities such as walking.

Some birth defects are inherited. Others have known risk factors that can be avoided such as prenatal exposure of the fetus to certain pharmaceuticals (such as Accutane® or Thalidomide); exposure to alcohol; maternal smoking, and insufficient folate in a woman's diet.[3-5] For example, birth defects resulting from fetal alcohol syndrome are prevented when a woman does not consume alcohol during pregnancy, and reported cases of neural tube defects such as spina bifida and anencephaly have been shown to decrease following mandatory folic acid fortification of cereal grain products.[6,7] About 60–70% of birth defects have unknown causes, but research suggests that some defects could be modified or caused by environmental factors, possibly in conjunction with genetic factors.[3,8-10] Several environmental contaminants cause birth defects when pregnant women are exposed to high concentrations. Mercury poisoning in Minamata, Japan resulted in birth defects such as deafness and blindness.[11] Prenatal exposures to high concentrations of polychlorinated biphenyls (PCBs) and related chemicals have resulted in skin alterations, including chloracne, a potentially serious inflammatory condition.[12] However, any possible relationship between exposures to lower concentrations of these or other environmental contaminants and birth defects is less clear.

A number of epidemiological studies have evaluated the relationship between environmental and occupational exposures to chemicals and birth defects. The majority of studies consider the relationship of birth defects to exposures to specific types of environmental contaminants, including solvents, pesticides, drinking water disinfection byproducts, endocrine disrupting chemicals, and air pollutants. Some studies consider other scenarios in which individuals may have elevated exposures without measuring or estimating exposure to any particular substances. These studies evaluate factors such as occupational category, or residence near a contaminated site or industrial facility.

Several studies have evaluated the relationship between maternal and paternal solvent exposure and birth defects. An extensive review of the literature concluded that the evidence linking neural tube defects to paternal exposures to solvents was suggestive of an association, although not strong enough to draw a conclusion regarding a causal relationship.[10] A meta-analysis that included multiple studies of women's occupational exposure to organic solvents reported an

increased risk for birth defects such as heart defects and oral cleft defects in children born to exposed women.[13] In a recent study conducted in Massachusetts, women who were exposed to drinking water contaminated with the solvent tetrachloroethylene around the time of conception were reported to have an increased risk of giving birth to a child with a birth defect.[14]

Multiple studies have suggested an association between maternal and paternal exposure to pesticides (both before and after conception) and increased risk of offspring having or dying from birth defects.[15-31] A subsequent review study that evaluated many of these individual studies together, however, concluded that the data are inadequate at this time to confirm an association between pesticide exposure and the risk of birth defects.[10]

Disinfection byproducts in drinking water have also been linked to birth defects in some epidemiological studies. Disinfection byproducts are formed when organic material found in source water reacts with chemicals (primarily chlorine) used in treatment of drinking water to control microbial contaminants. Some individual epidemiological studies have reported associations between the presence of disinfection byproducts in drinking water and increased risk of birth defects, especially neural tube defects and oral clefts; however, recent articles reviewing the body of literature determined that the evidence is too limited to make conclusions about a possible association between exposure to disinfection byproducts and birth defects.[10,32-35]

Some studies have also reported associations between exposure to endocrine disrupting chemicals and urogenital malformations in newborn boys, such as cryptorchidism (undescended testes) and hypospadias (abnormally placed urinary opening).[19,22,36-44] An analysis of a large national database showed a significant increase in the incidence of congenital penile anomalies, particularly hypospadias, from 1988–2000.[45] According to studies by the Centers for Disease Control and Prevention, the prevalence of hypospadias in the United States has doubled in recent decades.[46] This considerable increase, combined with evidence of an association between endocrine-disrupting contaminants and urogenital birth defects in animal studies, has led to the hypothesis that environmental exposures are a contributing factor.[47] However, a review study recently concluded that there is inadequate evidence at this time of associations between male genital birth defects and exposure to environmental contaminants such as pesticides, PCBs, wood preservatives, and phthalates.[10]

A limited number of studies have investigated the relationship between birth defects and prenatal exposure to air pollution, specifically carbon monoxide, ozone, particulate matter, nitrogen dioxide, and sulfur dioxide.[48-57] Most of these studies have focused on cardiac and oral cleft birth defects. A recent pooled analysis of these studies reported statistically significant associations between nitrogen dioxide, sulfur dioxide and particulate matter and certain cardiac birth defects.[58] No statistically significant associations were found between any of the pollutants and oral cleft defects.

Since the discovery of extensive environmental contamination in the Love Canal community in New York State in the 1970s, there has been increased awareness that contaminated sites can be associated with negative birth outcomes, including birth defects.[59,60] Multiple epidemiological

studies conducted over the last 25 years have found possible associations between residence near contaminated sites and an increased risk of birth defects, particularly neural tube defects and congenital heart defects.[38,61-64] Studies have also reported associations between residence near hazardous waste sites or active industrial facilities and chromosomal birth defects.[65,66] The majority of these studies use maternal proximity to sites of interest in order to classify exposure and do not distinguish between specific types of contaminant exposures; however, a few studies have reported associations between birth defects and sites that emit heavy metals or solvents.[64,65] Some studies have suggested that the greatest impact may be for mothers residing within a half mile of a contaminated site.[61,67] Studies comparing Superfund sites undergoing assessment or remediation to active industrial facilities reporting toxic chemical releases reported no association between birth defect rates and proximity to Superfund sites, but did report significant associations with proximity to the active industrial sites.[65,68] A recent study of birth defect records for children born to mothers living with proximity to any of 154 Superfund cleanup sites reported an overall reduced incidence of birth defects.[69]

The process of fetal development is intensely complicated, requiring the precise coordination of cell division, growth, and movement. During the process of fetal development there are critical periods of susceptibility or vulnerability, at which point exposure to environmental contaminants may be especially damaging.[70] For example, two air pollution epidemiology studies found that the first two months of gestation are a particularly vulnerable period, during which exposure to air pollutants may cause birth defects of the heart and oral clefts.[52,56] Similarly, studies hypothesizing a role for pesticide exposure in birth defects have reported that conception during the spring is a risk factor for birth defects.[25,29,71] Agricultural use of certain pesticides is at its highest during spring, potentially leading to increased exposures that could contribute to the observed seasonal pattern in the incidence of birth defects.[25,29,71] These types of studies are useful for generating hypotheses for future research investigating the relationship between environmental exposures and the development of birth defects.

There is currently no unified national monitoring system for birth defects. Information on prevalence of birth defects comes from birth certificates and from state birth defects monitoring systems. Many birth defects can be observed shortly after delivery and are recorded on birth certificates. A national-scale indicator could be constructed using birth certificate data, but would miss any birth defect that is not immediately recognized and recorded at birth. Comparisons of birth defects recorded on birth certificates and birth defect registries have indicated that typically, less than half of birth defects are recorded on birth certificates.[72,73] Most states have some type of birth defects monitoring program, although the type of tracking varies widely among the states. As of 2008, 45 states had some type of existing birth defects monitoring program.[74] A small portion of these states have the most complete type of tracking system, which includes actively researching medical records for birth defects and following children through at least the first year of life. The remaining states have some type of monitoring program, but do not have all the aspects of a complete surveillance system. The National Birth Defects Prevention Network has pooled data from several state registries to

derive prevalence estimates for a subset of 21 selected birth defects for the years 1999–2001 and 2004–2006.[75]

The Texas monitoring program, which has monitored birth defects since 1995, is considered one of the most complete in the nation.[76] Data from the Texas registry for several categories of birth defects are presented in this section, as an example.

Measure S1: Birth defects in Texas, 1999–2007

About the Measure: Measure S1 presents information about the number of infants born with birth defects in Texas. The data come from a registry of birth defects for the state of Texas, which compiles data on any birth defects identified in the first year after each child is born. The Texas Registry staff routinely review medical records at all hospitals and birthing centers where babies are delivered or treated to identify birth defects. Measure S1 shows how the rates of different types of birth defects have changed over time. The rates of birth defects in Texas are not necessarily representative of those in other states.

The Texas Birth Defects Registry

The Texas Birth Defects Epidemiology and Surveillance Branch of the Texas Department of State Health Services provides information on birth defects in the state of Texas. The Texas program began monitoring the Houston/Galveston and South Texas areas in 1995 and expanded so that beginning in 1999, it covered the entire state. The Texas monitoring program covers approximately 380,000 births each year, which represents almost 10% of all births in the United States. In addition to live births, the Texas monitoring program also covers birth defects occurring in a fetal death or pregnancy termination. The Texas monitoring program reports a wide array of birth defects.

Although most states have a birth defects monitoring program in place, the comprehensiveness of these programs varies. Texas's birth defects monitoring program is one of the most complete in the nation, using high-quality active surveillance methods to examine a wide range of birth defects throughout a child's first year of life.[76] Specifically, the Texas Registry staff employ robust approaches to collecting, verifying, and ascertaining cases of birth defects such as routinely visiting all hospitals and birthing centers where babies are delivered or treated to individually review logs, discharge lists, and medical records.[77] As a result, a joint review by the Trust for America's Health and the National Birth Defects Prevention Network of the birth defects tracking activities in all 50 states assigned the Texas Registry their highest grade ranking, based on a number of criteria such as the ability to carry out tracking and the resources devoted to the task.[76] Although the Texas Registry data are of high quality, the rates and types of birth defects in Texas are not necessarily representative of those in other states.

Comparing the Texas Birth Defects Registry with Other Data Sources

To examine whether the rate of birth defects in Texas is similar to the rate for the country as a whole, it is useful to compare birth defect rates from birth certificates. Birth certificates record only those birth defects apparent at birth, and do not represent defects that become apparent after some time. Most states report birth defects on birth certificates using the standard birth certificate format recommended by the National Center for Health Statistics. The birth certificate reported rates of birth defects for Texas are generally similar to the nationwide rates.[78]

Comparing the Texas Birth Defects Registry data to the birth certificate data for Texas reveals that the active surveillance strategies detect a far greater number of birth defects than can be detected at an infant's birth. For specific birth defects that could be directly compared, the Texas monitoring program typically detects two to three times the number of birth defects reported on birth certificates, demonstrating the importance of tracking birth defects that are not observed at the time of delivery.[77,78] Texas birth certificates list potential birth defects for clinicians to choose from when recording the details of an infant's birth. An analysis by the Texas Birth Defects Registry found that birth certificates identify these listed birth defects only 15% of the time that they occur. Furthermore, of those birth defects listed on Texas birth certificates, the most obvious birth defects, such as spina bifida and cleft palate, are only identified 36-42% of the time.[73]

As mentioned previously, there is currently no unified national monitoring system for birth defects. However, CDC, in collaboration with the National Birth Defects Prevention Network, pools data from states with active and passive monitoring programs to estimate national prevalence rates for several selected birth defects. The pooled data set currently accounts for about 30% of births nationwide.[75]

Data Presented in the Measure

Measure S1 displays the number of birth defects per 10,000 live births for the state of Texas. Measure S1 shows data for 1999–2007 and groups birth defects by structural categories. A supplemental data table for this measure provides information showing how birth defect rates vary by race/ethnicity.[i]

Trends in the rates of birth defects may be influenced by differences in clinical practice. For example, increasing trends in the prevalence of some birth defects could represent more accurate recording of birth defects and/or better diagnosis of subtle defects due to the use of more sensitive examinations and technology.[79-82] Trends for specific birth defects may also be masked when grouping birth defects by structural categories. For example, anencephaly is included in the structural category of central nervous system defects. Incidence of central nervous system birth defects overall in Texas increased from 1999–2007, but the incidence of anencephaly defects specifically appear to be decreasing in the same years.[83]

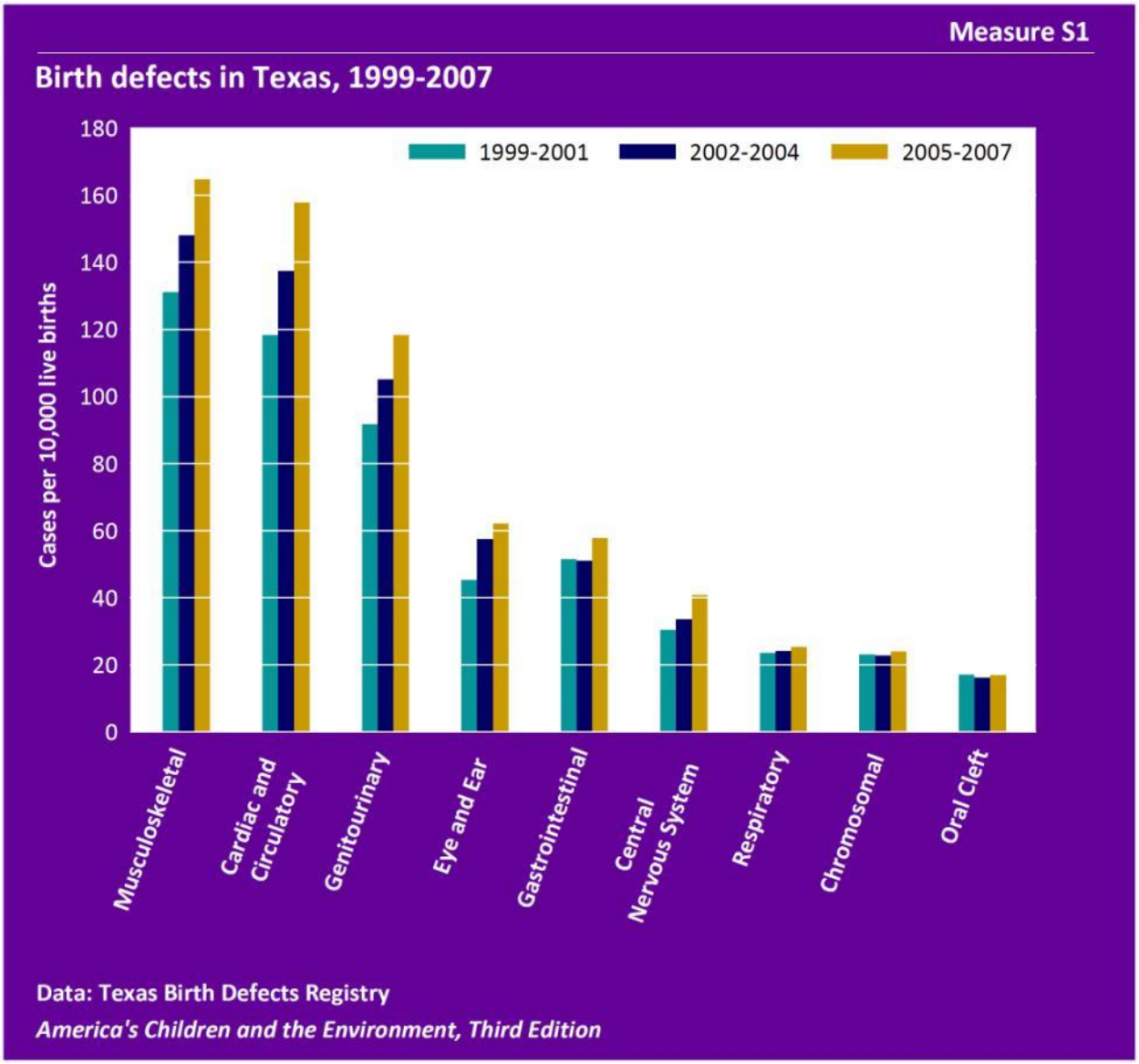
Statistical Testing

Statistical analysis has been applied to Measure S1 to evaluate trends over time or differences between demographic groups in the prevalence of birth defects. These analyses use a 5% significance level, meaning that a conclusion of statistical significance is made only when there is no more than a 5% probability that the observed trend or difference occurred by chance ($p \leq 0.05$). The statistical analysis of trends over time is dependent on how the values in the

[i] 95% confidence intervals for the birth defects rates are provided in a file available on the ACE website (www.epa.gov/ace).

measure vary over time as well as on the number of time periods. For example, the statistical test is more likely to detect a trend when data have been obtained over a longer period. A finding of statistical significance for differences between demographic groups depends on the magnitude of the difference and the number of observations in each group. It should be noted that conducting statistical testing for multiple categories of birth defects increases the probability that some trends or differences identified as statistically significant may actually have occurred by chance.

A finding of statistical significance is useful for determining that an observed trend or difference was unlikely to have occurred by chance. However, a determination of statistical significance by itself does not convey information about the magnitude of the increase, decrease, or difference. Furthermore, a lack of statistical significance means only that occurrence by chance cannot be ruled out. Thus a conclusion about statistical significance is only part of the information that should be considered when determining the public health implications of trends or differences in the prevalence of birth defects.



Data characterization

- Data for this measure are obtained from the Texas Birth Defects Registry.
- The Registry employs robust surveillance methods to monitor all births in Texas and identify cases of birth defects.
- The Registry represents almost 10% of all births in the United States, but the rates and types of birth defects in Texas are not necessarily representative of those in other states.

- Musculoskeletal defects are the most common type of birth defect in Texas, with 165 cases per 10,000 live births for the years 2005–2007. The second most common type of birth defect in Texas is cardiac and circulatory, with 158 cases per 10,000 live births for the years 2005–2007.

- The rates for all categories of birth defects in Texas have increased or remained stable for the period of 1999–2007. Some of the biggest increases were seen for musculoskeletal defects, cardiac and circulatory defects, genitourinary defects, eye and ear defects, and central nervous system defects.
  - The increases were statistically significant for musculoskeletal defects, cardiac and circulatory defects, genitourinary defects, eye and ear defects, gastrointestinal defects, and central nervous system defects.
- The prevalence of birth defects varies by race/ethnicity for most of the anatomical categories examined. Compared with White non-Hispanics, Black non-Hispanics had lower rates of musculoskeletal, genitourinary, eye and ear, gastrointestinal, chromosomal, and oral cleft birth defects, and these differences were statistically significant. There were no statistically significant differences between Black non-Hispanics and White non-Hispanics in rates of cardiac and circulatory, central nervous system, and respiratory birth defects. (See Table S1a.)
- Compared with White non-Hispanics, Hispanics had higher rates of cardiac and circulatory, eye and ear, and respiratory defects, whereas rates of musculoskeletal and genitourinary birth defects were lower. These differences were statistically significant. There were no statistically significant differences between Hispanics and White non-Hispanics in rates of gastrointestinal, central nervous system, chromosomal, and oral cleft defects. (See Table S1a.)

Supplementary Topics

Birth Defects

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Supplementary Topics

Birth Defects

Table S1: Birth defects in Texas, 1999-2007

	Cases per 10,000 live births		
	1999-2001	**2002-2004**	**2005-2007**
Musculoskeletal	131.1	148.1	164.8
Cardiac and Circulatory	118.4	137.4	157.9
Genitourinary	91.7	105.1	118.4
Eye and Ear	45.2	57.5	62.1
Gastrointestinal	51.5	51.0	57.8
Central Nervous System	30.5	33.6	40.7
Respiratory	23.5	24.1	25.3
Chromosomal	23.0	22.8	23.9
Oral Cleft	17.0	16.2	16.9

DATA: Texas Birth Defects Registry

Table S1a: Birth defects in Texas, 2005-2007, by race/ethnicity

	Cases per 10,000 live births			
	White non-Hispanic *(n=414,420)*	**Black non-Hispanic** *(n=134,427)*	**Hispanic** *(n=594,073)*	**Other non-Hispanic** *(n=48,327)*
Musculoskeletal	171.6	163.2	162.1	142.6
Cardiac and Circulatory	154.6	151.1	164.5	125.8
Genitourinary	132.2	115.1	109.6	120.2
Eye and Ear	60.1	48.0	67.3	52.4
Gastrointestinal	60.2	46.1	60.2	39.5
Central Nervous System	41.8	43.7	39.5	35.8
Respiratory	23.1	23.4	27.6	20.5
Chromosomal	23.5	19.9	25.3	18.2
Oral Cleft	18.1	11.1	17.5	15.7

DATA: Texas Birth Defects Registry