Tennessee Birth Defects
2002-2006

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Executive Summary

This is a statewide population-based report produced by the Tennessee Birth Defects Registry (TBDR). Its purpose is to provide general information about birth defects, the prevalence of birth defects among Tennessee infants and to inform readers regarding birth defect risk factors and preventive measures that may decrease the likelihood of birth defects in Tennessee. It details the birth prevalence of 45 major birth defects for Tennessee infants born in the years 2002 through 2006.

The report contains sections detailing the overall statewide birth defects counts and rates for each of the 45 birth defects diagnoses tracked by the TBDR. These birth defects comprise a list of birth defects compiled by the National Birth Defects Prevention Network (NBDPN) and the Centers for Disease Control and Prevention (CDC). Overall statewide counts and rates are presented, as well as counts and rates broken down by infant sex, race/ethnicity, and perinatal region. In addition, the mission, organization and methods of the TBDR are described. It also presents detailed data on maternal diabetes, which is a significant risk factor for birth defects. Diabetes is increasing among the Tennessee maternal population, putting an increasing number of affected mothers at increased risk of having a baby born with a birth defect. The report concludes with a section containing general information regarding a healthy pregnancy and known prevention strategies to reduce a woman's risk of having a baby born with a birth defect.

Overall, the 45 birth defects monitored by the TBDR accounted for a statewide birth defects rate of 351.6 per 10,000 live births or 3.5%. However, of the 18,769 infants born with one of the 45 birth defects, 2,301 were affected by multiple birth defects with 205 having 4 or more birth defects. This resulted in an overall case rate (i.e., affected infants) of 305.7 per 10,000 live births or 3.1%. Between 2003 and 2004, the number of infants with birth defect diagnoses increased 9.5% and increased an additional 6.4% and 3.9% in 2005 and 2006, respectively. Rates had not significantly increased in the previous years for which there are data, 1999 to 2003. The reason for the increase from 2003 to 2004 and subsequent years remains unexplained. It may represent a true increase in birth defects rates related to familial, maternal or environmental risk factors, improved birth defects surveillance or increased false positive diagnoses. It may very well represent a combination of all of these.

The five most common birth defects observed during this period were 1) the cardiovascular defects: atrial septal defect, patent ductus ateriosus, and ventricular septal defect; 2) the genitourinary defect: hypospadias; and 3) the gastrointestinal defect: pyloric stenosis. Removing these five birth defects from the analysis causes the trend of increasing birth defects to disappear. There is also reason to believe that the counts for these defects are subject to elevated rates of false positive diagnoses. Thus, it appears that the apparent increasing trend may be more artifact than reality. Continued surveillance and analyses of the present and subsequent years' data are necessary to determine its true nature.

Overall, birth defects are more common in whites, males and babies born to mothers aged 35 and older, but this is not the case for all types of birth defects. Birth defect rates vary by perinatal region with the highest rates in the Northeast and East perinatal regions and lower rates in the Southeast, Middle and West regions. The TBDR is working to evaluate factors that may affect regional differences as well as the racial/ethnic and gender differences in birth defects rates. The TBDR is also reviewing individual case records in Tennessee hospitals that have reported birth defects in order to evaluate data quality and obtain additional details for further analyses. The

efforts of the TBDR and its collaborations with the NBDPN and CDC are focused on effective surveillance with an emphasis on prevention initiatives that will ultimately diminish the burden of birth defects in Tennessee and elsewhere.

This report also contains information on diabetes as a risk factor for birth defects. Mothers with Type 1 and Type 2 diabetes are at elevated risk for birth defects. Our analyses showed that mothers with Type 1 and Type 2 diabetes were at elevated risk for 17 of the 45 birth defects tracked by the TBDR with their elevated risk ranging from more than twice as likely for obstructive genitourinary defects to more than eleven times more likely for renal agenisis/ hypoplasia. The birth defects affected by diabetes included 11 cardiovascular defects, including one of the more costly and deadly cardiovascular birth defects, hypoplastic left heart, which was four times more likely to occur in babies born to diabetic mothers.

In order to reduce the risk of birth defects diabetic women and obese women, who are at risk for becoming diabetic, should work with their health care provider to control their blood sugar before and during their pregnancies. The CDC recommends that a diabetic woman who wants to become pregnant should: 1) Plan her pregnancy; 2) See her doctor to assess the effects of her diabetes; 3) Eat healthy foods from a meal plan made for her as a person with diabetes; 4) Exercise regularly; 5) Monitor blood sugar often; 6) Take her medications on time; 7) Control and treat low blood sugar and high blood sugar quickly; and 8) Follow-up regularly with her health care provider. Under the heading Prevention Education, the report provides information on a number of simple prevention strategies and things to obtain, consume or avoid in order to increase the likelihood of having a healthy baby. First and foremost is to connect with a medical provider. A woman planning to become pregnant should connect with a medical provider and have a full health assessment prior to becoming pregnant. Likewise a woman with an unplanned pregnancy should connect with a health provider as soon as possible and begin with a full health assessment.

Overview

Impact of Birth Defects

Birth defects are the leading cause of infant mortality in the United States, accounting for nearly one fifth (20%) of all infant deaths, followed by short gestation/low birthweight (17%) and sudden infant death syndrome (8%).[1] During the period 2002-2006 birth defects were the second leading cause of infant deaths (18.4%) in Tennessee, following short gestation/low birthweight (18.6%).[2] As in the national statistics, sudden infant death syndrome was the third leading cause (10%). A major birth defect, as defined by the National Birth Defects Prevention Network, is an abnormality of structure, function, or metabolism (body chemistry) that is present at birth and requires medical or surgical treatment, has serious effects on health and development, or a significant cosmetic impact.[3] Most birth defects have their origins in the first three months of pregnancy with many of the most serious birth defects occurring in the first six to eight weeks. Nearly one in every 33 babies is born with a birth defect. Some defects are obvious at birth while others may not be apparent until adulthood. Some defects can result in life-long debilitating illnesses or death, whereas surgery and medical interventions may correct others, but not without cost. Birth defects account for nearly 15% of all pediatric hospital admissions.[4] Hospital costs alone for birth defects totaled $2.6 billion in the United States in 2004, with birth defect admissions being on average more than twice as costly as other admissions.[5] The lifetime medical costs associated with the neural tube defect, spina bifida, are estimated to total $635,000 per individual.[6] The CDC estimates that up to 70% of all spina bifida cases could be prevented if all women of child-bearing age took a vitamin containing 400 micrograms of folic acid everyday before and during early pregnancy.[7]

Unfortunately, the underlying causes of individual birth defects are largely unknown; nearly 70% of birth defects have no known cause. This leaves many questions about the causes and patterns of birth defects unanswered. Information obtained through monitoring diseases and surveillance of births defects can assist with the task of addressing such questions. The primary use of data collected by TBDR is to observe patterns and detect changes in the patterns of leading birth defects. These data provide the basis for research regarding birth defect risk and protective factors and help in developing and evaluating birth defects prevention initiatives.

History of the Tennessee Birth Defects Registry

The Tennessee Birth Defects Registry (TBDR) was established in law (TCA 68-5-506) by the Tennessee State Legislature in June 2000. The TBDR was established with the mission of: 1) providing annual information on birth defects prevalence and trends; 2) to provide information on the possible association of environmental hazards and other potential causes of birth defects; 3) to evaluate current birth defects prevention initiatives, providing guidance and strategies for improving those initiatives; and 4) to provide families of children with birth defects information on public services available to children with birth defects. Initially, the TBDR was a pilot program conducting birth defects surveillance in Northeast Tennessee. Since then, the program has expanded to provide population-based surveillance of birth defects for the entire state of Tennessee. The TBDR was established in order to 1) provide information on birth defect prevalence and trends; 2) to provide information on possible association of environmental hazards, behavioral risk factors and other potential causes of birth defects; 3) to evaluate current birth defects prevention initiatives, providing guidance and strategies for improving those initiatives; and 4) to provide families of children with birth defects information on public services available to children with birth defects.

The TBDR gathers data from hospital discharge reports and vital records (birth, fetal death, and infant death certificates) to ascertain birth defect information for infants born to Tennessee residents. Gathering data from archival data systems such as these is sometimes called a passive surveillance approach. The TBDR also employs an active surveillance approach reviewing and abstracting medical records of infants identified with specific birth defects. This is done primarily to evaluate and improve the validity of TBDR case ascertainment. These medical record reviews are conducted by specially trained public health nurses visiting Tennessee hospitals that reported birth defects.

The TBDR shares birth defect statistics and related information with other state agencies and public interest groups such as the March of Dimes, the Tennessee Perinatal Association, the Tennessee Folic Acid Council and the Centers for Disease Control and Prevention. The TBDR also actively participates in collaborative research projects organized by the National Birth Defects Prevention Network (NBDPN). Currently, Tennessee birth defects data are available from 1999 through the end of 2006; the data presented in this report correspond to the period 2002 to 2006.

Methods

Case Definition and Data Collection

The TBDR is located in the Research Division within the Office of Policy, Planning, and Assessment (PPA) in the Tennessee Department of Health. The surveillance system consists of data abstracted from the Hospital Discharge Data System (HDDS) and the Birth, Death, and Fetal Death Statistical Data Systems, which are compiled, processed, and stored by the Health Statistics and Vital Records sections of PPA.

This report presents data on selected birth defects among Tennessee residents born during the calendar years 2002 through 2006. Unless otherwise stated, all counts and rates in this report were aggregated over the five year period of 2002 through 2006. Birth defect counts include:

(1) A birth defect in a live birth diagnosed during the first year of life.
(2) A birth defect diagnosed in a fetal death that was at least 500 grams in weight or in the absence of weight, at least 22-weeks gestational age.

The program does not monitor birth defects associated with elective terminations of pregnancy. Hospital discharge records provide birth defects diagnostic information for live-born infants, whereas fetal death certificates provide diagnostic information for spontaneous abortions and still births. The birth, death, and fetal death certificate data systems offer additional information on maternal characteristics and demographics, and residential geography not included in the hospital discharge information. In 2004, Tennessee adopted the 2003 revision of the United States Standard Certificate of Live Birth. This resulted in changes to the birth certificate data system. For example, the new birth certificate no longer collects information about alcohol use during pregnancy; however, more detailed information about tobacco use during pregnancy is available. Generally, the revised certificate has resulted in improved data quality and facilitated matching records across the various data systems. The TBDR tracks 45 major congenital anomalies in eight diagnostic categories (Central Nervous System; Ear and Eye; Cardiovascular; Orofacial; Gastrointestinal; Genitourinary; Musculoskeletal; Chromosomal). The TBDR currently has linked birthing events and birth defects diagnoses for infants born in the years 1999 through 2006.

Data Analysis

The TBDR follows guidelines developed by the CDC and NBDPN and recognizes that a defect may occur alone or in conjunction with other defects.[3] Therefore, birth defects counts and rates are presented in two ways: 1) the number of birth defect diagnoses (i.e., birth defects rate); and 2) the number of patients, or cases, affected by birth defects (i.e., case rate). For example, when an infant or case has multiple birth defect diagnoses, we count and report each diagnosis separately. The totals for each of the eight birth defects categories, however, represent the number of cases (or patients) with one or more diagnoses in that category. Since it is also possible for a case to have diagnoses in multiple categories, the category totals cannot be added to obtain the total number of Tennessee cases, as this would overestimate the cases (i.e., affected infants). More specifically, of the 12,284 infants diagnosed with a birth defect between 2002 and 2006, 2,301 (18.7%) had more than one birth defect and while each represents a single case within a category, some are counted as cases in more than one diagnostic category.

Birth prevalence is the standard method of reporting birth defects as established by the NBDPN and CDC.[3] Birth prevalence is calculated as the number of birth defects cases born at a point in time per 10,000 live births. The prevalence tables list the number of cases found, the estimated prevalence rate per 10,000 live births, and the 95% confidence interval (CI) for that rate.[a] The width of the confidence interval is dependent on the number of birth defects cases and the number of births, with larger counts supporting greater confidence.[b] The reader is advised to use caution when interpreting rates based on a small number of observed cases as it is more difficult to make predictions with confidence under such circumstances. Confidence intervals for 100 or fewer cases are exact Poisson; otherwise confidence intervals are based on the normal approximation.

We also examined the presence of risk factors among infants affected by birth defects compared to infants not affected by birth defects. Chi-square tests of statistical significance, either Mantel-Haenszel or Fisher exact, were used to evaluate these effects. Relative risk ratios (RR) with their associated 95% CIs are reported to describe the magnitude of those effects that were statistically significant. The Cochran-Armitage trend-test was used to evaluate trends in risk factors and birth defects rates. All statistical significance tests were two-tailed with $p < .05$.

Data Limitations

Data limitations exist in any large scale population-based surveillance registry and may lead to an under or over-reporting of birth defects. Considerations in the data interpretation common to TBDR and like registries include:

- The TBDR reports a statistical compilation of infants' hospital discharge data linked with birth certificate data, as well as fetal death and death certificate data. Thus, underreported defects may include: (1) defects not diagnosed during the first year of life (e.g., asymptomatic kidney or heart defects, fetal alcohol syndrome); (2) defects diagnosed within the first year of life but outside of the hospital setting and do not require hospitalization or outpatient treatment at a licensed hospital within the first

[a] The 95% CI for a prevalence rate is the range that should contain the true rate 95% of the time. Wide confidence intervals reflect less certainty that the estimated rate is the true rate.

[b] As a general rule, rates based on fewer than 20 observed cases tend to be less reliable and less likely to reflect the true rate than those rates based on larger numbers of observed cases.

year of life; and (3) defects among Tennessee residents diagnosed and hospitalized outside of Tennessee.

- Misclassification of birth defects may occur through coding errors, vague diagnoses or missing information. The TBDR attempts to identify these errors by investigating the reliability of case ascertainment with public health nurses systematically reviewing and abstracting birth defects information from medical records at Tennessee hospitals. This approach started in 2005, reviewing all reported cases and a random sample of infants identified as not having any birth defects. Currently, medical record reviews are focused on a limited subset of birth defects diagnoses that have been identified as likely to include a significant proportion of false positive diagnoses.

- With advancements in medical technology, prenatal diagnosis of birth defects is improving and occurring more often in non-hospital, clinic settings than in previous decades. The early identification of birth defects provides women with options in the management of their affected pregnancies such as earlier referrals to obstetricians that specialize in high risk pregnancies, arrange for special medical therapies or choose an elective termination. For example, studies report that over 70% of pregnancies with a serious neurological prenatal diagnosis are terminated.[8,9] The Texas Birth Defects Registry also found that including information on terminations before 20 weeks increased case numbers by 6% to 29% for nine birth defects.[10] Of note, the TBDR does not collect data on elective terminations.

Confidentiality

We treat all personal identifying information collected and maintained by the TBDR as confidential and follow established procedures to guarantee the confidentiality of personal medical information and to protect the privacy of infants and their families. Published reports present only aggregated data. These practices uphold our ethical and legal obligations to safeguard confidentiality and fully comply with state and federal laws and guidelines.

Overall Birth Defects by Organ System in Tennessee, 2002-2006

The birth defects counts and rates for the 45 diagnoses reported in Tennessee from 2002 through 2006 are presented in Table 1. For the period 2002 through 2006, Tennessee residents reported 401,874 live births with approximately 3.1% of those births affected by one or more of the monitored birth defects. The overall birth defects case rate was 305.7 cases per 10,000 live births or 3.1%. However, 18.1% of the cases had more than one defect, resulting in a birth defects rate of 351.6 per 10, 000 live births or 3.5%.

Table 1. Birth Defects Counts and Rates by Organ System, 2002 - 2006

Birth Defect	Count[1]	Rate[2]	95% CI[3]
Central Nervous System			
Anencephalus	63	1.57	1.20-2.01
Spina Bifida	179	4.45	3.83-5.16
Hydrocephalus	279	6.94	6.15-7.81
Encephalocele	43	1.07	0.77-1.44
Microcephalus	298	7.42	6.60-8.31
Total Central Nervous System Cases	**838**	**20.85**	**19.46-22.31**
Ear/Eye			
Aniridia	5	0.12	0.04-0.29
Anophthalmia/Microthalmia	39	0.97	0.69-1.33
Congenital Cataract	83	2.07	1.65-2.56
Anotia/Microtia	21	0.52	0.32-0.80
Total Ear and Eye Cases	**143**	**3.56**	**3.00-4.19**
Cardiovascular			
Common Truncus	44	1.09	0.80-1.47
Transposition of Great Arteries	238	5.92	5.19-6.72
Tetralogy of Fallot	213	5.30	4.61-6.06
Ventricular Septal Defect	1,715	42.68	40.68-44.74
Atrial Septal Defect	2,011	50.04	47.88-52.28
Endocardial Cushion Defect	151	3.76	3.18-4.41
Pulmonary Valve Atresia & Stenosis	410	10.20	9.24-11.24
Tricuspid Valve Atresia & Stenosis	44	1.09	0.80-1.47
Ebsteins Anomaly	25	0.62	0.40-0.92
Aortic Valve Stenosis	71	1.77	1.38-2.23
Hypoplastic Left Heart Syndrome	122	3.04	2.52-3.62
Patent Ductus Arteriosus[4]	1,909	47.50	45.40-49.68
Coarctation of Aorta	239	5.95	5.22-6.75
Total Cardiovascular Cases	**5,132**	**127.70**	**124.23-131.24**
Orofacial			
Cleft Palate w/o Cleft Lip	280	6.97	6.18-7.83
Cleft Lip w/ & w/o Cleft Palate	441	10.97	9.97-12.05
Choanal Atresia	83	2.07	1.65-2.56
Total Orofacial Cases	**801**	**19.93**	**18.57-21.36**
Gastrointestinal			
Esophageal Atresia/Tracheoesophageal Fistula	105	2.61	2.14-3.16
Rectal & Large Intestinal Atresia/Stenosis	191	4.75	4.10-5.48
Pyloric Stenosis	1,496	37.23	35.36-39.16
Hirschprungs Disease (congenital megacolon)	114	2.84	2.34-3.41
Biliary Atresia	26	0.65	0.42-0.95
Total Gastrointestinal Cases	**1,915**	**47.65**	**45.54-49.83**

Birth Defect	Count[1]	Rate[2]	95% CI[3]
Genitourinary			
Bladder Exstrophy	16	0.40	0.23-0.65
Hypospadias	2,001	49.79	47.63-52.02
Epispadias	35	0.87	0.61-1.21
Obstructive Genitourinary Defect	959	23.86	22.38-25.42
Renal Agenesis/Hypoplasia	155	3.86	3.27-4.51
Total Genitourinary Cases	**3,120**	**77.64**	**74.94-80.41**
Musculoskeletal			
Reduction Deformity (upper limbs)	85	2.12	1.69-2.62
Reduction Deformity (lower limbs)	54	1.34	1.01-1.75
Gastroschisis	201	5.00	4.33-5.74
Omphalocele	121	3.01	2.50-3.60
Diaphragmatic Hernia	120	2.99	2.48-3.57
Congenital Hip Dislocation	287	7.14	6.34-8.02
Total Musculoskeletal Cases	**846**	**21.05**	**19.66-22.52**
Chromosomal			
Trisomy 13	38	0.95	0.67-1.30
Down Syndrome	540	13.44	12.33-14.62
Trisomy 18	56	1.39	1.05-1.81
Total Chromosomal Cases	**629**	**15.65**	**14.45-16.92**
Other			
Fetal Alcohol Syndrome	78	1.94	1.53-2.42
Total Cases	**12,284**	**305.67**	**300.29-311.12**
Total Live Births	**401,874**		

[1] Counts include birth defects in live births and fetal deaths.
[2] Rates per 10,000 live births.
[3] Confidence intervals (CI) for 100 or less cases are exact Poisson; otherwise confidence intervals are based on the normal approximation.
[4] Patent ductus arteriosis is counted as a birth defect only for birth weights of 2500 grams or more.

Diagnostic data were derived from the Tennessee Hospital Discharge Data System (2002-2007), the Tennessee Death Statistical Death System (2002-2007) and the Tennessee Fetal Death Statistical System (2002-2006).

Total live births and birth weights are from the Tennessee Birth Statistical System (2002-2006).

The rate of infants affected by birth defects increased significantly over the period 2002 to 2006 from 278/10,000 live births in 2002 to 338/10,000 live births in 2006 (Figure 1). The majority of birth defects fell into two categories, cardiovascular (47%) and genitourinary (20%) (Figure 2). Together these two organ systems accounted for four of the top five diagnosed birth defects in the Tennessee birth population for 2002 to 2006 (Table 2).

Figure 1: Annual Birth Defects Case Rates 2002-2006

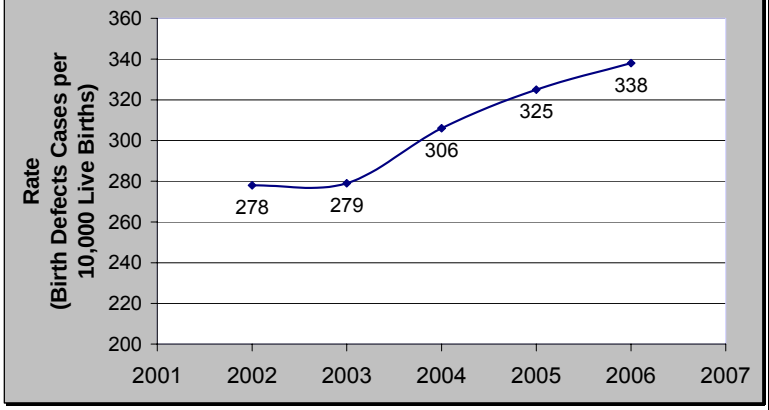
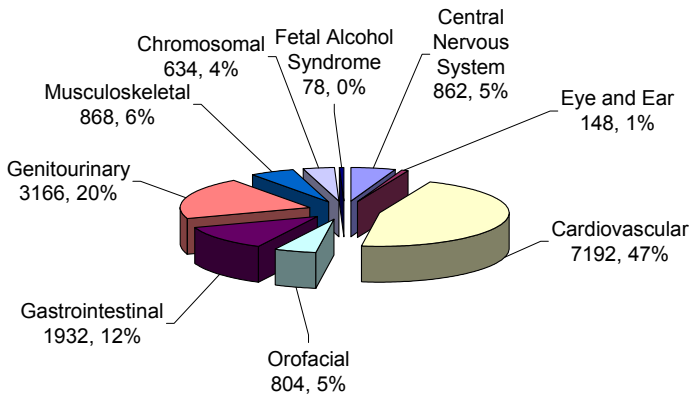


Figure 2: Percentage of Birth Defects by Organ System (N, %)



The five most common diagnoses are presented in Table 2. The number one overall diagnosis was atrial septal defect or ASD. ASD is a hole in the atrial septum, i.e., the wall separating the upper chambers of the heart. The hole is a part of normal fetal development called the foramen ovale. The foramen ovale allows the blood flow to bypass the lungs prior to birth. Generally, the hole closes or becomes very small within a few weeks or months. If the hole remains large after birth it is an ASD and may require surgery. The hole may also decrease in size, but remain as a patent foramen ovale (PFO). It is estimated that 29% percent of adults have an undiagnosed PFO.[11] These are generally nonsymptomatic. However, they may play a role in the creation of blood clots that put an affected person at risk of stroke or other circulatory problems later in life. PFO also has the same ICD-9 diagnosis code as ASD. Thus, ASD counts derived from the Hospital Discharge Data System are likely inflated. Though related to ASDs, PFOs are classified as a minor birth defect. There may also be institutional and regional differences in diagnosing and coding PFOs. Hypospadias, which is a misplaced urethral opening on the underside of the penis, has a similar coding problem. It has three levels of severity relating to the degree of urethral misplacement. However, these are coded together under a single diagnostic code and only the most severe instance is considered a major birth defect. Thus, hypospadias is also likely overcounted. These defects are the curent focus of the medical record reviews being conducted at select hospitals. Reviews completed to date suggest that corrections to these counts and rates will significantly reduce the counts and rates associated with these birth defects, but most or all will likely remain among the top five.

Table 2. Top Five Birth Defects Diagnoses (2002-2006)

Birth Defect	Count	Rate*	95% CI
Atrial Septal Defect	2,011	50.04	47.88-52.28
Hypospadias	2,001	49.79	47.63-52.02
Patent Ductus Arteriosus†	1,909	47.50	45.40-49.68
Ventricular Septal Defect	1,715	42.68	40.68-44.74
Pyloric Stenosis	1,496	37.23	35.36-39.16

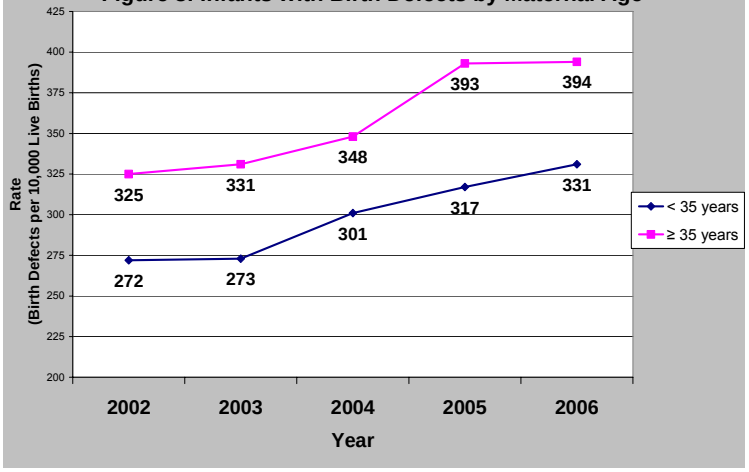
*Per 10,000 live births
†Patent Ductus Arteriosus only counted for birthweights greater than 2500 grams

Characteristics Associated with Birth Defects

The TBDR data permits the identification of high risk groups and other characteristics associated with elevated birth defects rates. Maternal age, infant gender, race and ethnicity, births of multiples, premature births and regions of residence within the state all have an impact on birth defects rates. While such characteristics may have a different impact or no impact on individual types of birth defects, overall the total birth defect rate is significantly impacted when examining the following characteristics.

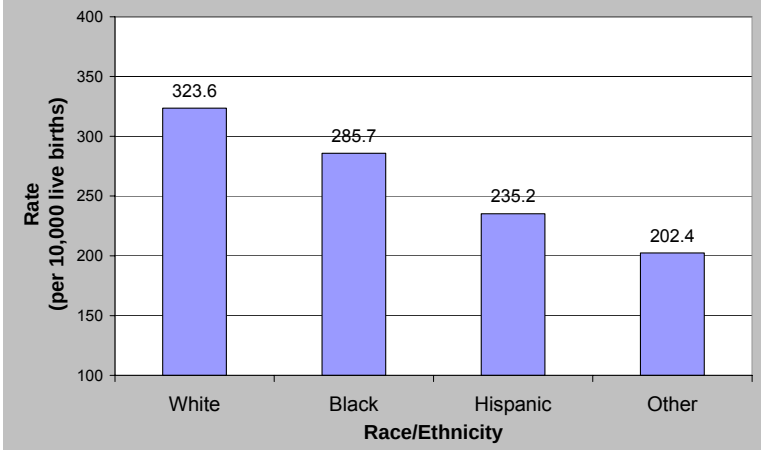
Maternal Age: Advanced maternal age was associated with increased birth defect rates (Figure 3). Infants with birth defects were 20% (RR 1.20; 95% CI 1.14-1.26) more likely to be born to mothers aged 35 years and older (359.01 cases per 10,000 live births; 95% CI 340.88-377.86) than to mothers aged less than 35 years (299.86 cases per 10,000 live births; 95% CI 294.23-305.57). However, this was not the case for all birth defects. Infants with gastroschisis, which is an abdominal wall defect with the intestines extruding outside of the body, were nearly 6 times (RR 5.90; 95% CI 4.13-8.42) more likely to be born to mothers aged 24 years and younger (9.52 cases per 10,000 live births; 95% CI 8.12-11.10) than to mothers older than 24 years (1.62 cases per 10,000 live births; 95% CI 1.14-2.23). Although the cause of gastroschisis is unknown, recent literature suggests a behavioral component including maternal smoking and perinatal illegal drug use.[12, 13, 14]

Figure 3: Infants with Birth Defects by Maternal Age



Race/Ethnicity: Infants affected by birth defects were more likely of white race than black race, Hispanic ethnicity or other races (aggregate of Asian, Native American, unknown or not categorized) (Appendix B; Table B1). White infants had a case rate of 323.56 infants per 10,000 live births (95% CI 316.88-330.34), while blacks had a rate of 285.65 (95% CI 274.37-297.26). Rates for Hispanics were lower than both whites and blacks (case rate 235.23; 95% CI 218.77-252.60) (Figure 4). Infants of other or unknown race or ethnicity had the lowest rate overall. White infants were 13% more likely to have a birth defect than black infants (RR 1.13; 95% CI 1.08-1.18) and 38% (RR 1.38; 95% CI 1.28-1.48) more likely to have a birth defect than Hispanic infants.

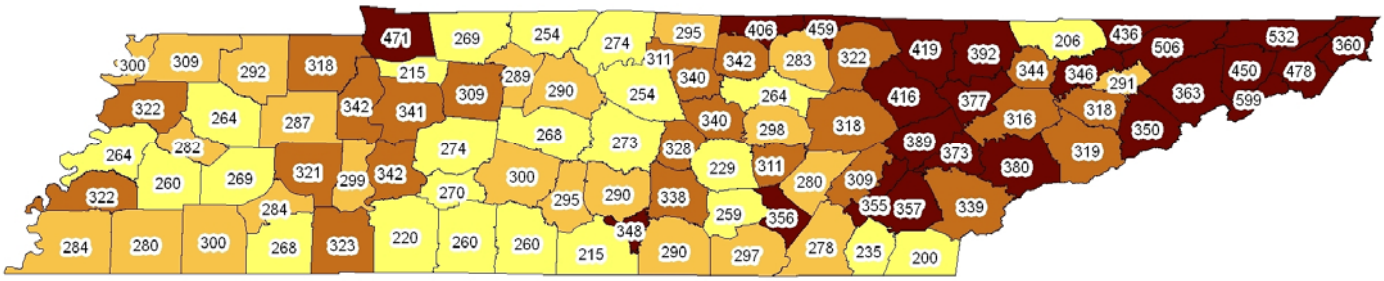
Figure 4: Infants with Birth Defects by Race/Ethnicity



Region of Residence: The state of Tennessee is broken down into five perinatal regions (Northeast, East, Southeast, Middle and West), each associated with a perinatal center hospital (See Reference Map in Appendix A; Figure A1 and Appendix B; Table B3). The overall rate of birth defects cases was highest in the Northeast with a rate of 474.88 per 10,000 live births (95% CI 449.12-501.66) and East regions with a rate of 336.40 (95% CI 323.06-350.14) with lower rates occurring in the Southeast, Middle and Western regions. When using one of the lower rates (the Middle perinatal region) as the reference, the Northeast region showed the highest risk of birth defects with increased risk of 68% (RR 1.68; 95% CI 1.58-1.79). Though less so, the East region also showed elevated risk (RR 1.19; 95% CI 1.14-1.25), whereas the Southeast and Western regions did not differ significantly from the Middle region, (RR 0.99; 95% CI 0.93-1.06) and (RR 1.02; 95% CI 0.97-1.06), respectively. Figures 5 shows county-level birth defects case rates (i.e. individual infants affected by birth defects, whether by single or multiple birth defects, per 10,000 live births).

Figure 5

Infants with Major Birth Defects in Tennessee 2002 - 2006



Quartiles for Birth Defect Case Rates
(per 10,000 live births)

- 344.1 - 599.1
- 308.7 - 344.0
- 274.0 - 308.6
- 200.2 -273.9

Region	Case Rate (per 10,000 live births)	95% CI
Northeast	474.8	449.2-501.7
East	336.4	323.1-350.1
Southeast	280.3	263.5-298.0
Middle	282.1	273.8-290.6
	286.5	276.6-296.6

Infant Gender: Male infants were 78% more likely to have a birth defect than female infants (RR 1.78; 95% CI 1.72-1.85). From 2002-2006 males in Tennessee were affected by birth defects at a rate of 389.25 cases per 10,000 live births (95% CI 380.76-397.89) compared to females with 218.82 cases per 10,000 live births (95% CI 211.82-224.93). Hypospadias/epispadias are exclusively male birth defects affecting the male genitalia. Hypospadias also ranked second in frequency among Tennessee birth defects in 2002-2006. With hypospadias/epispadias removed from the analysis, male infants were still approximately 34% (RR 1.34; 95% CI 1.29-1.39) more likely to have a birth defect than a female infant (See Appendix B; Table B2). Pyloric stenosis is also sex-related with male infants 61% more likely go be affected by pyloric stenosis than female infants (RR 1.61; 95% CI 1.57-1.65). From 2002-2006 male infants were affected by pyloric stenosis at rate of 59.81 cases per 10,000 live births (95% CI 56.51-63.25) compared to female infants with a pyloric stenosis rate of 13.68 (95% CI 12.09-15.41).

Premature Births: Premature infants born prior to 38 weeks gestational age were more than twice as likely to have a birth defect than full term infants (RR 2.34; 95% CI 2.25-2.44). Premature infants were affected at a rate of 501.08 per 10,000 live births (95% CI: 486.50-515.99), whereas term infants were affected at a rate of 249.53 per 10,000 live births (95% CI: 244.01-255.14).

Multiple Births: Multiple births (twins or greater) were 53% more likely to have birth defects than singleton births (RR 1.53; 95% CI 1.41-1.66). Multiple birth infants were affected at a rate of 459.73 per 10,000 live births (95% CI: 423.32-498.44), whereas singleton infants were affected at a rate of 300.65 per 10,000 live births (95% CI: 295.23-306.15).

Prevention Focus: Diabetes

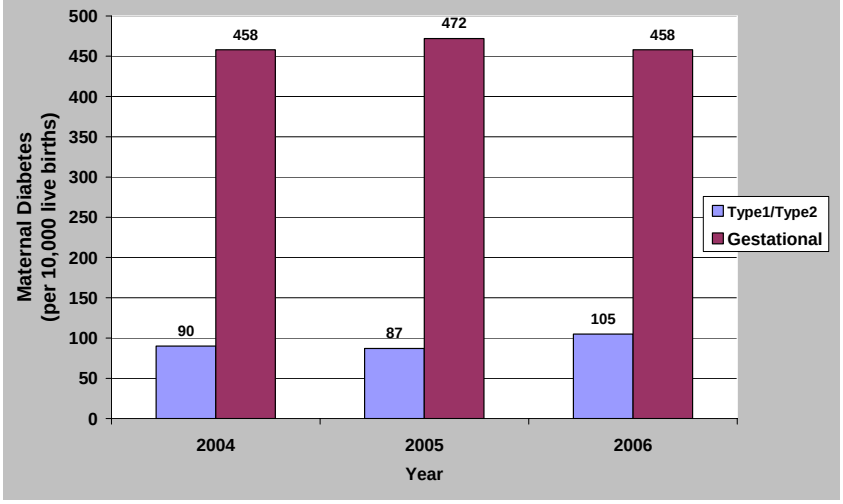
TBDR data permits focused evaluations of various subpopulations, such as mothers with diabetes. Diabetes may appear in the maternal population in any one of three types: Type 1, Type 2 or gestational. Both Type 1 and Type 2 diabetes are associated with increased risk for birth defects. Gestational diabetes is generally not associated with birth defects, because it develops later during pregnancy. Thus, the potential n-egative effects of gestational diabetes are not present during the first two months of pregnancy, when most birth defects originate. However, babies born to mothers with gestational diabetes are at elevated risk for a number of other negative birth outcomes.

All babies born to mothers with diabetes, including gestational diabetes, are at risk of being born very large, a condition known as macrosomia. If a mother's blood sugar is poorly controlled and she becomes hyperglycemic, elevated blood sugar will cause the fetus to develop excess fatty tissue and gain excessive weight. This may cause problems for both the baby and the mother at delivery, including birth trauma for the baby and an increased likelihood of a cesarean (i.e., C-section) delivery for the mother. Later in life these extra large babies are also at elevated risk of becoming obese and developing Type 2 diabetes.

In order to reduce the above risks, women who are pregnant or are planning to become pregnant and have Type 1 or Type 2 diabetes, develop gestational diabetes or are obese and thus at risk of developing diabetes need to control their blood sugar throughout their pregnancy. According to doctors at the University of Wisconsin,[15] more than 20% of pregnant women with Type 1 and Type 2 diabetes will deliver a baby with a birth defect. However, the risk of these birth defects could be reduced by 90%, if all diabetic women worked with a doctor or healthcare provider to manage their risk before becoming pregnant. This advice is consistent with that offered by the CDC's National Center for Birth Defects and Disabilities.[16] In short, the CDC suggests that a diabetic woman who wants to get pregnant should: 1) Plan the pregnancy; 2) See her doctor to assess the effects of her diabetes; 3) Eat healthy foods from a meal plan made for her as a person with diabetes; 4) Exercise regularly; 5) Monitor blood sugar often; 6) Take her medications on time; 7) Control and treat low blood sugar and high blood sugar quickly; and 8) Follow-up regularly with her health care provider.

To investigate the relationship of diabetes and birth defects we used diabetes diagnoses from the birth certificate data system linked with birth defects diagnoses from the hospital discharge data system. This allowed us to assess the overall prevalence of diabetes among birth mothers (Figure 6) and its effect on birth defects rates (Table 3).

Figure 6: Maternal Diabetes Tennessee 2004-2006



In order to properly identify cases and assess the relationship this analysis begins in 2004. Prior to 2004 the birth certificate data system contained a single variable indicating

a diagnosis of any diabetes, Type 1, Type 2 or gestational. With the adoption of the revised 2003 United States Standard Certificate of Live Birth in 2004, the data system began capturing two diabetes variables, one indicating gestational diabetes and the other indicating Type 1 or Type 2 diabetes. Looking at Figure 6, it is apparent that gestational diabetes is approximately 4.5 times more common among Tennessee mothers than Type 1 and Type 2 diabetes. Although babies of mothers with gestational diabetes are at less risk of birth defects than those whose mothers have Type 1 or Type 2 diabetes, many of these babies are likely to be born with macrosomia and are at increased risk for developing Type 2 diabetes later in life. Thus, without intervention and control, this will likely add to an increasing cycle of babies born to mothers with diabetes. Our analyses showed that these babies were also at increased risk of birth defects (RR 1.31; 95% CI 1.20-1.43). However, this may due in part to mothers with undiagnosed Type 2 diabetes being mistakenly diagnosed with gestational diabetes.

Over the three year period, 2004 through 2006, there were 2,317 Tennessee babies born to mothers with Type 1 or Type 2 diabetes. Each of these babies was at elevated risk of being born with one or more of the 17 birth defects listed in Table 3. Four of the five most prevalent birth defects in Tennessee during this period (see, Table 2) were affected by diabetes. Ventricular and atrial septal defects were more than four times more likely among babies of diabetic mothers, patent ductus arteriosus was five times more likely and hypospadias was nearly two and a half times more likely. Renal agenesis/hypoplasia was more than 11 times more likely in babies of diabetic mothers. Tricuspid valve atresia was nearly eight times more likely and common truncus and esophageal atresia/tracheoesophageal fistula were both more than seven times more likely in babies born to diabetic mothers. Hypoplastic Left Heart, which is one of the most costly and deadly birth defects, was more than four times more likely in these babies.

These birth defects may be significantly reduced if diabetic mothers actively partner with their medical providers to monitor and control their blood sugar and maintain their overall health in the time leading up to and during their pregnancies. It is optimal that all pregnancies are planned and prepared for, as all of these birth defects have their origins in the early weeks of pregnancy, before most women know they are pregnant. If a pregnancy is unplanned, it is still important to see a medical provider as soon as possible.

Table 3. Maternal Diabetes: Elevated Risk for Birth Defects

Birth Defect	Rate*	Relative Risk	95% CI
Spina Bifida	17.0	3.57	1.36-9.36
Microcephalus	26.0	2.90	1.31-6.38
Common Truncus	9.0	7.32	1.92-27.88
Transposition of Great Arteries	39.0	5.91	3.13-11.16
Tetralogy of Fallot	22.0	3.93	1.66-9.30
Ventricular Septal Defect	190.0	4.35	3.25-5.83
Atrial Septal Defect	233.0	4.30	3.30-5.61
Endocardial Cushion Defect	22.0	5.47	2.33-12.87
Pulmonary Valve Atresia	35.0	2.92	1.47-5.79
Tricuspid Valve Atresia	9.0	7.86	2.07-29.84
Hypoplastic Left Heart	13.0	4.03	1.33-12.23
Patent Ductus Ateriosus	246.0	5.02	3.88-6.49
Coarctation of the Aorta	30.0	4.80	2.32-9.81
Esophageal Atresia / Tracheoesopageal Fistula	17.0	7.45	2.89-19.18
Renal Agenesis/Hypoplasia	52.0	11.21	6.55-19.17
Obstructive Genitourinary Defect	56.0	2.29	1.34-3.93
Hypospadias	125.0	2.45	1.71-3.52

** per 10,000 live births to diabetic mothers*

Prevention Education

Prevention is the best strategy in public health. A woman can reduce her risk of delivering a baby born with a birth defect or other adverse outcome by taking precautions before and during pregnancy. The best time to start preventing pregnancy related complications occur even **before** a woman becomes pregnant (preconception). Most of the baby's vital organs and systems are formed in the first four to eight weeks of gestation, often before a woman realizes she is pregnant. The majority of birth defects occur during this four to eight week period, and the public health and medical community have begun to learn of a few simple actions that women can do to improve the health of their children; unfortunately many of these actions are only most effective if started **prior** to becoming pregnant.[17] While no guarantee exists that one will have a healthy baby, the following preventive measures can improve a woman's chances of having a healthy baby.[17, 18]

- ***Be connected to a medical provider prior to becoming pregnant.*** Having a medical provider regularly available to assess a woman's health prior to conception and thus having a source of reliable health information is essential to improving the health and well-being of the mother and infant. Being connected to a physician allows for medical intervention in four main categories of preconception care:

    - Maternal health assessment: Assessing in the pre-conception phase any prior medical conditions such as pre-existing diabetes or high-blood pressure or any other condition requiring treatment will provide the physician-patient team time to optimize the patient's health prior to conception. Good diabetes management has been shown to significantly reduce the prevalence of birth defects among infants of diabetic mothers. Mothers can also learn about any harmful medications they are currently taking or might take during pregnancy. Some medications used for seizure control (*i.e.* anti-convulsants), blood thinners (*i.e.* anticoagulants), severe acne (*i.e.* Accutane), and a few over-the-counter (OTC) medications (*i.e.* large doses of certain vitamins such as Vitamin A) have been shown to be harmful to fetuses.
    - Updating vaccinations: Updating vaccinations prior to pregnancy reduces the risk of adverse pregnancy outcomes from exposure to such illnesses as Rubella, Varicella (chicken pox), and Hepatitis B.[18]
    - Screening: Prepregancy screening for HIV and STDs allows for treatment or appropriate interventions to avoid vertical transmission of infectious agent to the infant. Screening is also available for those families with prior history of genetic disorders such as cystic fibrosis.
    - Counseling on behavior choices: Physician counseling and patient education regarding lifestyle choices before and during pregnancy target behaviors (*e.g.* smoking, alcohol, and illicit drug use) associated with increased health risks for the fetus.

- ***Consume at least 400 micrograms of folic acid daily.*** Studies have shown that consuming a daily vitamin with 400 micrograms of folic acid prior to becoming pregnant and during pregnancy can greatly reduce the risk of neural tube defects. Consuming

folic acid may also be able to prevent other birth defects such as cleft lip/cleft palate and certain cardiac defects.

- ***Eat a healthy, balanced diet.*** A well-balanced diet and multivitamin will provide essential nutrients to the mother and her growing fetus. Having a balanced diet allows for many nutrients to be available in several bio-available formats, allowing for greater bio-availability (*i.e.* access of nutrients to the body in forms that are useful to the body).

- ***Exercise regularly.*** Regular exercise allows for increased strength for the mother and often reduces the normal side-effects of pregnancy such as back pain due to increased mass in the abdominal area and shortness of breath due to decreased lung volume as the fetus pushes up on the mother's diaphragm.

- ***Be at an ideal body weight prior to pregnancy.*** Women who are significantly underweight or overweight may encounter more problems during pregnancy. Women who are overweight prior to conception have an increased risk of high blood pressure and diabetes during pregnancy. If underweight prior to conception, a woman may have an increased risk of delivering a premature infant.

- ***Avoid smoking.*** In general, all people should avoid smoking or second-hand smoke as much as possible. Avoidance of smoke should continue during and after pregnancy. Smoking during pregnancy is associated with an increased risk of spontaneous abortion (miscarriage) and with still birth as well as SIDS (sudden infant death syndrome), low birth weight, premature birth, and is potentially associated with increased risk of certain birth defects. Second-hand smoke exposure can lead to significant respiratory complications in infants and small children.

- ***Avoid alcohol.*** Alcohol consumption is the leading cause of preventable mental retardation among infants. The most severe effects of alcohol are seen with Fetal Alcohol Syndrome (FAS) where the infant has physical, mental, and behavioral problems. While the exact threshold of alcohol exposure that leads to birth defects is unknown presently and may depend on many unknown maternal factors, the current recommendations are to avoid alcohol consumption during pregnancy and to avoid binge drinking and/or frequent drinking prior to pregnancy.

- ***Avoid illicit drugs.*** Illicit drugs such as cocaine, heroin, marijuana and others can seriously harm a mother and her unborn fetus. Use of intravenous drugs carries the risk of infections that could be passed from mother to infant such as HIV and/or Hepatitis C (and/or Hepatitis B if not previously successfully immunized). Cocaine is associated with placental abruption (*i.e.* when the placenta separates from the uterine wall) and is usually the reason for late term vaginal bleeding; placental abruption can lead to significant morbidity and/or mortality for both mother and fetus.

- ***Limit exposure to environmental hazards.***
  - Chemicals and toxic substances should be avoided during pregnancy.
  - Pregnant women should also avoid changing cat litter to prevent Toxoplasma infection (toxoplasmosis) to the fetus; cats are known hosts to the parasite and can transmit the parasite from cat feces through oral ingestion by humans who fail to wash hands properly. The parasite can also be found and cause infection

by consumption of raw and undercooked meats. Toxoplasmosis during pregnancy can result in a congenital infection in the fetus and lead to visual impairment, learning disabilities, and/or mental retardation. Toxoplasma infection in a healthy child/adult individual usually is benign.

- Listeriosis is another infection that is usually not serious in the healthy individual but can be quite serious for pregnant woman (particularly for the fetus) and for immunocompromised people (*i.e.* those whose immune system is not at full strength due to illness or due to medical treatment). Maternal infection has been associated with preterm labor, spontaneous abortion (miscarriage), and fetal death. Food born transmission usually causes sporadic outbreaks, and it is for this reason that pregnant women are instructed to avoid soft cheeses (*i.e.* Brie, feta, Camembert, blue-veined cheese, and Mexican queso cheese); unpasteurized milk products; delicatessen meats/cheeses; and refrigerated meat spreads such as paté.[18]

Summary

The Tennessee Birth Defects Registry provides the statewide population-based data necessary to assess potential trends and possible causes of birth defects in Tennessee. This report summarizes the birth prevalence of 45 major birth defects for Tennessee infants born during the period 2002 to 2006 and informs readers regarding birth defect risk factors and preventive measures that may decrease the likelihood of birth defects. Birth defects are the leading cause of infant mortality in the United States, and the second leading cause of infant mortality in Tennessee. The goal of the TBDR is to diminish the effect of birth defects in Tennessee through the provision of information on risk factors to be avoided and measures that can be taken to reduce the likelihood of birth defects. In this report, we demonstrated the effect of increased birth defects rates associated with maternal diabetes among Tennessee mothers. We also listed simple and effective measures that can be taken by diabetic women to reduce the likelihood of giving birth to a child affected by birth defects.

Unfortunately, nearly 70% of birth defects have no known cause. Information obtained through monitoring diseases and surveillance of births defects can assist in addressing such questions. Data collected by TBDR is also used to observe patterns and changes in patterns of leading birth defects so that prevention measures, if available, may be implemented. It may also serve as a strong tool for research and future monitoring by providing baseline data, and by allowing for comparative analyses across time, space, and populations. A follow-up report will be completed by September 30th, 2010.

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Glossary of Terms

Agenesis Absence of part(s) of the body. Lack of development or failure to develop part(s) of the body.

Alpha-fetoprotein A protein produced by the fetus during gestation. The level of this protein can be measured during the pregnancy. The level of this protein is elevated in pregnancies with neural tube defects and may be decreased in pregnancies with Down syndrome.

Amniocentesis A method of prenatal diagnosis which a small amount of amniotic fluid is withdrawn to obtain fetal cells, which can be tested for the presence of some genetic diseases.

Anencephalus Congenital absence of the skull, with cerebral hemispheres completely missing or reduced to small masses attached to the base of the skull. Anencephaly is not compatible with life.

Aniridia The complete absence of the iris of the eye or a defect of the iris.

Anophthalmia A developmental defect characterized by complete absence of the eyes, or by the presence of vestigial eyes.

Anotia A congenital absence of one or both ears.

Aortic valve stenosis A cardiac anomaly characterized by a narrowing or stricture of the aortic valve.

Aplasia Absence of a tissue or organ due to lack of cell proliferation.

Atresia Absence or closure of a normal opening.

Atrial septal defect A congenital cardiac malformation in which there are one or several openings in the atrial septum (wall between the right and left atria). Most common type is called ostium secundum defect.

Biliary atresia A congenital absence or underdevelopment of one or more of the ducts in the biliary tract.

Bladder exstrophy Incomplete closure of the anterior wall of the bladder and the abdominal cavity. The upper urinary tract is generally normal. Often associated with anorectal and genital malformations.

Congenital cataract An opacity (clouding) of the lens of the eye that has its origin prenatally.

Choanal atresia or stenosis A congenital anomaly in which a bony or membranous formation blocks the passageway between the nose and the pharynx.

Chromosome Threadlike structure in cells that individual genes are arranged along.

Chromosome abnormalities A major group of genetic diseases in which alterations of chromosome number or structure occur and are observable by microscope.

Cleft lip The congenital failure of the fetal components of the lip to fuse or join, forming a groove or fissure in the lip. Infants with this condition can have difficulty feeding and may use assistive devices for feeding. This condition is corrected when the infant can tolerate surgery.

Cleft palate The congenital failure of the palate to fuse properly forming a grooved depression or fissure in the roof of the mouth. This defect varies in degree of severity. The fissure can extend into the hard and soft palate and into the nasal cavities. Infants with this condition have difficulty feeding, and may use assistive devices for feeding. Surgical correction is begun as soon as possible. Children with cleft palates are at high risk for hearing problems due to ear infections.

Coarctation of the aorta Localized narrowing of the aorta. This condition can vary from mild to severe.

Common truncus arteriosus A congenital heart defect in which the common arterial trunk fails to divide into pulmonary artery and aorta.

Confidence interval (95%) The interval that contains the true prevalence (which can only be estimated) 95% of the time.

Congenital Existing at or dating from birth although the defect may not be recognized at the time of birth.

Congenital hip dislocation Location of the head of the femur (bone of the upper leg) outside its normal location in the cup-shaped cavity formed by the hip bones (acetabulum).

Diaphragmatic hernia A failure of the diaphragm to form completely, leaving a hole. Abdominal organs can protrude through the hole into the chest cavity and interfere with development of the heart and lungs. Usually life-threatening and requires emergent surgery.

Down syndrome (Trisomy 21) The chromosomal abnormality characterized by an extra copy of chromosome 21. In rare cases this syndrome is caused by translocation. Down syndrome is characterized by moderate to severe retardation, sloping forehead, small ear canals, flat-bridge of the nose and short fingers and toes. Many infants have congenital heart disease.

Dysgenesis Anomalous or disorganized formation of an organ.

Dysplasia Disorganized cell structure or arrangement within a tissue or organ.

Ebstein anomaly A congenital heart defect in which the tricuspid valve is displaced downward into the right ventricle.

Edwards syndrome See Trisomy 18.

Embryonic period The first eight weeks after fertilization, during which most, but not all, organs are formed.

Encephalocele Herniation of the brain through a defect in the skull.

Endocardial cushion defect In the complete form, a septal defect involving both the upper chambers (atria, atrial septal defect) and lower chambers (ventricles, ventricular septal defect) such that there is a single large atrioventricular septal defect. There are incomplete forms as well.

Epispadias Displacement of the opening of the urethra (urethral meatus) dorsally and proximally (on top and closer to the body) in relation to the tip of the glans of the penis.

Esophageal stenosis or atresia A narrowing or incomplete formation of the esophagus. Usually a surgical emergency. Frequently associated with a Tracheoesophageal Fistula.

Extremely low birth weight Birth weight less than 1,000 grams, regardless of gestational age.

Fetal alcohol syndrome A constellation of physical abnormalities (including characteristic abnormal facial features and growth retardation), and problems of behavior and cognition in children born to mothers who drank alcohol during pregnancy.

Fetal death (stillborn) Death prior to complete expulsion or extraction of an infant or fetus of 500 grams or more, or, in absence of weight, of 22 weeks' gestation or greater; death is indicated by the fact that, after expulsion or extraction, the fetus does not breathe or show any other evidence of life, such as beating of the heart, pulsation of the umbilical cord or definite movement of voluntary muscles (68-3-102).

Fetal period The period from the ninth week after fertilization through delivery.

Fetal ultrasound A diagnostic examination of the fetus using ultrasound (sound waves at a frequency above what is detectable to human hearing).

Fistula An abnormal passage from an internal organ to the body surface or between two internal organs or structures.

Folic acid deficiency A lack of folic acid in the mother's diet which may lead to an increased risk for neural tube defects. Current recommendations from the March of Dimes indicate that women who are or may become pregnant should take a folic acid supplement to decrease the risk of neural tube defect.

Gastroschisis A congenital opening of the abdominal wall with protrusion of the intestines. This condition is surgically treated.

Genetic counseling The delivery of information about the risks, natural history, and management of genetic diseases to patients and/or their families.

Hirschsprung's disease The congenital absence of autonomic ganglia (nerves controlling involuntary and reflexive movement) in the muscles of the colon. This results in immobility of the intestines and may cause obstruction or stretching of the intestines. This condition is repaired surgically in early childhood by the removal of the affected portion of the intestine.

Holocephalus The abnormal accumulation of fluid within the spaces of the brain.

Hydrocephalus The abnormal accumulation of fluid within the skull.

Hyperplasia Overgrowth characterized by an increase in the number of cells of tissue.

Hypoplasia A condition of arrested development in which an organ or part remains below the normal size or in an immature state.

Hypoplastic left heart syndrome Atresia, or a marked hypoplasia, of the aortic valve, atresia or marked hypoplasia for the mitral valve, with hypoplasia of the ascending aorta and underdevelopment of the left ventricle.

Hypospadias A congenital defect in which the urinary meatus (urinary outlet) is on the underside of the penis or on the perineum (area between the genitals and anus). The urinary sphincters are not defective so incontinence does not occur. The condition may be surgically corrected if needed for cosmetic, urologic, or reproductive reasons.

Infant death Death of a live-born infant before 12 months of age.

Live birth Spontaneous delivery of an infant that exhibits signs of life, including a heartbeat, spontaneous breathing, or movement of voluntary muscles. Transient cardiac contractions and fleeting respiratory efforts or gasps are not necessarily considered signs of life by all programs.

Lower limb reduction defects The congenital absence of a portion of the lower limb. There are two general types of defect, transverse and longitudinal. Transverse defects appear like amputations, or like missing segments of the limb. Longitudinal defects are missing rays of the limb (for example, a missing tibia and great toe).

Low birth weight Birth weight less than 2,500 grams, regardless of gestational age.

Malformation A primary morphologic defect resulting from an abnormal developmental process.

Maternal serum screening A diagnostic method that examines the mother's blood serum for indicators of anomalies in the process of fetal development.

Mental retardation A condition of below average intellectual ability (IQ less than 70) that is present from birth or infancy.

Microcephaly Congenital smallness of the head, with corresponding smallness of the brain.

Microphthalmia The congenital abnormal smallness of one or both eyes. Can occur in the presence of other ocular defects.

Microtia A small or maldeveloped external ear and atretic or stenotic external auditory canal.

Multifactorial A term used to describe characteristics or diseases that are caused by a combination of multiple genetic and environmental factors.

Multiple congenital anomaly Term used to describe the presence of more than one anomaly at birth.

Mutagen Substance that is known to cause a mutation.

Mutations Alterations in the sequence of DNA.

Neonatal death Death of a live-born infant within the first 28 days after birth. *Early neonatal death* refers to death during the first 7 days. *Late neonatal death* refers to death after 7 days but before 29 days.

Neonatal (newborn) period The first 28 days following delivery of a live-born infant.

Neural tube defect A defect resulting from failure of the neural tube to close in the first month of pregnancy. The major conditions include anencephaly, spina bifida, and encephalocele.

Obstructive genitourinary defect Stenosis or atresia of the urinary tract at any level. Severity of the defect depends largely upon the level of the obstruction. Urine accumulates behind the obstruction.

Omphalocele The protrusion of intestines into the umbilicus. The defect is usually closed surgically soon after birth.

Patau Syndrome See Trisomy 13

Patent ductus arteriosus A blood vessel between the pulmonary artery and the aorta. This is normal in fetal life, but can cause problems after birth, particularly in premature infants.

Periconceptual At or around the time of conception.

Perinatal Before, during, or after delivery. The exact time period may vary from 20 to 28 complete weeks of gestation through 7 to 28 days after delivery, depending on the context in which the term is used.

Postnatal After delivery.

Postterm infant An infant born after 42 completed weeks of gestation.

Prenatal Before delivery.

Preterm infant An infant born before 37 completed weeks of gestation.

Pulmonary artery anomaly Abnormality in the formation of the pulmonary artery such as stenosis or atresia.

Pulmonary valve atresia or stenosis Failure of formation of the pulmonary valve or a narrowing or obstruction of the pulmonary valve, resulting in obstruction of blood flow from the right ventricle to the pulmonary artery.

Pyloric stenosis A narrowing of the outlet from the stomach to the small intestine resulting in complete or partial obstruction of the passage of food and gastric contents.

Rectal and large intestinal atresia/stenosis Complete or partial occlusion of the lumen of one or more segments of the large intestine and/or rectum.

Reduction defects: lower and upper limbs The congenital absence of a portion of the lower or upper limbs. There are two general types of defect, transverse and longitudinal. Transverse defects appear like amputations with the complete or partial absence of the arm or leg. Longitudinal defects are missing rays of the limb and may involve the preaxial (thumb or big toe side) or central parts of the arm or leg.

Renal agenesis or dysgenesis The failure, or deviation, of embryonic development of the kidney.

Spina bifida An incomplete closure of the vertebral spine (usually posterior) through which spinal cord tissue or membranes (meninges) covering the spine herniated.

Stenosis A narrowing or constriction the diameter of a bodily passage or orifice.

Stenosis or atresia of the small intestine A narrowing or incomplete formation of the small intestine obstructing movement through the digestive tract.

Syndrome A pattern of multiple primary malformations or defects all due to a single underlying cause (for example, Down syndrome).

Teratogen A substance in the environment that can cause a birth defect.

Term infant An infant born after 37 complete weeks and before 42 complete weeks of gestation.

Tetralogy of Fallot The simultaneous presence of a ventricular septal defect, pulmonic stenosis, a malpositioned aorta that overrides the ventricular septum, and right ventricular hypertrophy.

Transposition of the great arteries A congenital malformation in which the aorta arises from the right ventricle and the pulmonary artery from the left ventricle (opposite of normal), so that the venous return from the peripheral circulation is recirculated without being oxygenated in the lungs. Immediate surgical correction is needed. When this is not associated with other cardiac defects, and not corrected, it is fatal.

Tricuspid valve atresia or stenosis A congenital cardiac condition characterized by the absence or constriction of the tricuspid valve.

Trisomy A chromosomal abnormality characterized by one more than the normal number of chromosomes. Normally, cells contain two of each chromosome. In trisomy, cells contain three copies of a specific chromosome.

Trisomy 13 (Patau syndrome) The chromosomal abnormality caused by an extra chromosome 13. Characterized by impaired midline facial development, cleft lip and palate, polydactyly and severe mental retardation. Most infants do not survive beyond 6 months of life.

Trisomy 18 (Edwards syndrome) The chromosomal abnormality caused by an extra copy of chromosome 18. It is characterized by mental retardation, growth retardation, low-set ears, skull malformation and short digits. Survival for more than a few months is rare.

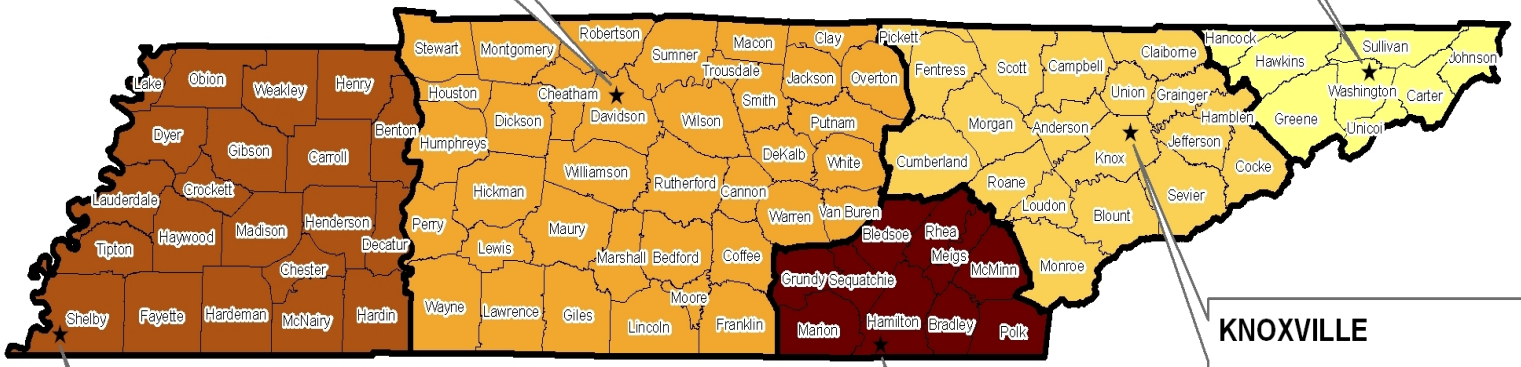
Trisomy 21 See Down Syndrome.

Ventricular Septal Defect	A congenital cardiac malformation in which there are one or several openings in the ventricular system (Muscular and fibrous wall between the right and left ventricle or right and left lower chambers of the heart).
Very Low Birth Weight	Birthweight less than 1,500 grams, regardless of gestational age.

Appendix A

Tennessee Perinatal Regions

TENNESSEE PERINATAL REGIONS AND PERINATAL CENTERS



Vanderbilt University Medical Center
Vanderbilt Children's Hospital

NASHVILLE

Johnson City Medical Center Hospital

JOHNSON CITY

KNOXVILLE

University of Tennessee
Medical Center at Knoxville

MEMPHIS

University of Tennessee
Regional Medical Center at Memphis

CHATTANOOGA

Erlanger Medical Center / T.C. Thompson
Children's Hospital

Appendix B

Birth Defect Tables

Table B1: **Birth Defects by Race/Ethnicity, 2002 – 2006**

Rates per 10,000 live births.

Birth Defect	Race/Ethnicity			
	White	**Black**	**Hispanic**	**Other**
Central Nervous System				
Anencephalus	42	12	8	1
Rate	1.52	1.42	2.49	1.07
95% Confidence Interval	1.10-2.06	0.73-2.48	1.07-4.90	0.03-5.93
Spina Bifida	124	28	25	2
Rate	4.50	3.31	7.77	2.13
95% Confidence Interval	3.74-5.36	2.20-4.78	5.03-11.47	0.26-7.70
Hydrocephalus	174	77	23	5
Rate	6.31	9.10	7.15	5.33
95% Confidence Interval	5.41-7.32	7.18-11.37	4.53-10.72	1.73-12.43
Encephalocele	27	9	6	1
Rate	0.98	1.06	1.86	1.07
95% Confidence Interval	0.65-1.43	0.49-2.02	0.68-4.06	0.03-5.93
Microcephalus	180	84	28	6
Rate	6.53	9.92	8.70	6.39
95% Confidence Interval	5.61-7.56	7.91-12.29	5.78-12.58	2.35-13.91
Total Central Nervous System Cases	535	205	84	14
Rate	19.41	24.22	26.10	14.91
95% Confidence Interval	17.80-21.12	21.02-27.77	20.82-32.32	8.15-25.02
Ear and Eye				
Aniridia	5	0	0	0
Rate	0.18	0.00	0.00	0.00
95% Confidence Interval	0.06-0.42	0.00-0.44	0.00-1.15	0.00-3.93
Anophthalmia/Microthalmia	21	10	6	2
Rate	0.76	1.18	1.86	2.13
95% Confidence Interval	0.47-1.16	0.57-2.17	0.68-4.06	0.26-7.70
Congenital Cataract	61	15	4	3
Rate	2.21	1.77	1.24	3.20
95% Confidence Interval	1.69-2.84	0.99-2.92	0.34-3.18	0.66-9.34
Anotia/Microtia	17	1	3	0
Rate	0.62	0.12	0.93	0.00
95% Confidence Interval	0.36-0.99	0.00-0.66	0.19-2.72	0.00-3.93
Total Ear and Eye Cases	100	25	13	5
Rate	3.63	2.95	4.04	5.33
95% Confidence Interval	2.95-4.41	1.91-4.36	2.15-6.91	1.73-12.43
Cardiovascular				
Common Truncus	35	6	3	0
Rate	1.27	0.71	0.93	0.00
95% Confidence Interval	0.88-1.77	0.26-1.54	0.19-2.72	0.00-3.93
Transposition of Great Arteries	175	38	22	3
Rate	6.35	4.49	6.84	3.20
95% Confidence Interval	5.44-7.36	3.18-6.16	4.28-10.35	0.66-9.34
Tetralogy of Fallot	145	53	7	8
Rate	5.26	6.26	2.18	8.52
95% Confidence Interval	4.44-6.19	4.69-8.19	0.87-4.48	3.68-16.79

Birth Defects by Race/Ethnicity, 2002 – 2006

Rates per 10,000 live births

Birth Defect	Race/Ethnicity			
	White	Black	Hispanic	Other
Ventricular Septal Defect	1,234	329	124	28
Rate	44.77	38.87	38.53	29.83
95% Confidence Interval	42.30-47.34	34.78-43.30	32.05-45.94	19.82-43.11
Atrial Septal Defect	1,422	444	110	35
Rate	51.59	52.45	34.18	37.28
95% Confidence Interval	48.94-54.34	47.69-57.56	28.09-41.20	25.97-51.85
Endocardial Cushion Defect	105	35	9	2
Rate	3.81	4.13	2.80	2.13
95% Confidence Interval	3.12-4.61	2.88-5.75	1.28-5.31	0.26-7.70
Pulmonary Valve Atresia & Stenosis	280	104	20	6
Rate	10.16	12.29	6.21	6.39
95% Confidence Interval	9.00-11.42	10.04-14.89	3.80-9.60	2.35-13.91
Tricuspid Valve Atresia & Stenosis	31	9	4	0
Rate	1.12	1.06	1.24	0.00
95% Confidence Interval	0.76-1.60	0.49-2.02	0.34-3.18	0.00-3.93
Ebsteins Anomaly	21	3	1	0
Rate	0.76	0.35	0.31	0.00
95% Confidence Interval	0.47-1.16	0.07-1.04	0.01-1.73	0.00-3.93
Aortic Valve Stenosis	56	10	4	1
Rate	2.03	1.18	1.24	1.07
95% Confidence Interval	1.53-2.64	0.57-2.17	0.34-3.18	0.03-5.93
Hypoplastic Left Heart Syndrome	86	27	8	1
Rate	3.12	3.19	2.49	1.07
95% Confidence Interval	2.50-3.85	2.10-4.64	1.07-4.90	0.03-5.93
Patent Ductus Arteriosus	1,278	488	115	28
Rate	46.36	57.65	35.74	29.83
95% Confidence Interval	43.85-48.98	52.65-63.00	29.50-42.90	19.82-43.11
Coarctation of Aorta	188	35	14	2
Rate	6.82	4.13	4.35	2.13
95% Confidence Interval	5.88-7.87	2.88-5.75	2.38-7.30	0.26-7.70
Total Cardiovascular Cases	3,586	1,152	313	81
Rate	130.09	136.09	97.26	86.28
95% Confidence Interval	125.87-134.42	128.34-144.18	86.78-108.66	68.52-107.24
Orofacial				
Cleft Palate w/o Cleft Lip	221	37	11	11
Rate	8.02	4.37	3.42	11.72
95% Confidence Interval	6.99-9.15	3.08-6.02	1.71-6.12	5.85-20.97
Cleft Lip w/ & w/o Cleft Palate	350	55	27	9
Rate	12.70	6.50	8.39	9.59
95% Confidence Interval	11.40-14.10	4.89-8.46	5.53-12.21	4.38-18.20
Choanal Atresia	64	14	5	0
Rate	2.32	1.65	1.55	0.00
95% Confidence Interval	1.79-2.96	0.90-2.77	0.50-3.63	0.00-3.93
Total Orofacial Cases	632	106	43	20
Rate	22.93	12.52	13.36	21.30
95% Confidence Interval	21.17-24.79	10.25-15.15	9.67-18.00	13.01-32.90

Birth Defects by Race/Ethnicity, 2002 – 2006

Rates per 10,000 live births

Birth Defect	Race/Ethnicity			
	White	Black	Hispanic	Other
Gastrointestinal				
Esophageal Atresia/Tracheoesophageal Fistula	80	18	7	0
Rate	2.90	2.13	2.18	0.00
95% Confidence Interval	2.30-3.61	1.26-3.36	0.87-4.48	0.00-3.93
Rectal & Large Intestinal Atresia/Stenosis	132	40	17	2
Rate	4.79	4.73	5.28	2.13
95% Confidence Interval	4.01-5.68	3.38-6.43	3.08-8.46	0.26-7.70
Pyloric Stenosis	1,188	166	133	9
Rate	43.10	19.61	41.33	9.59
95% Confidence Interval	40.68-45.62	16.74-22.83	34.60-48.98	4.38-18.20
Hirschprungs Disease (congenital megacolon)	75	32	7	0
Rate	2.72	3.78	2.18	0.00
95% Confidence Interval	2.14-3.41	2.59-5.34	0.87-4.48	0.00-3.93
Biliary Atresia	14	10	1	1
Rate	0.51	1.18	0.31	1.07
95% Confidence Interval	0.28-0.85	0.57-2.17	0.01-1.73	0.03-5.93
Total Gastrointestinal Cases	1,478	263	162	12
Rate	53.62	31.07	50.34	12.78
95% Confidence Interval	50.92-56.42	27.43-35.06	42.89-58.72	6.60-22.33
Genitourinary				
Bladder Exstrophy	13	3	0	0
Rate	0.47	0.35	0.00	0.00
95% Confidence Interval	0.25-0.81	0.07-1.04	0.00-1.15	0.00-3.93
Hypospadias	1,501	413	62	25
Rate	54.45	48.79	19.27	26.63
95% Confidence Interval	51.73-57.28	44.20-53.73	14.77-24.70	17.23-39.31
Epispadias	25	9	1	0
Rate	0.91	1.06	0.31	0.00
95% Confidence Interval	0.59-1.34	0.49-2.02	0.01-1.73	0.00-3.93
Obstructive Genitourinary Defect	739	134	62	24
Rate	26.81	15.83	19.27	25.56
95% Confidence Interval	24.91-28.81	13.26-18.75	14.77-24.70	16.38-38.04
Renal Agenesis/Hypoplasia	106	34	12	3
Rate	3.85	4.02	3.73	3.20
95% Confidence Interval	3.15-4.65	2.78-5.61	1.93-6.51	0.66-9.34
Total Genitourinary Cases	2,349	584	135	52
Rate	85.22	68.99	41.95	55.39
95% Confidence Interval	81.80-88.73	63.51-74.82	35.17-49.65	41.37-72.64
Musculoskeletal				
Reduction Deformity (upper limbs)	60	19	5	1
Rate	2.18	2.24	1.55	1.07
95% Confidence Interval	1.66-2.80	1.35-3.51	0.50-3.63	0.03-5.93
Reduction Deformity (lower limbs)	31	17	5	1
Rate	1.12	2.01	1.55	1.07
95% Confidence Interval	0.76-1.60	1.17-3.22	0.50-3.63	0.03-5.93

Birth Defects by Race/Ethnicity, 2002 – 2006

Rates per 10,000 live births

Birth Defect	Race/Ethnicity			
	White	Black	Hispanic	Other
Gastroschisis	153	35	9	4
Rate	5.55	4.13	2.80	4.26
95% Confidence Interval	4.71-6.50	2.88-5.75	1.28-5.31	1.16-10.91
Omphalocele	79	36	4	2
Rate	2.87	4.25	1.24	2.13
95% Confidence Interval	2.27-3.57	2.98-5.89	0.34-3.18	0.26-7.70
Diaphragmatic Hernia	80	26	10	4
Rate	2.90	3.07	3.11	4.26
95% Confidence Interval	2.30-3.61	2.01-4.50	1.49-5.71	1.16-10.91
Congenital Hip Dislocation	236	27	17	7
Rate	8.56	3.19	5.28	7.46
95% Confidence Interval	7.50-9.73	2.10-4.64	3.08-8.46	3.00-15.36
Total Musculoskeletal Cases	624	155	48	19
Rate	22.64	18.31	14.92	20.24
95% Confidence Interval	20.90-24.48	15.54-21.43	11.00-19.78	12.19-31.60
Chromosomal				
Trisomy 13	25	10	3	0
Rate	0.91	1.18	0.93	0.00
95% Confidence Interval	0.59-1.34	0.57-2.17	0.19-2.72	0.00-3.93
Down Syndrome	380	102	50	8
Rate	13.79	12.05	15.54	8.52
95% Confidence Interval	12.43-15.24	9.82-14.63	11.53-20.48	3.68-16.79
Trisomy 18	32	18	6	0
Rate	1.16	2.13	1.86	0.00
95% Confidence Interval	0.79-1.64	1.26-3.36	0.68-4.06	0.00-3.93
Total Chromosomal Cases	433	129	59	8
Rate	15.71	15.24	18.33	8.52
95% Confidence Interval	14.26-17.26	12.72-18.11	13.96-23.65	3.68-16.79
Other				
Fetal Alcohol Syndrome	37	40	0	1
Rate	1.34	4.73	0.00	1.07
95% Confidence Interval	0.95-1.85	3.38-6.43	0.00-1.15	0.03-5.93
Total Cases	8,919	2,418	757	190
Rate	323.56	285.65	235.23	202.39
95% Confidence Interval	316.88-330.34	274.37-297.26	218.77-252.60	174.63-233.30
Total Live Births	275,655	84,650	32,181	9,388

Table B2: **Birth Defects by Sex, 2002-2006**

Rates per 10,000 live births

Birth Defect	Sex	Count	Rate	95% Confidence Interval
Central Nervous System				
Anencephalus[1]	Male	27	1.32	0.87-1.91
	Female	35	1.78	1.24-2.47
Spina Bifida[2]	Male	92	4.48	3.61-5.50
	Female	86	4.37	3.50-5.40
Hydrocephalus	Male	154	7.51	6.37-8.79
	Female	125	6.35	5.29-7.57
Encephalocele	Male	22	1.07	0.67-1.62
	Female	21	1.07	0.66-1.63
Microcephalus	Male	127	6.19	5.16-7.37
	Female	171	8.69	7.44-10.10
Total Central Nervous System Cases	Male	409	19.94	18.05-21.96
	Female	427	21.71	19.70-23.87
Ear and Eye				
Aniridia	Male	5	0.24	0.08-0.57
	Female	0	0.00	0.00-0.19
Anophthalmia/Microthalmia	Male	21	1.02	0.63-1.56
	Female	18	0.92	0.54-1.45
Congenital Cataract	Male	39	1.90	1.35-2.60
	Female	44	2.24	1.63-3.00
Anotia/Microtia	Male	13	0.63	0.34-1.08
	Female	8	0.41	0.18-0.80
Total Ear and Eye Cases	Male	76	3.70	2.92-4.64
	Female	67	3.41	2.64-4.33
Cardiovascular				
Common Truncus	Male	26	1.27	0.83-1.86
	Female	18	0.92	0.54-1.45
Transposition of Great Arteries	Male	148	7.21	6.10-8.47
	Female	90	4.58	3.68-5.62
Tetralogy of Fallot	Male	123	6.00	4.98-7.15
	Female	90	4.58	3.68-5.62
Ventricular Septal Defect	Male	835	40.70	37.99-43.56
	Female	880	44.74	41.83-47.79
Atrial Septal Defect	Male	1,092	53.23	50.12-56.48
	Female	919	46.72	43.75-49.84
Endocardial Cushion Defect	Male	68	3.31	2.57-4.20
	Female	83	4.22	3.36-5.23
Pulmonary Valve Atresia & Stenosis	Male	225	10.97	9.58-12.50
	Female	185	9.40	8.10-10.86
Tricuspid Valve Atresia & Stenosis	Male	27	1.32	0.87-1.91
	Female	17	0.86	0.50-1.38
Ebsteins Anomaly	Male	12	0.58	0.30-1.02
	Female	13	0.66	0.35-1.13
Aortic Valve Stenosis	Male	53	2.58	1.94-3.38
	Female	18	0.92	0.54-1.45

Birth Defects by Sex, 2002-2006

Rates per 10,000 live births

Birth Defect	Sex	Count	Rate	95% Confidence Interval
Hypoplastic Left Heart Syndrome	Male	75	3.66	2.88-4.58
	Female	47	2.39	1.76-3.18
Patent Ductus Arteriosus	Male	1,058	51.57	48.51-54.77
	Female	851	43.26	40.40-46.27
Coarctation of Aorta	Male	154	7.51	6.37-8.79
	Female	85	4.32	3.45-5.34
Total Cardiovascular Cases	Male	2,742	133.65	128.69-138.75
	Female	2,390	121.50	116.68-126.47
Orofacial				
Cleft Palate w/o Cleft Lip	Male	126	6.14	5.12-7.31
	Female	154	7.83	6.64-9.17
Cleft Lip w/ & w/o Cleft Palate	Male	287	13.99	12.42-15.70
	Female	154	7.83	6.64-9.17
Choanal Atresia	Male	43	2.10	1.52-2.82
	Female	40	2.03	1.45-2.77
Total Orofacial Cases	Male	453	22.08	20.09-24.21
	Female	348	17.69	15.88-19.65
Gastrointestinal				
Esophageal Atresia/Tracheoesophageal Fistula	Male	53	2.58	1.94-3.38
	Female	52	2.64	1.97-3.47
Rectal & Large Intestinal Atresia/Stenosis[3]	Male	114	5.56	4.58-6.68
	Female	74	3.76	2.95-4.72
Pyloric Stenosis	Male	1,227	59.81	56.51-63.25
	Female	269	13.68	12.09-15.41
Hirschprungs Disease (congenital megacolon)	Male	91	4.44	3.57-5.45
	Female	23	1.17	0.74-1.75
Biliary Atresia	Male	12	0.58	0.30-1.02
	Female	14	0.71	0.39-1.19
Total Gastrointestinal Cases	Male	1,487	72.48	68.84-76.26
	Female	425	21.61	19.60-23.76
Genitourinary				
Bladder Exstrophy[4]	Male	8	0.39	0.17-0.77
	Female	7	0.36	0.14-0.73
Hypospadias	Male	2,001	97.53	93.31-101.90
	Female	0	0.00	0.00-0.19
Epispadias	Male	35	1.71	1.19-2.37
	Female	0	0.00	0.00-0.19
Obstructive Genitourinary Defect	Male	677	33.00	30.56-35.58
	Female	282	14.34	12.71-16.11
Renal Agenesis/Hypoplasia[5]	Male	101	4.92	4.01-5.98
	Female	52	2.64	1.97-3.47
Total Genitourinary Cases	Male	2,780	135.50	130.51-140.64
	Female	337	17.13	15.35-19.06

Birth Defects by Sex, 2002-2006

Rates per 10,000 live births

Birth Defect	Sex	Count	Rate	95% Confidence Interval
Musculoskeletal				
Reduction Deformity (upper limbs)	Male	51	2.49	1.85-3.27
	Female	34	1.73	1.20-2.42
Reduction Deformity (lower limbs)	Male	27	1.32	0.87-1.91
	Female	27	1.37	0.90-2.00
Gastroschisis	Male	107	5.22	4.27-6.30
	Female	94	4.78	3.86-5.85
Omphalocele	Male	69	3.36	2.62-4.26
	Female	52	2.64	1.97-3.47
Diaphragmatic Hernia	Male	78	3.80	3.01-4.74
	Female	42	2.14	1.54-2.89
Congenital Hip Dislocation	Male	79	3.85	3.05-4.80
	Female	208	10.57	9.19-12.11
Total Musculoskeletal Cases	Male	395	19.25	17.40-21.25
	Female	451	22.93	20.86-25.14
Chromosomal				
Trisomy 13	Male	18	0.88	0.52-1.39
	Female	20	1.02	0.62-1.57
Down Syndrome	Male	286	13.94	12.37-15.65
	Female	254	12.91	11.37-14.60
Trisomy 18	Male	16	0.78	0.45-1.27
	Female	40	2.03	1.45-2.77
Total Chromosomal Cases	Male	318	15.50	13.84-17.30
	Female	311	15.81	14.10-17.67
Other				
Fetal Alcohol Syndrome	Male	43	2.10	1.52-2.82
	Female	35	1.78	1.24-2.47
Total Cases	Male	7,986	389.25	380.76-397.89
	Female	4,294	218.30	211.82-224.93
Total Live Births	Male	205,162		
	Female	196,705		
	Unknown	7		

* In addition to seven live births of unknown sex, there were three fetal deaths of unknown sex. Of those with unknown sex, four had birth defects and six did not. Those with birth defects resulted in:

[1] One case of anencephalus,
[2] One case of spina bifida,
[3] Three cases of rectal & large intestinal atresia/stenosis,
[4] One case of bladder exstrophy and
[5] Two cases of renal agenesis/hypoplasia.

Table B3: Birth Defects by Perinatal Region, 2002 – 2006

Rates per 10,000 live births

Birth Defect	Perinatal Region				
	Northeast	East	Southeast	Middle	West
Central Nervous System					
Anencephalus	1	4	7	33	18
Rate	0.37	0.56	1.90	2.12	1.62
95% Confidence Interval	0.01-2.07	0.15-1.44	0.76-3.92	1.46-2.97	0.96-2.56
Spina Bifida	12	36	16	74	41
Rate	4.46	5.05	4.35	4.75	3.69
95% Confidence Interval	2.31-7.80	3.54-7.00	2.48-7.06	3.73-5.96	2.65-5.01
Hydrocephalus	27	52	31	87	82
Rate	10.04	7.30	8.42	5.58	7.38
95% Confidence Interval	6.62-14.61	5.45-9.57	5.72-11.95	4.47-6.88	5.87-9.17
Encephalocele	2	5	4	19	13
Rate	0.74	0.70	1.09	1.22	1.17
95% Confidence Interval	0.09-2.69	0.23-1.64	0.30-2.78	0.73-1.90	0.62-2.00
Microcephalus	25	64	38	71	100
Rate	9.30	8.99	10.32	4.55	9.01
95% Confidence Interval	6.02-13.72	6.92-11.47	7.31-14.17	3.56-5.74	7.33-10.95
Total Central Nervous System Cases	66	159	93	276	244
Rate	24.54	22.32	25.27	17.70	21.97
95% Confidence Interval	18.98-31.22	18.99-26.08	20.39-30.95	15.68-19.92	19.30-24.91
Eye and Ear					
Aniridia	0	0	0	5	0
Rate	0.00	0.00	0.00	0.32	0.00
95% Confidence Interval	0.00-1.37	0.00-0.52	0.00-1.00	0.10-0.75	0.00-0.33
Anophthalmia/Microthalmia	5	8	1	9	16
Rate	1.86	1.12	0.27	0.58	1.44
95% Confidence Interval	0.60-4.34	0.48-2.21	0.01-1.51	0.26-1.10	0.82-2.34
Congenital Cataract	6	16	6	32	23
Rate	2.23	2.25	1.63	2.05	2.07
95% Confidence Interval	0.82-4.86	1.28-3.65	0.60-3.55	1.40-2.90	1.31-3.11
Anotia/Microtia	4	9	1	5	2
Rate	1.49	1.26	0.27	0.32	0.18
95% Confidence Interval	0.41-3.81	0.58-2.40	0.01-1.51	0.10-0.75	0.02-0.65
Total Ear and Eye Cases	14	30	8	51	40
Rate	5.21	4.21	2.17	3.27	3.60
95% Confidence Interval	2.85-8.73	2.84-6.01	0.94-4.28	2.44-4.30	2.57-4.91
Cardiovascular					
Common Truncus	0	8	6	17	13
Rate	0.00	1.12	1.63	1.09	1.17
95% Confidence Interval	0.00-1.37	0.48-2.21	0.60-3.55	0.64-1.75	0.62-2.00
Transposition of Great Arteries	7	53	26	88	64
Rate	2.60	7.44	7.06	5.64	5.76
95% Confidence Interval	1.05-5.36	5.57-9.73	4.61-10.35	4.53-6.95	4.44-7.36
Tetralogy of Fallot	13	41	22	77	60
Rate	4.83	5.76	5.98	4.94	5.40
95% Confidence Interval	2.57-8.27	4.13-7.81	3.75-9.05	3.90-6.17	4.12-6.96
Ventricular Septal Defect	136	364	141	611	463
Rate	50.57	51.11	38.31	39.19	41.70
95% Confidence Interval	42.43-59.82	45.99-56.64	32.24-45.18	36.14-42.42	37.98-45.67
Atrial Septal Defect	461	306	137	522	585
Rate	171.43	42.96	37.22	33.48	52.68
95% Confidence Interval	156.14-187.82	38.28-48.06	31.25-44.00	30.67-36.48	48.50-57.13

Birth Defects by Perinatal Region, 2002 – 2006

Rates per 10,000 live births.

	Perinatal Region				
Birth Defect	**Northeast**	**East**	**Southeast**	**Middle**	**West**
Endocardial Cushion Defect	8	36	13	47	47
Rate	2.97	5.05	3.53	3.01	4.23
95% Confidence Interval	1.28-5.86	3.54-7.00	1.88-6.04	2.22-4.01	3.11-5.63
Pulmonary Valve Atresia & Stenosis	41	59	23	185	102
Rate	15.25	8.28	6.25	11.87	9.19
95% Confidence Interval	10.94-20.68	6.31-10.69	3.96-9.38	10.22-13.70	7.49-11.15
Tricuspid Valve Atresia & Stenosis	2	9	5	14	14
Rate	0.74	1.26	1.36	0.90	1.26
95% Confidence Interval	0.09-2.69	0.58-2.40	0.44-3.17	0.49-1.51	0.69-2.12
Ebsteins Anomaly	0	7	1	12	5
Rate	0.00	0.98	0.27	0.77	0.45
95% Confidence Interval	0.00-1.37	0.40-2.02	0.01-1.51	0.40-1.34	0.15-1.05
Aortic Valve Stenosis	6	13	7	28	17
Rate	2.23	1.83	1.90	1.80	1.53
95% Confidence Interval	0.82-4.86	0.97-3.12	0.76-3.92	1.19-2.60	0.89-2.45
Hypoplastic Left Heart Syndrome	7	21	13	50	31
Rate	2.60	2.95	3.53	3.21	2.79
95% Confidence Interval	1.05-5.36	1.83-4.51	1.88-6.04	2.38-4.23	1.90-3.96
Patent Ductus Arteriosus	283	331	135	561	599
Rate	105.24	46.47	36.68	35.98	53.94
95% Confidence Interval	93.33-118.24	41.60-51.76	30.75-43.41	33.07-39.09	49.71-58.44
Coarctation of Aorta	20	41	26	104	48
Rate	7.44	5.76	7.06	6.67	4.32
95% Confidence Interval	4.54-11.49	4.13-7.81	4.61-10.35	5.45-8.08	3.19-5.73
Total Cardiovascular Cases	731	937	379	1,619	1,466
Rate	271.84	131.55	102.97	103.84	132.02
95% Confidence Interval	252.49-292.28	123.27-140.26	92.86-113.87	98.85-109.03	125.35-138.96
Orofacial					
Cleft Palate w/o Cleft Lip	21	58	23	114	64
Rate	7.81	8.14	6.25	7.31	5.76
95% Confidence Interval	4.83-11.94	6.18-10.53	3.96-9.38	6.03-8.78	4.44-7.36
Cleft Lip w/ & w/o Cleft Palate	34	99	37	182	89
Rate	12.64	13.90	10.05	11.67	8.02
95% Confidence Interval	8.76-17.67	11.30-16.92	7.08-13.86	10.04-13.50	6.44-9.86
Choanal Atresia	10	13	5	32	23
Rate	3.72	1.83	1.36	2.05	2.07
95% Confidence Interval	1.78-6.84	0.97-3.12	0.44-3.17	1.40-2.90	1.31-3.11
Total Orofacial Cases	65	170	65	326	175
Rate	24.17	23.87	17.66	20.91	15.76
95% Confidence Interval	18.66-30.81	20.41-27.74	13.63-22.51	18.70-23.31	13.51-18.28
Gastrointestinal					
Esophageal Atresia/ Tracheoesophageal Fistula	5	16	7	47	30
Rate	1.86	2.25	1.90	3.01	2.70
95% Confidence Interval	0.60-4.34	1.28-3.65	0.76-3.92	2.22-4.01	1.82-3.86
Rectal & Large Intestinal Atresia/Stenosis	14	36	13	73	55
Rate	5.21	5.05	3.53	4.68	4.95
95% Confidence Interval	2.85-8.73	3.54-7.00	1.88-6.04	3.67-5.89	3.73-6.45
Pyloric Stenosis	143	294	138	575	346
Rate	53.18	41.28	37.49	36.88	31.16
95% Confidence Interval	44.82-62.64	36.69-46.28	31.50-44.30	33.93-40.02	27.96-34.62
Hirschprungs Disease (congenital megacolon)	9	16	14	41	34
Rate	3.35	2.25	3.80	2.63	3.06
95% Confidence Interval	1.53-6.35	1.28-3.65	2.08-6.38	1.89-3.57	2.12-4.28

Birth Defects by Perinatal Region, 2002 – 2006

Rates per 10,000 live births.

	Perinatal Region				
Birth Defect	**Northeast**	**East**	**Southeast**	**Middle**	**West**
Biliary Atresia	2	4	3	13	4
Rate	0.74	0.56	0.82	0.83	0.36
95% Confidence Interval	0.09-2.69	0.15-1.44	0.17-2.38	0.44-1.43	0.10-0.92
Total Gastrointestinal Cases	171	365	174	741	464
Rate	63.59	51.25	47.27	47.53	41.79
95% Confidence Interval	54.42-73.87	46.12-56.78	40.51-54.84	44.17-51.08	38.07-45.77
Genitourinary					
Bladder Exstrophy	2	5	1	5	3
Rate	0.74	0.70	0.27	0.32	0.27
95% Confidence Interval	0.09-2.69	0.23-1.64	0.01-1.51	0.10-0.75	0.06-0.79
Hypospadias	122	395	177	849	458
Rate	45.37	55.46	48.09	54.46	41.25
95% Confidence Interval	37.67-54.17	50.12-61.21	41.26-55.72	50.85-58.25	37.55-45.20
Epispadias	1	7	5	15	7
Rate	0.37	0.98	1.36	0.96	0.63
95% Confidence Interval	0.01-2.07	0.40-2.02	0.44-3.17	0.54-1.59	0.25-1.30
Obstructive Genitourinary Defect	97	267	59	355	181
Rate	36.07	37.49	16.03	22.77	16.30
95% Confidence Interval	29.25-44.00	33.12-42.26	12.20-20.68	20.46-25.27	14.01-18.86
Renal Agenesis/Hypoplasia	7	36	7	64	41
Rate	2.60	5.05	1.90	4.11	3.69
95% Confidence Interval	1.05-5.36	3.54-7.00	0.76-3.92	3.16-5.24	2.65-5.01
Total Genitourinary Cases	222	703	248	1,271	676
Rate	82.56	98.70	67.38	81.52	60.88
95% Confidence Interval	72.05-94.16	91.54-106.28	59.25-76.31	77.10-86.13	56.37-65.65
Musculoskeletal					
Reduction Deformity (upper limbs)	4	21	8	28	24
Rate	1.49	2.95	2.17	1.80	2.16
95% Confidence Interval	0.41-3.81	1.83-4.51	0.94-4.28	1.19-2.60	1.38-3.22
Reduction Deformity (lower limbs)	5	11	1	21	16
Rate	1.86	1.54	0.27	1.35	1.44
95% Confidence Interval	0.60-4.34	0.77-2.76	0.01-1.51	0.83-2.06	0.82-2.34
Gastroschisis	13	36	17	77	58
Rate	4.83	5.05	4.62	4.94	5.22
95% Confidence Interval	2.57-8.27	3.54-7.00	2.69-7.39	3.90-6.17	3.97-6.75
Omphalocele	5	32	8	42	34
Rate	1.86	4.49	2.17	2.69	3.06
95% Confidence Interval	0.60-4.34	3.07-6.34	0.94-4.28	1.94-3.64	2.12-4.28
Diaphragmatic Hernia	10	18	11	45	36
Rate	3.72	2.53	2.99	2.89	3.24
95% Confidence Interval	1.78-6.84	1.50-3.99	1.49-5.35	2.11-3.86	2.27-4.49
Congenital Hip Dislocation	30	60	40	108	49
Rate	11.16	8.42	10.87	6.93	4.41
95% Confidence Interval	7.53-15.93	6.43-10.84	7.76-14.80	5.68-8.36	3.26-5.83
Total Musculoskeletal Cases	65	172	84	315	210
Rate	24.17	24.15	22.82	20.20	18.91
95% Confidence Interval	18.66-30.81	20.67-28.04	18.20-28.25	18.03-22.56	16.44-21.65
Chromosomal					
Trisomy 13	3	7	4	12	12
Rate	1.12	0.98	1.09	0.77	1.08
95% Confidence Interval	0.23-3.26	0.40-2.02	0.30-2.78	0.40-1.34	0.56-1.89
Down Syndrome	36	98	47	202	157
Rate	13.39	13.76	12.77	12.96	14.14
95% Confidence Interval	9.38-18.53	11.17-16.77	9.38-16.98	11.23-14.87	12.01-16.53

Birth Defects by Perinatal Region, 2002 – 2006

Rates per 10,000 live births.

	Perinatal Region				
Birth Defect	**Northeast**	**East**	**Southeast**	**Middle**	**West**
Trisomy 18	0	8	9	21	18
Rate	0.00	1.12	2.45	1.35	1.62
95% Confidence Interval	0.00-1.37	0.48-2.21	1.12-4.64	0.83-2.06	0.96-2.56
Total Chromosomal Cases	39	111	60	234	185
Rate	14.50	15.58	16.30	15.01	16.66
95% Confidence Interval	10.31-19.83	12.82-18.77	12.44-20.98	13.15-17.06	14.35-19.24
Other					
Fetal Alcohol Syndrome	6	17	9	22	24
Rate	2.23	2.39	2.45	1.41	2.16
95% Confidence Interval	0.82-4.86	1.39-3.82	1.12-4.64	0.88-2.14	1.38-3.22
Total Cases	1,277	2,396	1,032	4,398	3,181
Rate	474.88	336.40	280.37	282.09	286.47
95% Confidence Interval	449.19-501.66	323.06-350.14	263.53-298.02	273.82-290.56	276.60-296.60
Total Live Births*	26,891	71,225	36,808	155,906	111,041

*There are three live births where the perinatal region is unknown.