TN Department of Health

Tennessee Birth Defects Registry Report 2009 – 2013

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Tennessee Birth Defects 2009-2013 was prepared by the Tennessee Department of Health, Division of Policy, Planning and Assessment.

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Executive Summary

According to the Centers for Disease Control and Prevention, an infant is born every four and half minutes with a birth defect. Nationally, nearly one out of every 33 babies is born with a birth defect and about 120,000 babies are affected by birth defects each year[1]. Tracking where and when birth defects occur and who they affect is the first step in preventing birth defects.

This is a statewide population-based birth defects report produced by the Tennessee Birth Defects Registry (TBDR). The report provides details about the prevalence of 46 major birth defects and fetal alcohol syndrome for Tennessee infants born in the years 2009 through 2013. Sections in this report provide specific information about birth defect rates by demographic factors, risk factors, and county of residence. Individual birth defect counts and rates are presented in tabular form for the state overall and broken down by infant sex, maternal education, race/ethnicity, maternal age, and maternal pre-pregnancy diabetes status (Table 3 to Table 9). Finally, birth defect counts and rates by organ systems for the five perinatal regions (East, Middle, Northeast, Southeast and West) and each of Tennessee's 95 counties are presented (Table 10 and Table 11).

During the period 2009-2013, there were 15,366 (an annual average of 3,073) confirmed diagnosed[2] birth defects and 59 confirmed cases of fetal alcohol syndrome. Two of the most common reported birth defects were of the cardiovascular system: atrial septal defect (ASD), a hole or opening in the upper chambers of the heart, and patent ductus arteriosus (PDA), an opening that failed to close from fetal circulation. The rates are generally equal for males and females, with the exception of the genitourinary defects due to hypospadias which affect only males. Certain types of birth defects, especially

[1]Accessed on December 7, 2016 http://www.cdc.gov/ncbddd/birthdefects/facts.html.

[2] Confirmed diagnostics include: (i) fetal death cases, (ii) linked infant death cases with maternal information from Tennessee birth statistics file, (iii) linked hospital discharged cases with maternal information from Tennessee birth statistics file. The linkage is essential for confirming that the mother was Tennessee resident at the time of delivery, especially in the case of diagnoses that happened after birth.

chromosomal defects, were more common among babies who were born to mothers aged 35 years old and greater.

Nationally, nearly one out of every 33 babies is born with a birth defect[3]. Birth defects can occur during any stage of pregnancy. Most birth defects occur in the first three months of pregnancy and can affect almost any part of the body. 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. Surgery and medical interventions may correct others, but not without cost.

Unfortunately, the underlying causes of individual birth defects are largely unknown, with a high percentage of infant birth defects having no known cause. This leaves many questions about the causes and patterns of birth defects unanswered. Information obtained through monitoring diseases and the surveillance of births defects can assist with the task of addressing these questions. While the direct causes of birth defects may not be fully understood, there are known risk factors that affect birth defects prevalence. For example: drinking alcohol during pregnancy, smoking during pregnancy, low blood folate levels, poorly controlled blood sugar levels in diabetic mothers, and maternal infections are all associated with increased risk of having a baby born with a birth defect.

Tennessee Birth Defects Registry

The TBDR was established in law (TCA 68-5-506) by the Tennessee state legislature in June 2000 with the mission: 1) to provide annual information on birth defect 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 defect 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

[3] Accessed on December 7, 2016 http://www.cdc.gov/ncbddd/birthdefects/facts.html.

children with birth defects. Since 2003, the program has expanded to provide population-based birth defect surveillance for the entire state of Tennessee.

The primary use of data collected by TBDR is to observe patterns and detect changes in the patterns of leading birth defects. The data provide the basis for research studies into the causes of birth defects and provide information to evaluate the effectiveness of birth defects prevention efforts. It also serves as a historic baseline used to evaluate the existence of suspected birth defect clusters. Birth defects tracking provide a way to identify and refer babies with birth defects to services and special care they often need.

Birth Defects Definition

"Birth defects are structural changes present at birth that can affect almost any part or parts of the body (e.g., heart, brain, foot). They may affect how the body looks, works, or both. Birth defects can vary from mild to severe."[4]

The tracking of birth defects is recommended by the Centers for Disease Control and Prevention (CDC) and the National Birth Defects Prevention Network (NBDPN). The Tennessee Department of Health does not receive federal funding for participation in the network. This report details the prevalence of 46 major birth defects and fetal alcohol syndrome for Tennessee infants who were born to resident mothers during the period 2009 through 2013.

Currently, 41 states maintain a birth defect registry or report data to the CDC. Unfortunately, rates across states should not be compared as collection methodology, years collected, and individual definitions vary widely. In Tennessee, birth defects are classified as major birth defects when they require medical or surgical treatment, have serious adverse effects on health and development, or have a significant cosmetic impact.

[4] Accessed on December 7, 2016 http://www.cdc.gov/ncbddd/birthdefects/facts.html.

Additionally, the 46 major birth defects can be organized within eight diagnostic categories corresponding to eight major organ systems: 1) Central Nervous System; 2) Eye and Ear; 3) Cardiovascular; 4) Orofacial (pertaining to the mouth and face); 5) Gastrointestinal; 6) Genitourinary; 7) Musculoskeletal; and 8) Chromosomal.

Birth defect counts include: 1) live-born infants diagnosed with a birth defect during the first year of life; and 2) diagnosed fetal-death cases that were at least 500 grams in weight or in the absence of weight at least 22 weeks gestation. As of July 1, 2010, the Department of Health's fetal death definition changed to include cases of at least 350 grams or 20 weeks completed gestation. The fetal death cases for 2011 forward were covered by the new definition and included in this report. The denominators used for calculating birth defects rates include only live births and are reported per 10,000 live births.

Data Sources and Limitations

The primary data sources for the TBDR are the Hospital Discharge Data System (HDDS) and the Birth, Death, and Fetal Death Statistical Data Systems, which are compiled, processed and stored by the Office of Vital Records and the Office of Health Statistics in the Division of Policy Planning and Assessment. The HDDS contains admission-level records for all patients treated in Tennessee-licensed hospitals and their outpatient treatment and rehabilitation centers. The TBDR uses these records to track the 46 major birth defects and fetal alcohol syndrome. Infants' HDDS records containing diagnostic codes corresponding to the tracked birth defects are extracted, compiled, and linked with their birth certificate records. The linkages provide validity checks and add information such as maternal risk factors, demographics, and street-level geography that are not available in the HDDS. Diagnostic data are also obtained from the fetal death and death certificate data systems. For the fetal death certificate identified cases, demographic, geographic, and risk factor information are obtained from the fetal death certificate system. For the death certificate identified cases, demographic, geographic, and risk factor information are obtained from

the death certificate data system. Together these sources provide statewide population-based birth defects surveillance for Tennessee.

The current methodology of data collection inhibits timeliness of the data availability and evaluation since finalization of the HDDS data is always one year behind the birth year. Additional limitations of administrative data systems such as these include coding errors. Some of the diagnostic codes used in the HDDS correspond to both the major and minor variants of a given birth defect. The coding system used in the HDDS, The International Classification of Diseases Revision 9 Clinical Modification (ICD-9-CM), prevents distinguishing these differences for certain birth defects. This may have the effect of elevating rates for some of the more common birth defects, such as atrial septal defects, which are congenital heart defects, and hypospadias, a common genitourinary defect in males. However, the upcoming implementation of the ICD-10-CM system should assist in correct coding. Less systematically, there are simple coding errors that result in both non-cases being miscoded as having a birth defect and valid cases not being recorded as having a birth defect.

Some options to assist with the current data limitations include required provider reporting similar to newborn screening and neonatal abstinence syndrome, active surveillance which is very resource and time intensive, and changing administrative collection methodology. Each of these options may present new challenges such as poor response rates with provider reporting and cost-prohibitive resource needs for active surveillance.

Overall Birth Defects Prevalence in Tennessee, 2009-2013

In Tennessee, an average of 80,215 live births occurred to resident mothers annually during the years 2009 through 2013. Approximately 75.6% of infants born were white and 21% were black (Table 1). During the same period, there was an average of 598 infant deaths per years (Table 2).

Table 1: Live Births by Race, Tennessee 2009-2013

Years	TOTAL	BLACK	WHITE
2009	82,109	17,360	61,082
2010	79,345	16,599	60,174
2011	79,462	16,482	60,252
2012	80,202	16,560	60,792
2013	79,954	16,863	60,954

Source: Tennessee Department of Health, Division of Policy, Planning and Assessment
Tennessee Birth Statistical System, 2009-2013.

Table 2: Infant Deaths per 1,000 Live Births by Race, Tennessee 2009-2013

	TOTAL		WHITE		BLACK	
Years	NUMBER	RATE	NUMBER	RATE	NUMBER	RATE
2009	655	8.0	364	6.0	277	16.0
2010	626	7.9	382	6.3	229	13.8
2011	587	7.4	361	6.0	211	12.8
2012	576	7.2	357	5.9	200	12.1
2013	542	6.8	326	5.3	196	11.6

Source: Tennessee Department of Health, Division of Policy, Planning and Assessment
Tennessee Death Statistical System, 2009-2013.

Table 3 shows overall the 46 birth defect types categorized into eight organ systems and fetal alcohol syndrome by count. Between January 2009 and December 2013, there were 15,366 confirmed diagnosed birth defects and 59 fetal alcohol syndrome cases. Out of the 15,366 defects, 9,322 were cardiovascular defects which represent 60.66% of the total. The

genitourinary system, with 2,648 defects, is the second most-affected organ system with a rate of 66.02 per 10,000 live births. The largest single birth defect in Tennessee is atrial septal defect with a count of 5,516 or 137.53 per 10,000 live births, followed by hypospadias (n = 2,127) and ventricular septal defect (n =1,933).

Table 3: Overall Birth Defects by Organ Systems and Fetal Alcohol Syndrome, 2009-2013

Birth Defect	Count[1]	Rate[2]	95%CI[3]
Cardiovascular	**9,322**	**232.4**	**227.7-237.2**
Aortic Valve Stenosis	78	1.9	1.5-2.4
Atrial Septal Defect	5,516	137.5	133.9-141.2
Coarctation of Aorta	302	7.5	6.7-8.4
Common Truncus	44	1.1	0.8-1.5
Double Outlet Right Ventricle	75	1.9	1.5-2.3
Ebstein's Anomaly	63	1.6	1.2-2.0
Endocardial Cushion Defect	208	5.2	4.5-5.9
Hypoplastic Left Heart Syndrome	149	3.7	3.1-4.3
Interrupted Aortic Arch	16	0.4	0.2-0.6
Pulmonary Valve Atresia & Stenosis	337	8.4	7.5-9.3
Single Ventricle	44	1.1	0.8-1.5
Tetralogy of Fallot	234	5.8	5.1-6.6
Total Anomalous Pulmonary Venous Return	48	1.2	0.9-1.6
Transposition of Great Arteries	219	5.5	4.7-6.2
Tricuspid Valve Atresia & Stenosis	56	1.4	1.1-1.8
Ventricular Septal Defect	1,933	48.2	46.1-50.3
Central Nervous System	**435**	**10.9**	**9.8-11.9**
Anencephalus	58	1.5	1.1-1.9
Encephalocele	55	1.4	1.0-1.8
Holoprosencephaly	156	3.9	3.3-4.5
Spina Bifida	166	4.1	3.5-4.8
Chromosomal	**698**	**17.4**	**16.1-18.7**
Deletion 22q11.2	5	0.1	0.0-0.3
Down Syndrome	577	14.4	13.2-15.6
Trisomy 13	32	0.8	0.5-1.1
Trisomy 18	73	1.8	1.4-2.3
Turner Syndrome	11	0.3	0.1-0.5
Ear/Eye	**165**	**4.1**	**3.5-4.7**
Anophthalmia/Microthalmia	49	1.2	0.9-1.6
Anotia/Microtia	35	0.9	0.6-1.2
Congenital Cataract	81	2.0	1.6-2.5

Birth Defect	Count[1]	Rate[2]	95%CI[3]
Gastrointestinal	**535**	**13.3**	**12.2-14.5**
Biliary Atresia	41	1.0	0.7-1.4
Esophageal Atresia/Tracheoesophageal Fistula	134	3.3	2.8-3.9
Rectal & Large Intestinal Atresia/Stenosis	244	6.1	5.3-6.9
Small intestinal atresia/stenosis	116	2.9	2.4-3.4
Genitourinary	**2,648**	**66.0**	**63.5-68.5**
Bladder Exstrophy	12	0.3	0.2-0.5
Cloacal Exstrophy	174	4.3	3.7-5.0
Congenital Posterior Urethral Valves	97	2.4	2.0-3.0
Hypospadias	2,127	53.0	50.8-55.3
Renal Agenesis/Hypoplasia	238	5.9	5.2-6.7
Musculoskeletal	**985**	**24.6**	**23.0-26.1**
Clubfoot	408	10.2	9.2-11.2
Diaphragmatic Hernia	163	4.1	3.4-4.7
Gastroschisis	223	5.6	4.8-6.3
Limb Deficiencies (Reduction Defects)	97	2.4	2.0-3.0
Omphalocele	94	2.3	1.9-2.9
Orofacial	**578**	**14.4**	**13.2-15.6**
Choanal Atresia	75	1.9	1.5-2.3
Cleft Palate without Cleft Lip	275	6.9	6.1-7.7
Cleft Lip only (without Cleft Palate)	91	2.3	1.8-2.8
Cleft Lip with Cleft Palate	137	3.4	2.8-4.0
Total Birth Defect by Organ System	**15,366**	**383.12**	**377.06-389.18**
Fetal Alcohol Syndrome	**59**	**1.5**	**1.1-1.9**

Source: Tennessee Department of Health, Division of Policy, Planning and Assessment, Tennessee Birth Defect Registry 2009-2013.

[1]Counts include cases resulting from live births and fetal deaths.

[2]Rates were computed per 10,000 live births.

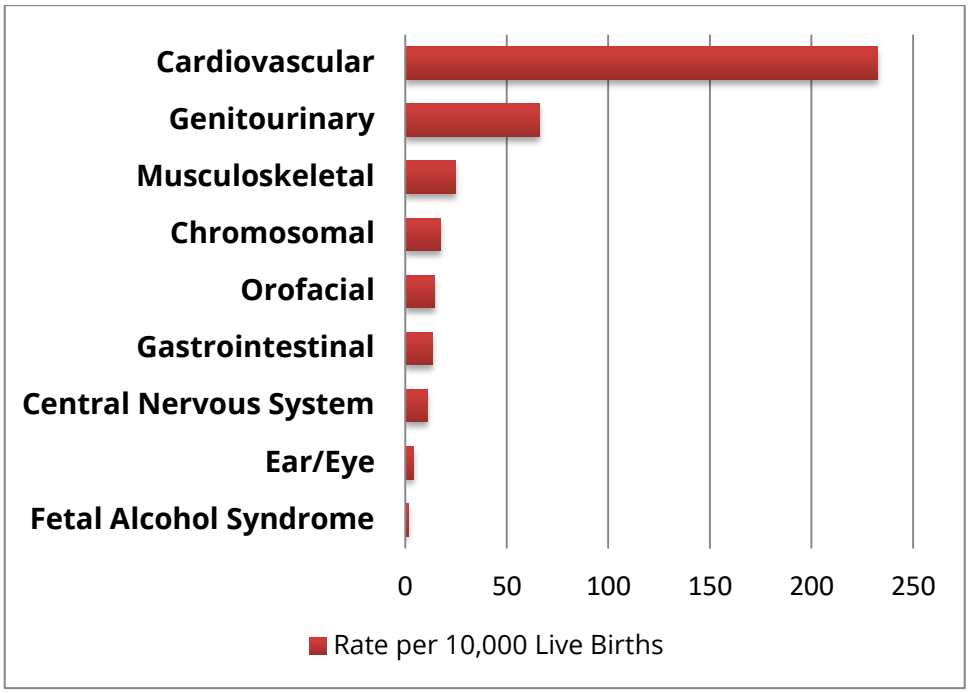
[3]Confidence intervals for 100 or less cases are exact Poisson; otherwise confidence intervals are based on the normal approximation.

Diagnostic data were derived from the Tennessee Hospital Discharge Data System (2009-2014), the Tennessee Death Statistical System (2009-2014) and the Tennessee Fetal Death Statistical System (2009-2013).

Total live births were derived from the Tennessee Birth Statistical System (2009-2013).

The prevalence rate in Figure 1 shows that cardiovascular system defects are the most commonly diagnosed forms of birth defect in Tennessee, with a rate of 232.43 per 10,000 live births.

Figure 1: Birth Defects by Organ Systems and Fetal Alcohol Syndrome 2009-2013



Source: Tennessee Department of Health, Division of Policy, Planning and Assessment, Tennessee Birth Defect Registry 2009-2013.
Rates were computed per 10,000 live births.
Diagnostic data were derived from the Tennessee Hospital Discharge Data System (2009-2014), the Tennessee Death Statistical System (2009-2014) and the Tennessee Fetal Death Statistical System (2009-2013).
Total live births were derived from the Tennessee Birth Statistical System (2009-2013).

Birth Defects by Socio-Demographic Factors

Infant Gender

The rates of birth defects by organ systems and the sex of the infants are shown in Table 4. Only the genitourinary system presents a significant gender difference in terms of birth defect rate. The rate of genitourinary defects in male babies (116.8 per 10,000 live births) was much higher than that in female babies (12.6 per 10,000 live births). This difference is explained by the fact that hypospadias only affected male babies. When hypospadias defects are excluded from the genitourinary group, the defect rate for males and females were respectively 14.3 (95%ci: 12.6-15.9) and 12.4 (95%ci: 10.8-13.9).

Table 4: Birth Defects by Organ System and Fetal Alcohol Syndrome by Infant Gender, 2009-2013

	Male		Female	
Birth Defects by Organ System	Rate	95%CI[3]	Rate	95%CI
Cardiovascular	235.0	228.3-241.6	229.8	223.1-236.5
Central Nervous System	10.4	9.0-11.8	11.3	9.8-12.7
Chromosomal	16.8	15.1-18.6	18.0	16.1-19.9
Ear/Eye	3.7	3.0-4.7	4.5	3.6-5.5
Gastrointestinal	14.3	12.6-15.9	12.4	10.8-13.9
Genitourinary	116.8	112.1-121.5	12.6	11.1-14.2
Musculoskeletal	27.6	25.4-29.9	21.3	19.3-23.4
Orofacial	14.1	12.4-15.7	14.8	13.1-16.5
Fetal Alcohol Syndrome	1.2	0.8-1.8	1.7	1.2-2.4

Source: Tennessee Department of Health, Division of Policy, Planning and Assessment, Tennessee Birth Defect Registry 2009-2013.
[1]Counts include cases resulting from live births and fetal deaths.
[2]Rates were computed per 10,000 live births.
[3]Confidence intervals for 100 or less cases are exact Poisson; otherwise confidence intervals are based on the normal approximation.
Diagnostic data were derived from the Tennessee Hospital Discharge Data System (2009-2014), the Tennessee Death Statistical System (2009-2014) and the Tennessee Fetal Death Statistical System (2009-2013).
Total live births were derived from the Tennessee Birth Statistical System (2009-2013).

Maternal Education

Birth defect rates and confidence intervals by maternal education for eight organ systems and fetal alcohol syndrome for the years 2009-2013 are presented in Table 5.

Table 5: Birth Defects by Organ System and Fetal Alcohol Syndrome by Maternal Education, 2009-2013

	No High School Diploma		High School Diploma		College or Above	
Birth Defects by Organ System	Rate[2]	95%CI[3]	Rate	95%CI	Rate[2]	95%CI[3]
Cardiovascular	271.5	259.6-283.4	253.4	244.2-262.6	207.9	201.8-214.0
Central Nervous System	12.8	10.3-15.7	13.0	10.9-15.1	8.9	7.6-10.2
Chromosomal	17.2	14.2-20.2	15.0	12.8-17.3	18.7	16.9-20.6
Ear/Eye	4.5	3.1-6.3	4.1	3.0-5.5	4.0	3.2-5.0
Gastrointestinal	14.7	11.9-17.5	12.9	10.9-15.0	13.1	11.5-14.6
Genitourinary	59.4	53.8-64.9	64.8	60.1-69.4	69.0	65.5-72.6
Musculoskeletal	29.8	25.9-33.8	26.6	23.6-29.6	21.6	19.6-23.5
Orofacial	13.6	11.1-16.6	16.1	13.8-18.4	13.7	12.2-15.3
Fetal Alcohol Syndrome	3.7	2.4-5.3	1.8	1.1-2.8	0.5	0.3-0.9

Source: Tennessee Department of Health, Division of Policy, Planning and Assessment, Tennessee Birth Defect Registry 2009-2013.
[1]Counts include cases resulting from live births and fetal deaths.
[2]Rates were computed per 10,000 live births.
[3]Confidence intervals for 100 or less cases are exact Poisson; otherwise confidence intervals are based on the normal approximation.
Diagnostic data were derived from the Tennessee Hospital Discharge Data System (2009-2014), the Tennessee Death Statistical System (2009-2014) and the Tennessee Fetal Death Statistical System (2009-2013).
Total live births were derived from the Tennessee Birth Statistical System (2009-2013).

Table 5 illustrates how the birth defect rates differ by maternal education level. For instance children born to women with at least some college education are less likely to have cardiovascular system defects and other birth defects (Table 5).

Race and Ethnicity

Table 6 and Table 7 below report the prevalence rate of birth defects by maternal race and ethnicity, respectively. There were 11,245 birth defects among white infants, corresponding to a rate of 371 birth defects per 10,000 live births. There were 3,789 birth defects among black infants with a rate of 452 per 10,000 live births. Although whites have the highest number of defects, the rate per 10,000 live births of blacks exceeded the rate of white infants.

Table 6: Birth Defects by Organ System and Fetal Alcohol Syndrome by Maternal Race, 2009-20013

	Black		White		Other	
Birth Defects By Organ System	**Rate**[2]	**95%CI**[3]	**Rate**	**95%CI**	**Rate**	**95%CI**
Cardiovascular	301.1	289.3-312.8	217.5	212.2-222.7	168.5	144.4-192.6
Central Nervous System	9.7	7.7-12.0	10.6	9.4-11.7	9.0	4.3-16.5
Chromosomal	16.9	14.1-19.7	17.0	15.5-18.4	16.1	9.6-25.5
Ear/Eye	4.3	3.0-5.9	4.0	3.3-4.7	6.3	2.5-12.9
Gastrointestinal	12.4	10.0-14.8	13.9	12.6-15.2	7.2	3.1-14.1
Genitourinary	74.4	68.6-80.2	65.1	62.2-67.9	35.9	25.6-48.8
Musculoskeletal	22.2	19.0-25.4	25.2	23.4-26.9	10.8	5.6-18.8
Orofacial	8.8	6.9-11.1	16.3	14.8-17.7	9.0	4.3-16.5
Fetal Alcohol Syndrome	2.0	1.2-3.2	1.4	1.0-1.8	0.9	0.0-5.0

Source: Tennessee Department of Health, Division of Policy, Planning and Assessment, Tennessee Birth Defect Registry 2009-2013.
[1]Counts include cases resulting from live births and fetal deaths.
[2]Rates were computed per 10,000 live births.
[3]Confidence intervals for 100 or less cases are exact Poisson; otherwise confidence intervals are based on the normal approximation.
Diagnostic data were derived from the Tennessee Hospital Discharge Data System (2009-2014), the Tennessee Death Statistical System (2009-2014) and the Tennessee Fetal Death Statistical System (2009-2013).
Total live births were derived from the Tennessee Birth Statistical System (2009-2013).

Birth defect rates by ethnic group are reported in Table 7. Significant differences of birth defect rates among Hispanic and non-Hispanic infants were only found for cardiovascular and genitourinary systems.

Table 7: Birth Defects by Organ System and Fetal Alcohol Syndrome by Maternal Ethnicity, 2009-2013

	Hispanic		Not Hispanic		Unknown Hispanic	
Birth Defect By Organ System	Rate[1]	95%CI[2]	Rate	95%CI	Rate	95%CI
Cardiovascular	210.2	195.1-225.3	234.6	229.7-239.6	234.6	229.7-239.6
Central Nervous System	15.0	11.2-19.6	10.5	9.4-11.5	10.5	9.4-11.5
Chromosomal	22.3	17.7-27.8	16.9	15.6-18.3	16.9	15.6-18.3
Ear/Eye	4.8	2.8-7.7	4.1	3.4-4.7	4.1	3.4-4.7
Gastrointestinal	13.3	9.8-17.7	13.4	12.2-14.5	13.4	12.2-14.5
Genitourinary	28.0	22.7-34.1	69.7	67.0-72.4	69.7	67.0-72.4
Musculoskeletal	24.6	19.7-30.3	24.6	23.0-26.2	24.6	23.0-26.2
Orofacial	12.4	9.0-16.7	14.6	13.4-15.9	14.6	13.4-15.9
Fetal Alcohol Syndrome	**	**	1.6	1.2-2.1	1.6	1.2-2.1

Source: Tennessee Department of Health, Division of Policy, Planning and Assessment, Tennessee Birth Defect Registry 2009-2013.
[1]Rates were computed per 10,000 live births.
[2]Confidence intervals for 100 or less cases are exact Poisson; otherwise confidence intervals are based on the normal approximation.
Diagnostic data were derived from the Tennessee Hospital Discharge Data System (2009-2014), the Tennessee Death Statistical System (2009-2014) and the Tennessee Fetal Death Statistical System (2009-2013).
Total live births were derived from the Tennessee Birth Statistical System (2009-2013).
**No cases recorded for the group.

Birth Defects by Potential Risk Factors

Maternal Age

Maternal age is a significant risk factor for certain types of birth defects, with advanced maternal age posing a higher risk for birth defects. Table 8 shows the rates of birth defects by maternal age.

The rate of chromosomal defects among babies born to mothers aged 35 years and greater (60.2 per 10,000 live births) is around four times higher than the rate among those born to mothers who are in the age groups of 20- 34 (12.6 per 10,000 live births). The average rate of chromosomal birth defects to mothers under the age of 20 is 10.6 per 10,000 live births, and was not statistically different from the average rate of the age group 20-34.

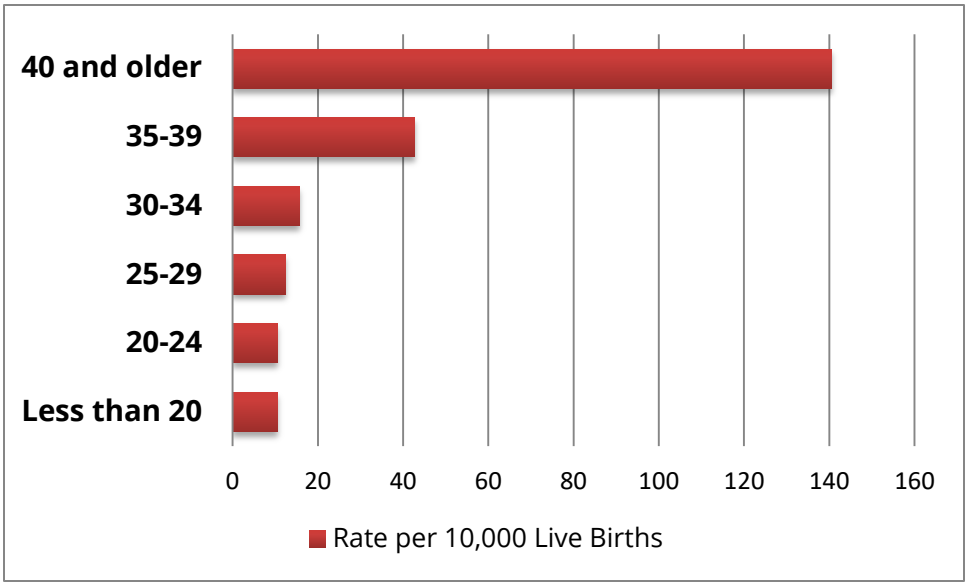
Table 8: Birth Defects by Organ System and Fetal Alcohol Syndrome by Maternal Age, 2009-2013

	Less than 20		20-34		35 and Older	
Birth Defect By organ system	Rate[2]	95%CI[3]	Rate	95%CI	Rate	95%CI
Cardiovascular	233.7	219.4-248.1	222.0	216.8-227.2	308.4	291.7-325.1
Central Nervous System	12.6	9.5-16.4	10.2	9.1-11.3	13.4	10.2-17.4
Chromosomal	10.6	7.7-14.1	12.6	11.3-13.8	60.2	52.8-67.6
Ear/Eye	6.4	4.3-9.3	3.5	2.8-4.1	6.6	4.4-9.5
Gastrointestinal	15.1	11.7-19.3	12.5	11.2-13.7	18.1	14.3-22.6
Genitourinary	70.0	62.1-77.8	64.5	61.7-67.3	73.2	65.0-81.3
Musculoskeletal	28.0	23.0-33.0	25.0	23.2-26.7	17.6	13.9-22.1
Orofacial	13.1	9.9-16.9	14.2	12.9-15.5	17.6	13.9-22.1
Fetal Alcohol Syndrome	1.1	0.4-2.7	1.5	1.1-1.9	1.9	0.8-3.7

Source: Tennessee Department of Health, Division of Policy, Planning and Assessment, Tennessee Birth Defect Registry 2009-2013.
[2]Rates were computed per 10,000 live births.
[3]Confidence intervals for 100 or less cases are exact Poisson; otherwise confidence intervals are based on the normal approximation.
Diagnostic data were derived from the Tennessee Hospital Discharge Data System (2009-2014), the Tennessee Death Statistical System (2009-2014) and the Tennessee Fetal Death Statistical System (2009-2013).
Total live births were derived from the Tennessee Birth Statistical System (2009-2013).

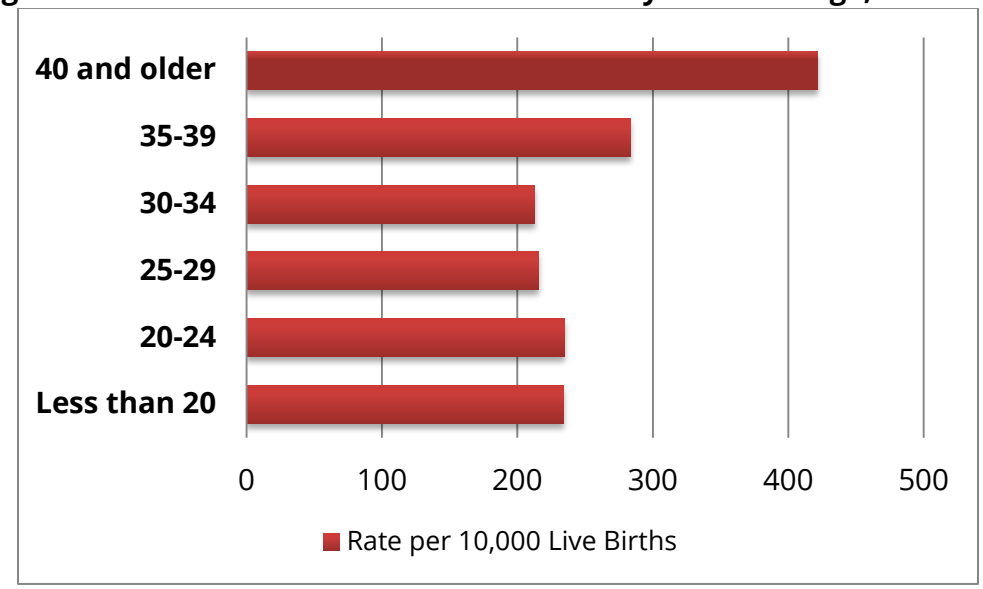
Figure 2 and Figure 3 illustrate further the significant role that maternal age plays in birth defect occurrence. Figure 2 demonstrates that children born to mothers aged 40 years and above are more likely to have a chromosomal system birth defect than those born to mothers in the other age groups. Figure 3 illustrates that the average rate of cardiovascular birth defects to mothers aged 40 years or greater (422 per 10,000 live births) is about two times the average rate for babies born to mothers in the age group 30-34.

Figure 2: Chromosomal Birth Defects Rates by Maternal Age, 2009-2013



Source: Tennessee Department of Health, Division of Policy, Planning and Assessment, Tennessee Birth Defect Registry 2009-2013.
Rates were computed per 10,000 live births.
Diagnostic data were derived from the Tennessee Hospital Discharge Data System (2009-2014), the Tennessee Death Statistical System (2009-2014) and the Tennessee Fetal Death Statistical System (2009-2013).
Total live births were derived from the Tennessee Birth Statistical System (2009-2013).

Figure 3: Cardiovascular Birth Defects Rates by Maternal Age, 2009-2013



Source: Tennessee Department of Health, Division of Policy, Planning and Assessment, Tennessee Birth Defect Registry 2009-2013.
Rates were computed per 10,000 live births.
Diagnostic data were derived from the Tennessee Hospital Discharge Data System (2009-2014), the Tennessee Death Statistical System (2009-2014) and the Tennessee Fetal Death Statistical System (2009-2013).
Total live births were derived from the Tennessee Birth Statistical System (2009-2013).

Maternal Diabetes

The 2009-2013 birth defects counts, rates, and confidence intervals by maternal pre-pregnancy diabetes for the 8 organ systems' defects and fetal alcohol syndrome are presented in Table 9.

Table 9: Birth Defects by Organ System and Fetal Alcohol Syndrome by Maternal Diabetes, 2009-2013

	Pre-Pregnancy Diabetes			No Pre-Pregnancy Diabetes		
Defects by Organ System	Count[1]	Rate[2]	95%CI[3]	Count	Rate	95%CI
Cardiovascular	277	1,413	1247-1580	9,045	226.6	222.0-231.3
Central Nervous System	8	40.8	17.6-80.4	407	10.2	9.2-11.2
Chromosomal	6	30.6	11.2-66.6	678	17.0	15.7-18.3
Ear/Eye	8	40.8	17.6-80.4	157	3.9	3.3-4.5
Fetal Alcohol Syndrome	**	**	**	59	1.5	1.1-1.9
Gastrointestinal	13	66.3	35.3-113.4	522	13.1	12.0-14.2
Genitourinary	56	285.7	215.8-371.0	2,586	64.8	62.3-67.3
Musculoskeletal	12	61.2	31.6-106.9	952	23.9	22.3-25.4
Orofacial	12	61.2	31.6-106.9	566	14.2	13.0-15.3

Source: Tennessee Department of Health, Division of Policy, Planning and Assessment, Tennessee Birth Defect Registry 2009-2013.
[1]Counts include cases resulting from live births and fetal deaths.
[2]Rates were computed per 10,000 live births.
[3]Confidence intervals for 100 or less cases are exact Poisson; otherwise confidence intervals are based on the normal approximation.
Diagnostic data were derived from the Tennessee Hospital Discharge Data System (2009-2014), the Tennessee Death Statistical System (2009-2014) and the Tennessee Fetal Death Statistical System (2009-2013).
Total live births were derived from the Tennessee Birth Statistical System (2009-2013).*Count suppressed if less than 10.
**No cases recorded for the group.

The birth defects rate of the cardiovascular system for mothers with pre-pregnancy diabetes was 1, 413 per 10,000 live births. The corresponding figure for mothers without pre-pregnancy diabetes was 226.6. This finding suggests that babies born to mothers with pre-pregnancy diabetes are at increased risk for cardiovascular system birth defects. The

defect rates for six other organ systems, Central Nervous System, Ear/Eye, Gastrointestinal, Genitourinary, Musculoskeletal and Orofacial, are also significantly different between babies born to mother with pre-pregnancy diabetes and those whose mother did not have diabetes prior to their pregnancy. However, given that the counts in the pre-pregnancy diabetes groups are very small for these six organ systems, the findings should be interpreted with caution.

Birth Defects by Maternal Perinatal Region and County of Residence

Perinatal Region

Table10 shows the prevalence of fetal alcohol syndrome and other birth defects by organ systems for each of the Tennessee perinatal regions. Fifteen defects lack county information, and are not included in the perinatal grouping. Northeast perinatal region had the highest rate of birth defects (514.5). The West perinatal region had the second highest rate of birth defects (434.1). Third highest rate was the East perinatal region (395.7). Perinatal regions of Southeast (342.9) and Middle (335.5) had the fourth and fifth place rates for birth defects.

Table 10: Birth Defects by Organ System and Fetal Alcohol Syndrome by Perinatal Region, 2009-2013

County	Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
East		**2,765**	**395.7**	**380.9-410.4**
	Cardiovascular	1,702	243.5	232.0-255.1
	Central nervous system	82	11.7	9.3-14.6
	Chromosomal	100	14.3	11.6-17.4
	Ear/Eye	32	4.6	3.1-6.5
	Gastrointestinal	96	13.7	11.1-16.8
	Genitourinary	448	64.1	58.2-70.0
	Musculoskeletal	177	25.3	21.6-29.1
	Orofacial	114	16.3	13.3-19.3
	Fetal Alcohol Syndrome	14	2.0	1.1-3.4

County	Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Middle		**5,451**	**335.5**	**326.6-344.4**
	Cardiovascular	2,880	177.2	170.8-183.7
	Central nervous system	170	10.5	8.9-12.0
	Chromosomal	303	18.6	16.5-20.7
	Ear/Eye	56	3.4	2.6-4.5
	Gastrointestinal	218	13.4	11.6-15.2
	Genitourinary	1,192	73.4	69.2-77.5
	Musculoskeletal	384	23.6	21.3-26.0
	Orofacial	232	14.3	12.4-16.1
	Fetal Alcohol Syndrome	16	1.0	0.6-1.6
Northeast		**1,300**	**514.5**	**486.6-542.5**
	Cardiovascular	894	353.8	330.6-377.0
	Central nervous system	24	9.5	6.1-14.1
	Chromosomal	45	17.8	13.0-23.8
	Ear/Eye	22	8.7	5.5-13.2
	Gastrointestinal	40	15.8	11.3-21.6
	Genitourinary	146	57.8	48.4-67.2
	Musculoskeletal	78	30.9	24.4-38.5
	Orofacial	46	18.2	13.3-24.3
	Fetal Alcohol Syndrome	5	2.0	0.6-4.6
Southeast		**1,249**	**342.9**	**323.9-361.9**
	Cardiovascular	746	204.8	190.1-219.5
	Central nervous system	41	11.3	8.1-15.3
	Chromosomal	63	17.3	13.3-22.1
	Ear/Eye	17	4.7	2.7-7.5
	Gastrointestinal	44	12.1	8.8-16.2
	Genitourinary	190	52.2	44.7-59.6
	Musculoskeletal	84	23.1	18.4-28.6
	Orofacial	55	15.1	11.4-19.7
	Fetal Alcohol Syndrome	9	2.5	1.1-4.7

County	Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
West		**4,645**	**434.1**	**421.6-446.6**
	Cardiovascular	3,100	289.7	279.5-299.9
	Central nervous system	111	10.4	8.4-12.3
	Chromosomal	183	17.1	14.6-19.6
	Ear/Eye	38	3.6	2.5-4.9
	Gastrointestinal	137	12.8	10.7-14.9
	Genitourinary	670	62.6	57.9-67.4
	Musculoskeletal	260	24.3	21.3-27.3
	Orofacial	131	12.2	10.1-14.3
	Fetal Alcohol Syndrome	15	1.4	0.8-2.3

Source: Tennessee Department of Health, Division of Policy, Planning and Assessment, Tennessee Birth Defect Registry 2009-2013.
[1]Counts include cases resulting from live births and fetal deaths.
[2]Rates were computed per 10,000 live births.
[3]Confidence intervals for 100 or less cases are exact Poisson; otherwise confidence intervals are based on the normal approximation.
Diagnostic data were derived from the Tennessee Hospital Discharge Data System (2009-2014), the Tennessee Death Statistical System (2009-2014) and the Tennessee Fetal Death Statistical System (2009-2013).
Total live births were derived from the Tennessee Birth Statistical System (2009-2013).
Note: Fifteen defect lack county information, and are not included in the grouping.

Maternal Resident County

Figure 4 depicts the birth defects rate by maternal county of residence. Counties located in the Middle perinatal region had the lowest rate of birth defects. Specific types of birth defect by organ system as well as overall defect rate are reported in Table 11. There are variations from one county to another in terms of specific defect rates. For instance, the defect rate of cardiovascular system and the overall defect rate are respectively 286.4 and 478.1 per 10,000 live births in Anderson County compared to 140.1 and 257.9 in Bedford County (Table 11). The differences may reflect underlying differences in the population and variations in risk factors. Given that the numbers are generally small the differences in rates should be interpreted with caution.

Figure 4: Birth Defects and Fetal Alcohol Syndrome Rates by Maternal Resident County, Tennessee, 2009-2013

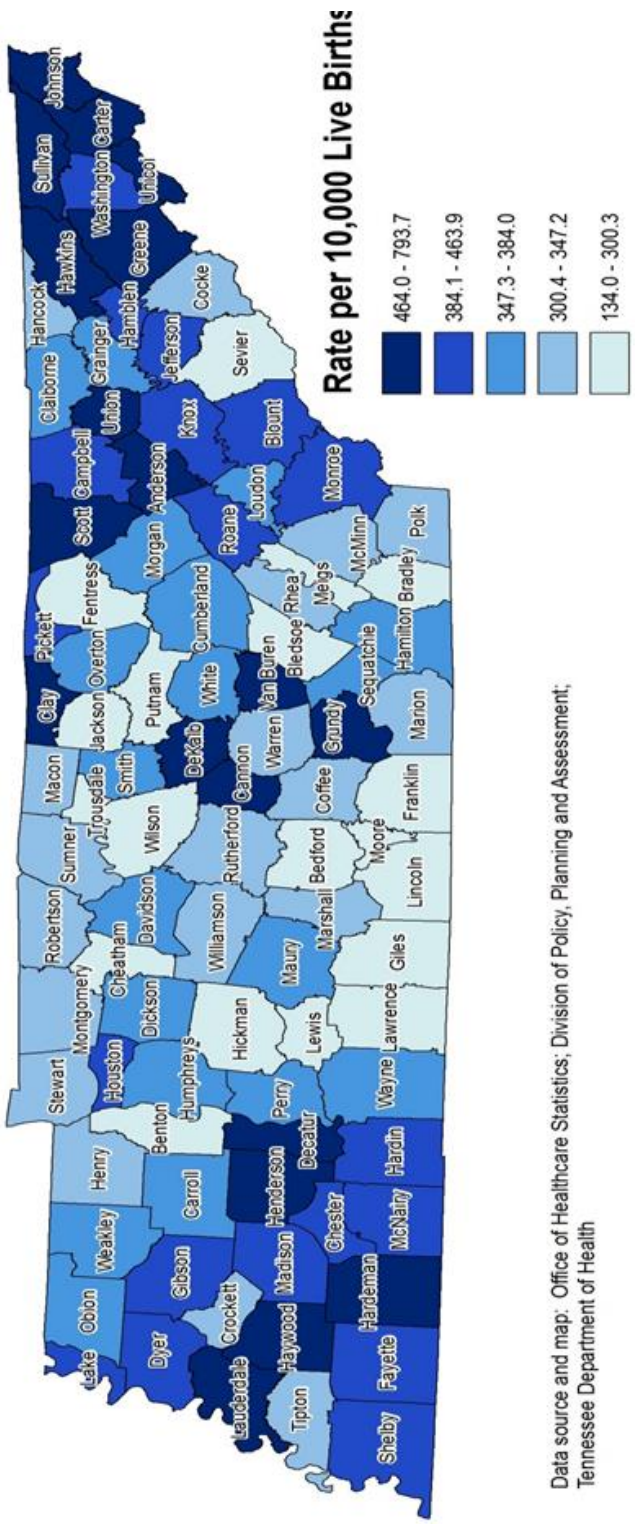


Table 11: Birth Defects by Organ System and Fetal Alcohol Syndrome by Maternal Resident County, 2009-2013

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Anderson	**Total**	**192**	**478.1**	**410.5-545.7**
	Cardiovascular	115	286.4	234.0-338.7
	Central Nervous System	6	14.9	5.5-32.5
	Chromosomal	7	17.4	7.0-35.9
	Ear/Eye	1	2.5	0.1-13.9
	Gastrointestinal	7	17.4	7.0-35.9
	Genitourinary	36	89.6	62.8-124.1
	Musculoskeletal	14	34.9	19.1-58.5
	Orofacial	6	14.9	5.5-32.5
Bedford	**Total**	**81**	**257.9**	**204.8-320.5**
	Cardiovascular	44	140.1	101.8-188.1
	Central Nervous System	1	3.2	0.1-17.7
	Chromosomal	3	9.6	2.0-27.9
	Gastrointestinal	4	12.7	3.5-32.6
	Genitourinary	19	60.5	36.4-94.5
	Musculoskeletal	6	19.1	7.0-41.6
	Orofacial	4	12.7	3.5-32.6
Benton	**Total**	**19**	**230.3**	**138.7-359.6**
	Cardiovascular	9	109.1	49.9-207.1
	Central Nervous System	1	12.1	0.3-67.5
	Chromosomal	1	12.1	0.3-67.5
	Gastrointestinal	1	12.1	0.3-67.5
	Genitourinary	5	60.6	19.7-141.4
	Orofacial	2	24.2	2.9-87.6
Bledsoe	**Total**	**8**	**134.0**	**57.9-264.0**
	Cardiovascular	1	16.8	0.4-93.3
	Genitourinary	1	16.8	0.4-93.3
	Musculoskeletal	4	67.0	18.3-171.6
	Orofacial	2	33.5	4.1-121.0
Blount	**Total**	**262**	**411.5**	**361.7-461.3**
	Cardiovascular	168	263.9	224.0-303.8
	Central Nervous System	8	12.6	5.4-24.8
	Chromosomal	9	14.1	6.5-26.8
	Ear/Eye	4	6.3	1.7-16.1
	Gastrointestinal	5	7.9	2.5-18.3
	Genitourinary	45	70.7	51.6-94.6
	Musculoskeletal	16	25.1	14.4-40.8
	Orofacial	6	9.4	3.5-20.5
	Fetal Alcohol Syndrome	1	1.6	0.0-8.8

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Bradley	**Total**	**176**	**300.3**	**255.9-344.7**
	Cardiovascular	100	170.6	138.8-207.5
	Central Nervous System	7	11.9	4.8-24.6
	Chromosomal	10	17.1	8.2-31.4
	Ear/Eye	4	6.8	1.9-17.5
	Gastrointestinal	4	6.8	1.9-17.5
	Genitourinary	28	47.8	31.7-69.0
	Musculoskeletal	9	15.4	7.0-29.1
	Orofacial	12	20.5	10.6-35.8
	Fetal Alcohol Syndrome	2	3.4	0.4-12.3
Campbell	**Total**	**85**	**402.1**	**321.2-497.2**
	Cardiovascular	49	231.8	171.5-306.4
	Central Nervous System	3	14.2	2.9-41.5
	Chromosomal	3	14.2	2.9-41.5
	Ear/Eye	2	9.5	1.1-34.2
	Gastrointestinal	2	9.5	1.1-34.2
	Genitourinary	16	75.7	43.3-122.9
	Musculoskeletal	5	23.7	7.7-55.2
	Orofacial	5	23.7	7.7-55.2
Cannon	**Total**	**34**	**489.2**	**338.8-683.6**
	Cardiovascular	18	259.0	153.5-409.3
	Chromosomal	1	14.4	0.4-80.2
	Ear/Eye	1	14.4	0.4-80.2
	Genitourinary	9	129.5	59.2-245.8
	Musculoskeletal	3	43.2	8.9-126.1
	Orofacial	2	28.8	3.5-104.0
Carroll	**Total**	**59**	**367.1**	**279.5-473.6**
	Cardiovascular	36	224.0	156.9-310.1
	Central Nervous System	1	6.2	0.2-34.7
	Chromosomal	2	12.4	1.5-45.0
	Gastrointestinal	1	6.2	0.2-34.7
	Genitourinary	9	56.0	25.6-106.3
	Musculoskeletal	5	31.1	10.1-72.6
	Orofacial	3	18.7	3.8-54.6
	Fetal Alcohol Syndrome	2	12.4	1.5-45.0

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Carter	**Total**	**194**	**707.5**	**608.0-807.1**
	Cardiovascular	156	568.9	479.6-658.2
	Central Nervous System	1	3.6	0.1-20.3
	Chromosomal	3	10.9	2.3-32.0
	Ear/Eye	3	10.9	2.3-32.0
	Gastrointestinal	5	18.2	5.9-42.6
	Genitourinary	14	51.1	27.9-85.7
	Musculoskeletal	11	40.1	20.0-71.8
	Orofacial	1	3.6	0.1-20.3
Cheatham	**Total**	**64**	**294.7**	**226.9-376.3**
	Cardiovascular	24	110.5	70.8-164.4
	Chromosomal	5	23.0	7.5-53.7
	Gastrointestinal	2	9.2	1.1-33.3
	Genitourinary	25	115.1	74.5-169.9
	Musculoskeletal	5	23.0	7.5-53.7
	Orofacial	3	13.8	2.8-40.4
Chester	**Total**	**39**	**414.5**	**294.7-566.6**
	Cardiovascular	26	276.3	180.5-404.8
	Central Nervous System	1	10.6	0.3-59.2
	Chromosomal	2	21.3	2.6-76.8
	Gastrointestinal	2	21.3	2.6-76.8
	Genitourinary	5	53.1	17.3-124.0
	Musculoskeletal	2	21.3	2.6-76.8
	Orofacial	1	10.6	0.3-59.2
Claiborne	**Total**	**56**	**350.4**	**264.7-455.1**
	Cardiovascular	43	269.1	194.7-362.5
	Central Nervous System	1	6.3	0.2-34.9
	Chromosomal	1	6.3	0.2-34.9
	Gastrointestinal	2	12.5	1.5-45.2
	Genitourinary	5	31.3	10.2-73.0
	Musculoskeletal	2	12.5	1.5-45.2
	Orofacial	2	12.5	1.5-45.2
Clay	**Total**	**21**	**481.7**	**298.1-736.3**
	Cardiovascular	11	252.3	125.9-451.4
	Central Nervous System	1	22.9	0.6-127.8
	Chromosomal	1	22.9	0.6-127.8
	Ear/Eye	1	22.9	0.6-127.8
	Gastrointestinal	1	22.9	0.6-127.8
	Genitourinary	3	68.8	14.2-201.1
	Musculoskeletal	1	22.9	0.6-127.8
	Orofacial	2	45.9	5.6-165.7

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Cocke	**Total**	**66**	**341.4**	**264.1-434.4**
	Cardiovascular	35	181.1	126.1-251.8
	Gastrointestinal	7	36.2	14.6-74.6
	Genitourinary	14	72.4	39.6-121.5
	Musculoskeletal	4	20.7	5.6-53.0
	Orofacial	5	25.9	8.4-60.4
	Fetal Alcohol Syndrome	1	5.2	0.1-28.8
Coffee	**Total**	**112**	**347.2**	**282.9-411.5**
	Cardiovascular	70	217.0	169.2-274.1
	Central Nervous System	5	15.5	5.0-36.2
	Chromosomal	5	15.5	5.0-36.2
	Gastrointestinal	3	9.3	1.9-27.2
	Genitourinary	12	37.2	19.2-65.0
	Musculoskeletal	12	37.2	19.2-65.0
	Orofacial	5	15.5	5.0-36.2
Crockett	**Total**	**28**	**312.2**	**207.4-451.1**
	Cardiovascular	17	189.5	110.4-303.4
	Central Nervous System	1	11.1	0.3-62.1
	Gastrointestinal	2	22.3	2.7-80.5
	Genitourinary	6	66.9	24.5-145.6
	Musculoskeletal	2	22.3	2.7-80.5
Cumberland	**Total**	**107**	**379.7**	**307.8-451.6**
	Cardiovascular	74	262.6	206.2-329.7
	Central Nervous System	4	14.2	3.9-36.3
	Chromosomal	5	17.7	5.8-41.4
	Gastrointestinal	4	14.2	3.9-36.3
	Genitourinary	12	42.6	22.0-74.4
	Musculoskeletal	7	24.8	10.0-51.2
	Orofacial	1	3.5	0.1-19.8
Davidson	**Total**	**1,809**	**372.5**	**355.3-389.7**
	Cardiovascular	995	204.9	192.2-217.6
	Central Nervous System	56	11.5	8.7-15.0
	Chromosomal	95	19.6	15.8-23.9
	Ear/Eye	17	3.5	2.0-5.6
	Gastrointestinal	63	13.0	10.0-16.6
	Genitourinary	406	83.6	75.5-91.7
	Musculoskeletal	105	21.6	17.5-25.8
	Orofacial	67	13.8	10.7-17.5
	Fetal Alcohol Syndrome	5	1.0	0.3-2.4

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Decatur	**Total**	**30**	**522.6**	**352.6-746.1**
	Cardiovascular	18	313.6	185.9-495.6
	Central Nervous System	1	17.4	0.4-97.1
	Chromosomal	1	17.4	0.4-97.1
	Genitourinary	7	122.0	49.0-251.3
	Musculoskeletal	1	17.4	0.4-97.1
	Orofacial	2	34.8	4.2-125.9
Dekalb	**Total**	**53**	**479.2**	**359.0-626.8**
	Cardiovascular	21	189.9	117.5-290.2
	Central Nervous System	5	45.2	14.7-105.5
	Chromosomal	10	90.4	43.4-166.3
	Gastrointestinal	2	18.1	2.2-65.3
	Genitourinary	7	63.3	25.4-130.4
	Musculoskeletal	2	18.1	2.2-65.3
	Orofacial	6	54.2	19.9-118.1
Dickson	**Total**	**116**	**384.0**	**314.1-453.9**
	Cardiovascular	51	168.8	125.7-222.0
	Central Nervous System	4	13.2	3.6-33.9
	Chromosomal	8	26.5	11.4-52.2
	Ear/Eye	1	3.3	0.1-18.4
	Gastrointestinal	4	13.2	3.6-33.9
	Genitourinary	37	122.5	86.2-168.8
	Musculoskeletal	6	19.9	7.3-43.2
	Orofacial	5	16.6	5.4-38.6
Dyer	**Total**	**104**	**429.8**	**347.2-512.3**
	Cardiovascular	69	285.1	221.8-360.8
	Central Nervous System	4	16.5	4.5-42.3
	Chromosomal	6	24.8	9.1-54.0
	Gastrointestinal	4	16.5	4.5-42.3
	Genitourinary	12	49.6	25.6-86.6
	Musculoskeletal	7	28.9	11.6-59.6
	Orofacial	2	8.3	1.0-29.9
Fayette	**Total**	**89**	**398.2**	**319.8-490.0**
	Cardiovascular	62	277.4	212.7-355.6
	Chromosomal	6	26.8	9.9-58.4
	Ear/Eye	3	13.4	2.8-39.2
	Gastrointestinal	1	4.5	0.1-24.9
	Genitourinary	11	49.2	24.6-88.1
	Musculoskeletal	3	13.4	2.8-39.2
	Orofacial	3	13.4	2.8-39.2

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Fentress	**Total**	**26**	**273.1**	**178.4-400.2**
	Cardiovascular	16	168.1	96.1-272.9
	Chromosomal	1	10.5	0.3-58.5
	Gastrointestinal	2	21.0	2.5-75.9
	Genitourinary	6	63.0	23.1-137.2
	Orofacial	1	10.5	0.3-58.5
Franklin	**Total**	**56**	**284.8**	**215.2-369.9**
	Cardiovascular	34	172.9	119.8-241.7
	Chromosomal	1	5.1	0.1-28.3
	Gastrointestinal	2	10.2	1.2-36.7
	Genitourinary	11	56.0	27.9-100.1
	Musculoskeletal	5	25.4	8.3-59.4
	Orofacial	2	10.2	1.2-36.7
	Fetal Alcohol Syndrome	1	5.1	0.1-28.3
Gibson	**Total**	**134**	**434.8**	**361.2-508.4**
	Cardiovascular	85	275.8	220.3-341.0
	Central Nervous System	2	6.5	0.8-23.4
	Chromosomal	6	19.5	7.1-42.4
	Ear/Eye	2	6.5	0.8-23.4
	Gastrointestinal	3	9.7	2.0-28.4
	Genitourinary	20	64.9	39.6-100.2
	Musculoskeletal	11	35.7	17.8-63.9
	Orofacial	5	16.2	5.3-37.9
Giles	**Total**	**33**	**214.3**	**147.5-300.9**
	Cardiovascular	17	110.4	64.3-176.7
	Central Nervous System	1	6.5	0.2-36.2
	Chromosomal	3	19.5	4.0-56.9
	Genitourinary	9	58.4	26.7-110.9
	Musculoskeletal	1	6.5	0.2-36.2
	Orofacial	2	13.0	1.6-46.9
Grainger	**Total**	**43**	**372.6**	**269.7-501.9**
	Cardiovascular	27	234.0	154.2-340.4
	Central Nervous System	2	17.3	2.1-62.6
	Chromosomal	3	26.0	5.4-76.0
	Gastrointestinal	2	17.3	2.1-62.6
	Genitourinary	5	43.3	14.1-101.1
	Musculoskeletal	1	8.7	0.2-48.3
	Orofacial	3	26.0	5.4-76.0

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Greene	**Total**	**170**	**533.1**	**452.9-613.2**
	Cardiovascular	104	326.1	263.4-388.8
	Central Nervous System	5	15.7	5.1-36.6
	Chromosomal	8	25.1	10.8-49.4
	Ear/Eye	3	9.4	1.9-27.5
	Gastrointestinal	10	31.4	15.0-57.7
	Genitourinary	21	65.9	40.8-100.7
	Musculoskeletal	11	34.5	17.2-61.7
	Orofacial	7	22.0	8.8-45.2
	Fetal Alcohol Syndrome	1	3.1	0.1-17.5
Grundy	**Total**	**43**	**537.5**	**389.0-724.0**
	Cardiovascular	24	300.0	192.2-446.4
	Central Nervous System	4	50.0	13.6-128.0
	Chromosomal	2	25.0	3.0-90.3
	Genitourinary	6	75.0	27.5-163.2
	Musculoskeletal	5	62.5	20.3-145.9
	Orofacial	2	25.0	3.0-90.3
Hamblen	**Total**	**161**	**410.2**	**346.8-473.6**
	Cardiovascular	93	236.9	191.2-290.3
	Central Nervous System	6	15.3	5.6-33.3
	Chromosomal	8	20.4	8.8-40.2
	Ear/Eye	2	5.1	0.6-18.4
	Gastrointestinal	7	17.8	7.2-36.7
	Genitourinary	20	51.0	31.1-78.7
	Musculoskeletal	13	33.1	17.6-56.6
	Orofacial	11	28.0	14.0-50.1
	Fetal Alcohol Syndrome	1	2.5	0.1-14.2
Hamilton	**Total**	**751**	**362.7**	**336.8-388.6**
	Cardiovascular	459	221.7	201.4-242.0
	Central Nervous System	22	10.6	6.7-16.1
	Chromosomal	39	18.8	13.4-25.7
	Ear/Eye	12	5.8	3.0-10.1
	Gastrointestinal	31	15.0	10.2-21.3
	Genitourinary	110	53.1	43.2-63.1
	Musculoskeletal	44	21.2	15.4-28.5
	Orofacial	27	13.0	8.6-19.0
	Fetal Alcohol Syndrome	7	3.4	1.4-7.0

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Hancock	**Total**	**12**	**339.0**	**175.2-592.1**
	Cardiovascular	3	84.7	17.5-247.7
	Central Nervous System	1	28.2	0.7-157.4
	Genitourinary	2	56.5	6.8-204.1
	Musculoskeletal	3	84.7	17.5-247.7
	Orofacial	3	84.7	17.5-247.7
Hardeman	**Total**	**74**	**523.0**	**410.6-656.5**
	Cardiovascular	47	332.2	244.1-441.7
	Central Nervous System	5	35.3	11.5-82.5
	Chromosomal	3	21.2	4.4-62.0
	Gastrointestinal	2	14.1	1.7-51.1
	Genitourinary	10	70.7	33.9-130.0
	Musculoskeletal	5	35.3	11.5-82.5
	Orofacial	1	7.1	0.2-39.4
	Fetal Alcohol Syndrome	1	7.1	0.2-39.4
Hardin	**Total**	**62**	**442.5**	**339.3-567.3**
	Cardiovascular	30	214.1	144.5-305.7
	Chromosomal	2	14.3	1.7-51.6
	Ear/Eye	2	14.3	1.7-51.6
	Gastrointestinal	3	21.4	4.4-62.6
	Genitourinary	19	135.6	81.7-211.8
	Musculoskeletal	1	7.1	0.2-39.8
	Orofacial	5	35.7	11.6-83.3
Hawkins	**Total**	**155**	**557.8**	**469.9-645.6**
	Cardiovascular	113	406.6	331.6-481.6
	Central Nervous System	2	7.2	0.9-26.0
	Chromosomal	5	18.0	5.8-42.0
	Ear/Eye	3	10.8	2.2-31.5
	Gastrointestinal	2	7.2	0.9-26.0
	Genitourinary	19	68.4	41.2-106.8
	Musculoskeletal	8	28.8	12.4-56.7
	Orofacial	3	10.8	2.2-31.5

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Haywood	**Total**	**64**	**553.6**	**426.4-707.0**
	Cardiovascular	40	346.0	247.2-471.2
	Central Nervous System	2	17.3	2.1-62.5
	Chromosomal	2	17.3	2.1-62.5
	Ear/Eye	1	8.7	0.2-48.2
	Gastrointestinal	2	17.3	2.1-62.5
	Genitourinary	9	77.9	35.6-147.8
	Musculoskeletal	5	43.3	14.0-100.9
	Orofacial	2	17.3	2.1-62.5
	Fetal Alcohol Syndrome	1	8.7	0.2-48.2
Henderson	**Total**	**94**	**572.5**	**462.6-700.6**
	Cardiovascular	59	359.3	273.5-463.5
	Central Nervous System	3	18.3	3.8-53.4
	Chromosomal	1	6.1	0.2-33.9
	Ear/Eye	1	6.1	0.2-33.9
	Gastrointestinal	7	42.6	17.1-87.8
	Genitourinary	14	85.3	46.6-143.1
	Musculoskeletal	5	30.5	9.9-71.1
	Orofacial	4	24.4	6.6-62.4
Henry	**Total**	**54**	**314.0**	**235.9-409.6**
	Cardiovascular	30	174.4	117.7-249.0
	Central Nervous System	2	11.6	1.4-42.0
	Chromosomal	1	5.8	0.1-32.4
	Gastrointestinal	1	5.8	0.1-32.4
	Genitourinary	12	69.8	36.0-121.9
	Musculoskeletal	4	23.3	6.3-59.5
	Orofacial	4	23.3	6.3-59.5
Hickman	**Total**	**39**	**294.6**	**209.5-402.7**
	Cardiovascular	15	113.3	63.4-186.9
	Central Nervous System	4	30.2	8.2-77.4
	Gastrointestinal	5	37.8	12.3-88.1
	Genitourinary	7	52.9	21.3-108.9
	Musculoskeletal	6	45.3	16.6-98.6
	Orofacial	2	15.1	1.8-54.6
Houston	**Total**	**19**	**439.8**	**264.8-686.8**
	Cardiovascular	12	277.8	143.5-485.2
	Chromosomal	1	23.1	0.6-129.0
	Gastrointestinal	1	23.1	0.6-129.0
	Genitourinary	4	92.6	25.2-237.1
	Musculoskeletal	1	23.1	0.6-129.0

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Humphreys	**Total**	**38**	**364.3**	**257.8-500.1**
	Cardiovascular	17	163.0	94.9-261.0
	Central Nervous System	2	19.2	2.3-69.3
	Gastrointestinal	3	28.8	5.9-84.1
	Genitourinary	7	67.1	27.0-138.3
	Musculoskeletal	3	28.8	5.9-84.1
	Orofacial	5	47.9	15.6-111.9
	Fetal Alcohol Syndrome	1	9.6	0.2-53.4
Jackson	**Total**	**9**	**176.8**	**80.9-335.7**
	Cardiovascular	2	39.3	4.8-141.9
	Chromosomal	1	19.6	0.5-109.5
	Gastrointestinal	1	19.6	0.5-109.5
	Genitourinary	2	39.3	4.8-141.9
	Musculoskeletal	2	39.3	4.8-141.9
	Orofacial	1	19.6	0.5-109.5
Jefferson	**Total**	**105**	**395.9**	**320.2-471.7**
	Cardiovascular	70	264.0	205.8-333.5
	Central Nervous System	4	15.1	4.1-38.6
	Chromosomal	5	18.9	6.1-44.0
	Ear/Eye	2	7.5	0.9-27.2
	Gastrointestinal	3	11.3	2.3-33.1
	Genitourinary	7	26.4	10.6-54.4
	Musculoskeletal	8	30.2	13.0-59.4
	Orofacial	6	22.6	8.3-49.2
Johnson	**Total**	**35**	**465.4**	**324.2-647.3**
	Cardiovascular	24	319.1	204.5-474.9
	Chromosomal	2	26.6	3.2-96.1
	Gastrointestinal	1	13.3	0.3-74.1
	Genitourinary	4	53.2	14.5-136.2
	Musculoskeletal	3	39.9	8.2-116.6
	Fetal Alcohol Syndrome	1	13.3	0.3-74.1
Knox	**Total**	**1,032**	**397.6**	**373.4-421.9**
	Cardiovascular	625	240.8	221.9-259.7
	Central Nervous System	28	10.8	7.2-15.6
	Chromosomal	40	15.4	11.0-21.0
	Ear/Eye	12	4.6	2.4-8.1
	Gastrointestinal	31	11.9	8.1-17.0
	Genitourinary	185	71.3	61.0-81.6
	Musculoskeletal	62	23.9	18.3-30.6
	Orofacial	44	17.0	12.3-22.8
	Fetal Alcohol Syndrome	5	1.9	0.6-4.5

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Lake	**Total**	**14**	**408.2**	**223.1-684.8**
	Cardiovascular	7	204.1	82.1-420.5
	Gastrointestinal	1	29.2	0.7-162.4
	Genitourinary	2	58.3	7.1-210.6
	Musculoskeletal	3	87.5	18.0-255.6
	Fetal Alcohol Syndrome	1	29.2	0.7-162.4
Lauderdale	**Total**	**82**	**509.0**	**404.8-631.8**
	Cardiovascular	56	347.6	262.6-451.4
	Central Nervous System	3	18.6	3.8-54.4
	Chromosomal	3	18.6	3.8-54.4
	Gastrointestinal	2	12.4	1.5-44.8
	Genitourinary	12	74.5	38.5-130.1
	Musculoskeletal	5	31.0	10.1-72.4
	Orofacial	1	6.2	0.2-34.6
Lawrence	**Total**	**69**	**246.8**	**192.0-312.3**
	Cardiovascular	32	114.4	78.3-161.6
	Central Nervous System	2	7.2	0.9-25.8
	Chromosomal	4	14.3	3.9-36.6
	Ear/Eye	1	3.6	0.1-19.9
	Gastrointestinal	2	7.2	0.9-25.8
	Genitourinary	20	71.5	43.7-110.5
	Musculoskeletal	4	14.3	3.9-36.6
	Orofacial	4	14.3	3.9-36.6
Lewis	**Total**	**18**	**283.9**	**168.3-448.7**
	Cardiovascular	8	126.2	54.5-248.6
	Central Nervous System	1	15.8	0.4-87.9
	Ear/Eye	1	15.8	0.4-87.9
	Gastrointestinal	1	15.8	0.4-87.9
	Genitourinary	6	94.6	34.7-206.0
	Musculoskeletal	1	15.8	0.4-87.9
Lincoln	**Total**	**38**	**211.0**	**149.3-289.6**
	Cardiovascular	14	77.7	42.5-130.4
	Central Nervous System	3	16.7	3.4-48.7
	Chromosomal	2	11.1	1.3-40.1
	Ear/Eye	2	11.1	1.3-40.1
	Gastrointestinal	2	11.1	1.3-40.1
	Genitourinary	10	55.5	26.6-102.1
	Musculoskeletal	5	27.8	9.0-64.8

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Loudon	**Total**	**101**	**379.4**	**305.4-453.4**
	Cardiovascular	54	202.9	152.4-264.7
	Central Nervous System	3	11.3	2.3-32.9
	Chromosomal	5	18.8	6.1-43.8
	Ear/Eye	1	3.8	0.1-20.9
	Gastrointestinal	8	30.1	13.0-59.2
	Genitourinary	19	71.4	43.0-111.5
	Musculoskeletal	8	30.1	13.0-59.2
	Orofacial	2	7.5	0.9-27.1
	Fetal Alcohol Syndrome	1	3.8	0.1-20.9
Macon	**Total**	**50**	**322.2**	**239.1-424.7**
	Cardiovascular	27	174.0	114.6-253.1
	Central Nervous System	3	19.3	4.0-56.5
	Chromosomal	2	12.9	1.6-46.6
	Ear/Eye	1	6.4	0.2-35.9
	Gastrointestinal	3	19.3	4.0-56.5
	Genitourinary	10	64.4	30.9-118.5
	Musculoskeletal	3	19.3	4.0-56.5
	Orofacial	1	6.4	0.2-35.9
Madison	**Total**	**298**	**463.5**	**410.9-516.2**
	Cardiovascular	219	340.6	295.5-385.8
	Central Nervous System	8	12.4	5.4-24.5
	Chromosomal	10	15.6	7.5-28.6
	Ear/Eye	1	1.6	0.0-8.7
	Gastrointestinal	8	12.4	5.4-24.5
	Genitourinary	31	48.2	32.8-68.4
	Musculoskeletal	16	24.9	14.2-40.4
	Orofacial	5	7.8	2.5-18.1
Marion	**Total**	**48**	**311.5**	**229.7-413.0**
	Cardiovascular	33	214.1	147.4-300.7
	Chromosomal	2	13.0	1.6-46.9
	Gastrointestinal	1	6.5	0.2-36.2
	Genitourinary	9	58.4	26.7-110.9
	Musculoskeletal	3	19.5	4.0-56.9

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Marshall	**Total**	**58**	**321.7**	**244.3-415.9**
	Cardiovascular	30	166.4	112.3-237.5
	Central Nervous System	4	22.2	6.0-56.8
	Chromosomal	2	11.1	1.3-40.1
	Ear/Eye	1	5.5	0.1-30.9
	Gastrointestinal	3	16.6	3.4-48.6
	Genitourinary	12	66.6	34.4-116.3
	Musculoskeletal	4	22.2	6.0-56.8
	Orofacial	2	11.1	1.3-40.1
Maury	**Total**	**200**	**362.1**	**311.9-412.2**
	Cardiovascular	114	206.4	168.5-244.3
	Central Nervous System	6	10.9	4.0-23.6
	Chromosomal	11	19.9	9.9-35.6
	Ear/Eye	2	3.6	0.4-13.1
	Gastrointestinal	4	7.2	2.0-18.5
	Genitourinary	44	79.7	57.9-106.9
	Musculoskeletal	11	19.9	9.9-35.6
	Orofacial	8	14.5	6.3-28.5
McMinn	**Total**	**95**	**334.9**	**270.9-409.3**
	Cardiovascular	62	218.5	167.6-280.2
	Central Nervous System	3	10.6	2.2-30.9
	Chromosomal	3	10.6	2.2-30.9
	Genitourinary	15	52.9	29.6-87.2
	Musculoskeletal	7	24.7	9.9-50.8
	Orofacial	5	17.6	5.7-41.1
McNairy	**Total**	**61**	**419.2**	**320.7-538.5**
	Cardiovascular	37	254.3	179.0-350.5
	Central Nervous System	2	13.7	1.7-49.7
	Chromosomal	3	20.6	4.3-60.3
	Gastrointestinal	4	27.5	7.5-70.4
	Genitourinary	12	82.5	42.6-144.1
	Musculoskeletal	2	13.7	1.7-49.7
	Orofacial	1	6.9	0.2-38.3
Meigs	**Total**	**14**	**236.5**	**129.3-396.8**
	Cardiovascular	6	101.4	37.2-220.6
	Gastrointestinal	2	33.8	4.1-122.0
	Genitourinary	4	67.6	18.4-173.0
	Musculoskeletal	2	33.8	4.1-122.0

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Monroe	**Total**	**108**	**435.5**	**353.4-517.6**
	Cardiovascular	66	266.1	205.8-338.6
	Central Nervous System	4	16.1	4.4-41.3
	Chromosomal	1	4.0	0.1-22.5
	Ear/Eye	1	4.0	0.1-22.5
	Gastrointestinal	5	20.2	6.5-47.0
	Genitourinary	16	64.5	36.9-104.8
	Musculoskeletal	9	36.3	16.6-68.9
	Orofacial	5	20.2	6.5-47.0
	Fetal Alcohol Syndrome	1	4.0	0.1-22.5
Montgomery	**Total**	**556**	**345.9**	**317.2-374.7**
	Cardiovascular	327	203.4	181.4-225.5
	Central Nervous System	19	11.8	7.1-18.5
	Chromosomal	27	16.8	11.1-24.4
	Ear/Eye	6	3.7	1.4-8.1
	Gastrointestinal	29	18.0	12.1-25.9
	Genitourinary	103	64.1	51.7-76.5
	Musculoskeletal	27	16.8	11.1-24.4
	Orofacial	18	11.2	6.6-17.7
Moore	**Total**	**4**	**161.3**	**43.9-413.0**
	Cardiovascular	2	80.6	9.8-291.3
	Musculoskeletal	2	80.6	9.8-291.3
Morgan	**Total**	**35**	**364.6**	**253.9-507.0**
	Cardiovascular	21	218.8	135.4-334.4
	Chromosomal	1	10.4	0.3-58.0
	Ear/Eye	1	10.4	0.3-58.0
	Gastrointestinal	1	10.4	0.3-58.0
	Genitourinary	8	83.3	36.0-164.2
	Musculoskeletal	1	10.4	0.3-58.0
	Orofacial	2	20.8	2.5-75.3
Obion	**Total**	**62**	**350.3**	**268.6-449.0**
	Cardiovascular	38	214.7	151.9-294.7
	Chromosomal	1	5.6	0.1-31.5
	Gastrointestinal	1	5.6	0.1-31.5
	Genitourinary	14	79.1	43.2-132.7
	Musculoskeletal	6	33.9	12.4-73.8
	Orofacial	2	11.3	1.4-40.8

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Overton	**Total**	**46**	**382.4**	**279.9-510.0**
	Cardiovascular	22	182.9	114.6-276.9
	Central Nervous System	1	8.3	0.2-46.3
	Chromosomal	2	16.6	2.0-60.1
	Gastrointestinal	1	8.3	0.2-46.3
	Genitourinary	12	99.8	51.5-174.2
	Musculoskeletal	4	33.3	9.1-85.1
	Orofacial	4	33.3	9.1-85.1
Perry	**Total**	**17**	**349.8**	**203.8-560.1**
	Cardiovascular	10	205.8	98.7-378.4
	Chromosomal	1	20.6	0.5-114.6
	Gastrointestinal	1	20.6	0.5-114.6
	Genitourinary	2	41.2	5.0-148.7
	Musculoskeletal	2	41.2	5.0-148.7
	Orofacial	1	20.6	0.5-114.6
Pickett	**Total**	**9**	**463.9**	**212.1-880.7**
	Cardiovascular	3	154.6	31.9-451.9
	Central Nervous System	1	51.5	1.3-287.2
	Gastrointestinal	1	51.5	1.3-287.2
	Genitourinary	3	154.6	31.9-451.9
	Orofacial	1	51.5	1.3-287.2
Polk	**Total**	**26**	**335.5**	**219.1-491.6**
	Cardiovascular	11	141.9	70.9-254.0
	Central nervous system	3	38.7	8.0-113.1
	Chromosomal	1	12.9	0.3-71.9
	Gastrointestinal	2	25.8	3.1-93.2
	Genitourinary	5	64.5	20.9-150.6
	Musculoskeletal	4	51.6	14.1-132.1
Putnam	**Total**	**129**	**286.4**	**237.0-335.8**
	Cardiovascular	69	153.2	119.2-193.9
	Central Nervous System	3	6.7	1.4-19.5
	Chromosomal	6	13.3	4.9-29.0
	Ear/Eye	2	4.4	0.5-16.0
	Gastrointestinal	1	2.2	0.1-12.4
	Genitourinary	25	55.5	35.9-81.9
	Musculoskeletal	14	31.1	17.0-52.2
	Orofacial	9	20.0	9.1-37.9

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Rhea	**Total**	**59**	**303.5**	**231.0-391.5**
	Cardiovascular	31	159.5	108.3-226.3
	Central Nervous System	2	10.3	1.2-37.2
	Chromosomal	4	20.6	5.6-52.7
	Ear/Eye	1	5.1	0.1-28.7
	Gastrointestinal	4	20.6	5.6-52.7
	Genitourinary	9	46.3	21.2-87.9
	Musculoskeletal	3	15.4	3.2-45.1
	Orofacial	5	25.7	8.4-60.0
Roane	**Total**	**109**	**443.6**	**360.3-526.9**
	Cardiovascular	67	272.7	211.3-346.3
	Central Nervous System	2	8.1	1.0-29.4
	Chromosomal	2	8.1	1.0-29.4
	Ear/Eye	3	12.2	2.5-35.7
	Gastrointestinal	5	20.4	6.6-47.5
	Genitourinary	16	65.1	37.2-105.8
	Musculoskeletal	7	28.5	11.5-58.7
	Orofacial	4	16.3	4.4-41.7
	Fetal Alcohol Syndrome	3	12.2	2.5-35.7
Robertson	**Total**	**147**	**321.0**	**269.1-372.8**
	Cardiovascular	86	187.8	150.2-231.9
	Central Nervous System	2	4.4	0.5-15.8
	Chromosomal	10	21.8	10.5-40.2
	Ear/Eye	4	8.7	2.4-22.4
	Gastrointestinal	6	13.1	4.8-28.5
	Genitourinary	28	61.1	40.6-88.4
	Musculoskeletal	3	6.6	1.4-19.1
	Orofacial	8	17.5	7.5-34.4
Rutherford	**Total**	**560**	**303.0**	**277.9-328.1**
	Cardiovascular	250	135.3	118.5-152.0
	Central Nervous System	21	11.4	7.0-17.4
	Chromosomal	38	20.6	14.5-28.2
	Ear/Eye	5	2.7	0.9-6.3
	Gastrointestinal	26	14.1	9.2-20.6
	Genitourinary	131	70.9	58.7-83.0
	Musculoskeletal	59	31.9	24.3-41.2
	Orofacial	26	14.1	9.2-20.6
	Fetal Alcohol Syndrome	4	2.2	0.6-5.5

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Scott	**Total**	**73**	**541.9**	**424.8-681.4**
	Cardiovascular	45	334.1	243.7-447.0
	Central Nervous System	4	29.7	8.1-76.0
	Chromosomal	5	37.1	12.1-86.6
	Ear/Eye	1	7.4	0.2-41.4
	Genitourinary	12	89.1	46.0-155.6
	Musculoskeletal	5	37.1	12.1-86.6
	Orofacial	1	7.4	0.2-41.4
Sequatchie	**Total**	**29**	**377.1**	**252.6-541.6**
	Cardiovascular	19	247.1	148.8-385.8
	Chromosomal	2	26.0	3.1-93.9
	Genitourinary	3	39.0	8.0-114.0
	Musculoskeletal	3	39.0	8.0-114.0
	Orofacial	2	26.0	3.1-93.9
Sevier	**Total**	**141**	**270.3**	**225.7-314.9**
	Cardiovascular	101	193.6	155.9-231.4
	Central Nervous System	3	5.8	1.2-16.8
	Chromosomal	4	7.7	2.1-19.6
	Gastrointestinal	3	5.8	1.2-16.8
	Genitourinary	16	30.7	17.5-49.8
	Musculoskeletal	8	15.3	6.6-30.2
	Orofacial	5	9.6	3.1-22.4
	Fetal Alcohol Syndrome	1	1.9	0.0-10.7
Shelby	**Total**	**3,086**	**441.9**	**426.3-457.5**
	Cardiovascular	2,089	299.1	286.3-311.9
	Central Nervous System	71	10.2	7.9-12.8
	Chromosomal	124	17.8	14.6-20.9
	Ear/Eye	28	4.0	2.7-5.8
	Gastrointestinal	88	12.6	10.1-15.5
	Genitourinary	426	61.0	55.2-66.8
	Musculoskeletal	170	24.3	20.7-28.0
	Orofacial	80	11.5	9.1-14.3
	Fetal Alcohol Syndrome	10	1.4	0.7-2.6
Smith	**Total**	**40**	**367.3**	**262.4-500.2**
	Cardiovascular	21	192.8	119.4-294.8
	Central Nervous System	2	18.4	2.2-66.3
	Chromosomal	2	18.4	2.2-66.3
	Gastrointestinal	4	36.7	10.0-94.0
	Genitourinary	5	45.9	14.9-107.1
	Musculoskeletal	5	45.9	14.9-107.1
	Orofacial	1	9.2	0.2-51.2

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Stewart	**Total**	**22**	**332.8**	**208.6-503.9**
	Cardiovascular	11	166.4	83.1-297.8
	Chromosomal	2	30.3	3.7-109.3
	Gastrointestinal	1	15.1	0.4-84.3
	Genitourinary	4	60.5	16.5-154.9
	Musculoskeletal	3	45.4	9.4-132.6
	Orofacial	1	15.1	0.4-84.3
Sullivan	**Total**	**372**	**470.5**	**422.7-518.3**
	Cardiovascular	242	306.1	267.5-344.7
	Central Nervous System	10	12.6	6.1-23.3
	Chromosomal	15	19.0	10.6-31.3
	Ear/Eye	3	3.8	0.8-11.1
	Gastrointestinal	11	13.9	6.9-24.9
	Genitourinary	47	59.4	43.7-79.1
	Musculoskeletal	27	34.2	22.5-49.7
	Orofacial	15	19.0	10.6-31.3
	Fetal Alcohol Syndrome	2	2.5	0.3-9.1
Sumner	**Total**	**321**	**330.1**	**294.0-366.2**
	Cardiovascular	169	173.8	147.6-200.0
	Central Nervous System	5	5.1	1.7-12.0
	Chromosomal	23	23.7	15.0-35.5
	Ear/Eye	2	2.1	0.2-7.4
	Gastrointestinal	13	13.4	7.1-22.9
	Genitourinary	69	71.0	55.2-89.8
	Musculoskeletal	27	27.8	18.3-40.4
	Orofacial	11	11.3	5.6-20.2
	Fetal Alcohol Syndrome	2	2.1	0.2-7.4
Tipton	**Total**	**127**	**334.1**	**276.0-392.2**
	Cardiovascular	85	223.6	178.6-276.5
	Central Nervous System	2	5.3	0.6-19.0
	Chromosomal	6	15.8	5.8-34.4
	Gastrointestinal	2	5.3	0.6-19.0
	Genitourinary	24	63.1	40.5-93.9
	Musculoskeletal	5	13.2	4.3-30.7
	Orofacial	3	7.9	1.6-23.1
Trousdale	**Total**	**11**	**243.4**	**121.5-435.4**
	Cardiovascular	5	110.6	35.9-258.1
	Gastrointestinal	2	44.2	5.4-159.8
	Genitourinary	3	66.4	13.7-194.0
	Musculoskeletal	1	22.1	0.6-123.3

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Unicoi	**Total**	**65**	**793.7**	**612.5-1012**
	Cardiovascular	48	586.1	432.1-777.1
	Central Nervous System	1	12.2	0.3-68.0
	Chromosomal	1	12.2	0.3-68.0
	Ear/Eye	3	36.6	7.6-107.0
	Gastrointestinal	3	36.6	7.6-107.0
	Genitourinary	3	36.6	7.6-107.0
	Musculoskeletal	5	61.1	19.8-142.5
	Orofacial	1	12.2	0.3-68.0
Union	**Total**	**54**	**498.2**	**374.2-650.0**
	Cardiovascular	30	276.8	186.7-395.1
	Central Nervous System	3	27.7	5.7-80.9
	Ear/Eye	2	18.5	2.2-66.6
	Gastrointestinal	1	9.2	0.2-51.4
	Genitourinary	7	64.6	26.0-133.1
	Musculoskeletal	7	64.6	26.0-133.1
	Orofacial	4	36.9	10.1-94.5
Van Buren	**Total**	**15**	**541.5**	**303.1-893.1**
	Cardiovascular	9	324.9	148.6-616.8
	Gastrointestinal	1	36.1	0.9-201.1
	Genitourinary	2	72.2	8.7-260.8
	Musculoskeletal	2	72.2	8.7-260.8
	Orofacial	1	36.1	0.9-201.1
Warren	**Total**	**75**	**309.9**	**243.8-388.5**
	Cardiovascular	41	169.4	121.6-229.8
	Central Nervous System	2	8.3	1.0-29.9
	Chromosomal	5	20.7	6.7-48.2
	Gastrointestinal	3	12.4	2.6-36.2
	Genitourinary	9	37.2	17.0-70.6
	Musculoskeletal	10	41.3	19.8-76.0
	Orofacial	4	16.5	4.5-42.3
	Fetal Alcohol Syndrome	1	4.1	0.1-23.0

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Washington	**Total**	**297**	**441.6**	**391.4-491.9**
	Cardiovascular	204	303.3	261.7-345.0
	Central Nervous System	4	5.9	1.6-15.2
	Chromosomal	11	16.4	8.2-29.3
	Ear/Eye	7	10.4	4.2-21.4
	Gastrointestinal	8	11.9	5.1-23.4
	Genitourinary	36	53.5	37.5-74.1
	Musculoskeletal	10	14.9	7.1-27.3
	Orofacial	16	23.8	13.6-38.6
	Fetal Alcohol Syndrome	1	1.5	0.0-8.3
Wayne	**Total**	**27**	**371.9**	**245.1-541.1**
	Cardiovascular	12	165.3	85.4-288.7
	Central Nervous System	2	27.5	3.3-99.5
	Chromosomal	1	13.8	0.3-76.7
	Gastrointestinal	1	13.8	0.3-76.7
	Genitourinary	6	82.6	30.3-179.9
	Musculoskeletal	4	55.1	15.0-141.1
	Orofacial	1	13.8	0.3-76.7
Weakley	**Total**	**65**	**352.7**	**272.2-449.5**
	Cardiovascular	41	222.5	159.6-301.8
	Central Nervous System	2	10.9	1.3-39.2
	Chromosomal	3	16.3	3.4-47.6
	Gastrointestinal	2	10.9	1.3-39.2
	Genitourinary	10	54.3	26.0-99.8
	Musculoskeletal	2	10.9	1.3-39.2
	Orofacial	5	27.1	8.8-63.3
White	**Total**	**51**	**349.3**	**260.1-459.3**
	Cardiovascular	19	130.1	78.4-203.2
	Central Nervous System	1	6.8	0.2-38.2
	Chromosomal	4	27.4	7.5-70.1
	Ear/Eye	1	6.8	0.2-38.2
	Gastrointestinal	4	27.4	7.5-70.1
	Genitourinary	13	89.0	47.4-152.3
	Musculoskeletal	3	20.5	4.2-60.0
	Orofacial	6	41.1	15.1-89.4

County	Birth Defects by Organ System	Count[1]	Rate[2]	95%CI[3]
Williamson	**Total**	**334**	**331.4**	**295.8-366.9**
	Cardiovascular	187	185.5	158.9-212.1
	Central Nervous System	12	11.9	6.2-20.8
	Chromosomal	19	18.9	11.3-29.4
	Ear/Eye	4	4.0	1.1-10.2
	Gastrointestinal	11	10.9	5.4-19.5
	Genitourinary	73	72.4	56.8-91.1
	Musculoskeletal	17	16.9	9.8-27.0
	Orofacial	11	10.9	5.4-19.5
Wilson	**Total**	**179**	**265.5**	**226.6-304.4**
	Cardiovascular	84	124.6	99.4-154.3
	Central Nervous System	2	3.0	0.4-10.7
	Chromosomal	8	11.9	5.1-23.4
	Ear/Eye	4	5.9	1.6-15.2
	Gastrointestinal	8	11.9	5.1-23.4
	Genitourinary	47	69.7	51.2-92.7
	Musculoskeletal	15	22.2	12.5-36.7
	Orofacial	9	13.3	6.1-25.3
	Fetal Alcohol Syndrome	2	3.0	0.4-10.7

Source: Tennessee Department of Health, Division of Policy, Planning and Assessment, Tennessee Birth Defect Registry 2009-2013.

[1]Counts include cases resulting from live births and fetal deaths.

[2]Rates were computed per 10,000 live births.

[3]Confidence intervals for 100 or less cases are exact Poisson; otherwise confidence intervals are based on the normal approximation.

Diagnostic data were derived from the Tennessee Hospital Discharge Data System (2009-2014), the Tennessee Death Statistical System (2009-2014) and the Tennessee Fetal Death Statistical System (2009-2013).

Total live births were derived from the Tennessee Birth Statistical System (2009-2013).

Note: Not all defects are observed in each county. A missing organ system in the list of a particular county means that no case of defect of that organ system where diagnosed and/or the mother's Tennessee residency status confirmed.
Fifteen defect lack county information, and are not included in the grouping.

Risk Factors and Prevention

Although the causal mechanisms of most birth defects are not fully understood, there are known risk factors that increase the likelihood of giving birth to a baby with a birth defect. Drinking alcohol and smoking cigarettes during pregnancy are associated with increased risk of having a baby born with a birth defect. Babies born to mothers who smoke cigarettes are more likely to be born premature and low birth weight. They are also more likely to be born with cardiovascular, orofacial, gastrointestinal, and musculoskeletal birth

defects. There is no amount of alcohol that is safe to drink during pregnancy. When a pregnant woman drinks, the alcohol in her system passes from mother to baby through the placenta and umbilical cord. Drinking can also cause fetal alcohol syndrome, which is a serious condition involving growth deficiencies, facial abnormalities, central nervous system impairment, and intellectual disabilities.

Diabetes is a chronic disease affecting an increasing number of mothers. Babies born to mothers with type I and type II diabetes are more likely to be born with central nervous system, ear/eye, gastrointestinal, genitourinary, musculoskeletal, orofacial, and, and cardiovascular birth defects.

Some infections that a woman can get during pregnancy can be harmful to the developing baby and can even cause birth defects. Women who develop rubella during pregnancy risk affecting the fetus and their baby being born with congenital rubella syndrome which affects the ear/eye and cardiovascular systems. Toxoplasmosis is caused by the parasite, Toxoplasma gondii. Babies born to women with a toxoplasmosis infection are at risk for hydrocephalus which affects the central nervous system.

Although not all birth defects can be prevented, avoiding the known risk factors could help to reduce one's risk of having a baby with a birth defect. 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 is before a woman becomes pregnant. Most of the baby's vital organ and systems are formed in the first four to eight weeks of gestation, often before a woman knows she is pregnant. The majority of birth defects occur in this same period, and there are a number of actions a woman can take to improve her baby's health. However many of these actions are only effective if begun prior to pregnancy.

Folic Acid is a B-complex vitamin that is proven to be protective against neural tube defects such as anencephalus and spina bifida which are defects of the central nervous system. It may also provide protection against other birth defects. To be fully effective a woman needs to begin taking the recommended daily dose of 400 micrograms at least a full month before becoming pregnant and continue to take folic acid daily during pregnancy. If a woman finds she is pregnant and has not been taking folic acid, it is best to start taking folic acid immediately and continue to do so thereafter. Folic acid is available in most multivitamins and is sold separately in folic acid tablets.

A woman should be sure to see her medical provider when planning a pregnancy and start prenatal care as soon as she thinks that she is pregnant. A pregnant woman should keep chronic diseases (like diabetes) under control, avoid drinking alcohol, avoid smoking cigarettes and prevent infections. Some easy steps to prevent infections include frequent hand-washing, cooking meat until its well done, and staying away from people who have an infection. Another way to prevent infections is to have the right vaccinations at the right time, for example, Rubella and Influenza vaccines prior to pregnancy.

While there are still certain hereditary and genetic factors that cannot be reduced, there are many factors that public health, new mothers-to-be and health care providers can address together to assist in reducing birth defect occurrences in infants born in Tennessee.

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.	**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.
Coarctation of the aorta	Localized narrowing of the aorta. This condition can vary from mild to severe.	**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, and small ear canals, flat-bridge of the nose and short fingers and toes. Many infants have congenital heart disease.
Common truncus arteriosus	A congenital heart defect in which the common arterial trunk fails to divide into pulmonary artery and aorta.	**Dysgenesis**	Anomalous or disorganized formation of an organ.
Confidence Interval (95%)	The interval that contains the true prevalence (which can only be estimated) 95% of the time.	**Dysplasia**	Disorganized cell structure or arrangement within a tissue or organ.
Congenital	Existing at or dating from birth although the defect may not be recognized at the time of birth..	**Ebstein anomaly**	A congenital heart defect in which the tricuspid valve is displaced downward into the right ventricle.
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).	***Edwards syndrome***	See Trisomy 18.

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

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 350 grams or more, or, in absence of weight, of 20 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 organ 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 of 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.
Intellectual disabilities	A condition of below average intellectual ability (IQ less than 70) that is present from birth or infancy.
Live birth	The complete expulsion or extraction from its mother or a product of human conceptions, irrespective of the duration of the pregnancy, that, after expulsion or extraction, breathless or shows any other evidence of life, such as beating of the heart, pulsation of the umbilical cord, or definite movement of voluntary muscles, whether or not the umbilical cord has been cut or the placenta is attached (TCA 8-3-102).

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.
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 anomalies	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.	**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.
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.	**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.
Postnatal	After delivery.	**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.
Postterm infant	An infant born after 42 completed weeks of gestation.	**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.
Prenatal	Before delivery.	**Renal agenesis or dysgenesis**	The failure, or deviation, of embryonic development of the kidney.
Preterm infant	An infant born before 37 completed weeks of gestation.	**Spina bifida**	An incomplete closure of the vertebral spine (usually posterior) through which spinal cord tissue or membranes (meninges) covering the spine herniate.
Pulmonary artery anomaly	Abnormality in the formation of the pulmonary artery such as stenosis or atresia.	**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 completed weeks and before 42 completed weeks of gestation.
Tetralogy of Fallot	The simultaneous presence of a ventricular septal defect, pulmonic stenosis, a malposition 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, the condition 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 (the condition of having more than 5 fingers or toes on each limb) and severe intellectual disabilities. 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 intellectual disabilities, 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.