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Population-based birth defects data in the United States, 2010–2014: A focus on gastrointestinal defects

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Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Supporting Information: Additional Supporting Information may be found online in the supporting information tab for this article. This includes the state-specific birth defects data and surveillance program directory.

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Abstract

Background—Gastrointestinal defects are a phenotypically and etiologically diverse group of malformations. Despite their combined prevalence and clinical impact, little is known about the epidemiology of these birth defects. Therefore, the objective of the 2017 National Birth Defects Prevention Network (NBDPN) data brief was to better describe the occurrence of gastrointestinal defects.

Methods—As part of the 2017 NBDPN annual report, 28 state programs provided additional data on gastrointestinal defects for the period 2010-2014. Counts and prevalence estimates (per 10,000 live births) were calculated overall and by demographic characteristics for (1) biliary atresia; (2) esophageal atresia/tracheoesophageal fistula; (3) rectal and large intestinal atresia/stenosis; and (4) small intestinal atresia/stenosis. Additionally, we explored the frequency of these malformations co-occurring with other structural birth defects.

Results—Pooling data from all participating registries, the prevalence estimates were: 0.7 per 10,000 live births for biliary atresia (713 cases); 2.3 per 10,000 live births for esophageal atresia/tracheoesophageal fistula (2,472 cases); 4.2 per 10,000 live births for rectal and large intestinal atresia/stenosis (4,334 cases); and 3.4 per 10,000 live births for small intestinal atresia/stenosis (3,388 cases). Findings related to co-occurring birth defects were especially notable for esophageal atresia/tracheoesophageal fistula, rectal and large intestinal atresia/stenosis, and small intestinal atresia/stenosis, where the median percentage of non-isolated cases was 53.9%, 45.5%, and 50.6%, respectively.

Conclusions—These population-based prevalence estimates confirm some previous studies, and provide a foundation for future epidemiologic studies of gastrointestinal defects. Exploring the genetic and environmental determinants of these malformations may yield new clues into their etiologies.

1. Introduction

To advance the field of birth defects surveillance and epidemiology, the National Birth Defects Prevention Network (NBDPN) began publishing state-level data on major structural birth defects with the first Congenital Malformations Surveillance report in 1997. Subsequently, annual publication of data on selected major defects began in 2000 with the list of requested defects remaining relatively unchanged until the 16th annual report of the NBDPN when there was a major revision of the list (Mai et al., 2014). The 2017 annual report is composed of three parts: (1) a data brief highlighting four gastrointestinal defects; (2) birth defects counts and prevalence estimates from 43 population-based birth defects surveillance systems in the United States (U.S.), reporting on up to 47 major birth defects enumerated in Table 1; and (3) a directory providing information on participating state birth defects surveillance programs including their case definition, surveillance methodology, sources of birth defects information, data collection procedures, and program contacts.

2. State-Specific Data Collection and Presentation of 47 Major Birth Defects

2.1. Data collection

In spring of 2017, the NBDPN Data Committee, in collaboration with the Centers for Disease Control and Prevention (CDC), updated the annual request for data, including the selection of a data brief topic on a subject matter of clinical and public health importance. The call for data was distributed to state-based birth defects surveillance programs in April 2017 and included a data dictionary, Microsoft Excel data collection tools, a SAS programming template with recommended data management procedures, and a fillable-PDF form used for collecting the directory information. Data on birth defects as well as descriptive program information were collected and validated by CDC staff. CDC prepared the directory and data tables for publication and sent them back to the population-based surveillance programs submitting data to provide final approval of their state's information.

The data collected from the state-based surveillance programs included the number of cases of each of the major structural birth defects on the NBDPN list (Table 1) by year of birth, beginning with January 1, 2010 and ending with December 31, 2014, and by maternal and infant variables of interest. For all states, birth defect counts were provided by maternal race/ethnicity, which was stratified into the U.S. Census groups: non-Hispanic white, non-Hispanic black, Hispanic, non-Hispanic Asian/Pacific Islander, non-Hispanic American Indian/Alaska Native, and other/unknown. For systems providing data in SAS, data for all submitted defects was also stratified by the following maternal age groups: less than 20 years, 20–24 years, 25–29 years, 30–34 years, 35–39 years, 40 or more years of age, and “unknown.” For surveillance programs providing data in Excel, only counts of the three trisomy conditions (trisomy 13, 18, and 21) and gastroschisis were reported by the seven maternal age categories mentioned above. Additionally, surveillance systems that reported data in SAS provided counts for all of the requested defects stratified by infant sex. Last, all states submitted counts of live births for the same 5-year period, stratified by each of the previously listed maternal and infant characteristics.

2.2. Data presentation

Data for the years 2010-2014 are presented in two separate tables for each of the 43 state surveillance programs (supplement). The first table displays counts and prevalence (per 10,000 live births) by maternal racial/ethnic groups for the 47 major birth defects on the NBDPN surveillance list. The second table presents counts and prevalence by two maternal age categories (<35 years, ≥35 years) but is limited to trisomies 13, 18, 21, and gastroschisis. For all defects, except hypospadias and Turner syndrome, prevalence is calculated as the count of birth defects cases within each stratum of a maternal or infant characteristic—regardless of pregnancy outcome (i.e., live birth, stillbirths, spontaneous/elective termination)—divided by the total number of live births within the same stratum, and then multiplied by 10,000 (Mason, Kirby, Sever, & Langlois, 2005). For hypospadias, the denominator is restricted to male live births and for Turner syndrome the denominator is restricted to female live births.

Although data are collected as uniformly as possible, variation by state is to be expected. To that end, each table is accompanied by footnotes that describe variations in case inclusion, whether caused by differences in data sources, coding system(s) used, or case ascertainment methodology. More in-depth information on each state's data collection methods and the potential sources of variation between state surveillance systems can be found within the supplement's program directory.

3. Focus: Gastrointestinal Defects

In addition to submitting data for the 47 NBDPN reportable birth defects, 28 state programs provided additional data on gastrointestinal defects. Gastrointestinal defects are a phenotypically and etiologically diverse group of malformations which were categorized as: (1) biliary atresia; (2) esophageal atresia/tracheoesophageal fistula; (3) rectal and large intestinal atresia/stenosis; and (4) small intestinal atresia/stenosis (Table 1). Collectively, these defects occur in approximately 10 per 10,000 births (Harris, Källen, & Robert, 1995); however, the birth prevalence varies by defect subtype.

Biliary atresia is the least common of these gastrointestinal defects and is characterized by inflammation and obliteration of the extrahepatic and intrahepatic bile ducts (Lee, Lewis, Schoen, Brand, & Ricketts, 2001; Sanchez-Valle et al., 2017; Sundaram, Mack, Feldman, & Sokol, 2017). While it is relatively rare with an estimated birth prevalence of 0.7 to 0.9 per 10,000 births (Caton, Druschel, & McNutt, 2004; Jimenez-Rivera, Jolin-Dahel, Fortinsky, Gozdyra, & Benchimol, 2013; Yoon, Bresee, Olney, James, & Khoury, 1997), biliary atresia is the most common cause of extrahepatic obstructive jaundice in the newborn and is the most frequent indication for liver transplantation in children (Sundaram et al., 2017; Yoon et al., 1997). Esophageal atresia and tracheoesophageal fistula are the most common major structural birth defects affecting the esophagus and the trachea. These birth defects frequently occur together (Forrester & Merz, 2004) and have an estimated birth prevalence ranging from 2.1 to 2.8 per 10,000 births (Harris et al., 1995; Torfs, Curry, & Bateson, 1995). Among gastrointestinal defects, rectal and large intestinal atresia/stenosis are considered to be the most frequent with a birth prevalence of approximately 4 per 10,000 births (Cuschieri, 2001, 2002). Finally, small intestinal atresia/stenosis is a gastrointestinal defect characterized by the abnormal closure, discontinuity, or narrowing of the duodenum, jejunum, or ileum. While there have been few studies evaluating the birth prevalence of small intestinal atresia/stenosis, it is estimated that these malformations occur in 1.6 to 2.9 per 10,000 births (Best et al., 2012; Cragan, Martin, Moore, & Khoury, 1993; Takahashi, Hiroma, Takamizawa, & Nakamura, 2014).

Like other birth defects, gastrointestinal defects are often classified based on the presence (nonisolated) or absence (isolated) of other major malformations. Among the gastrointestinal defects evaluated here, biliary atresia is most likely to occur in isolation. Approximately 15–30% of biliary atresia cases co-occur with other birth defects (Caton et al., 2004; Schwarz et al., 2013). In contrast, a majority of cases with esophageal atresia/tracheoesophageal fistula or rectal and large intestinal atresia/stenosis have multiple major malformations (Cuschieri, 2001, 2002; Forrester & Merz, 2004; Scott, 2014; Shaw-Smith, 2006). In fact, these defects are often part of multiple malformation syndromes, sequences, and other nonrandom birth

defect associations like VACTERL (vertebral, anal, cardiac, tracheo-esophageal, renal, limb) association (Cuschieri, 2001, 2002; Forrester & Merz, 2004; Scott, 2014; Shaw-Smith, 2006).

Gastrointestinal defects are also known to occur more often than expected in the presence of chromosomal anomalies. For example, trisomies 13, 18, and 21 have been reported in children with esophageal atresia/tracheoesophageal fistula (Felix, Tibboel, & de Klein, 2007). Additionally, a European Surveillance of Congenital Anomalies (EUROCAT) report found that 20% of small intestinal atresia cases were associated with a chromosomal anomaly (Best et al., 2012). However, these estimates have not been confirmed in other contemporary populations.

Despite their combined prevalence and clinical impact, little is known about the epidemiology of gastrointestinal defects. Few large-scale population-based studies have investigated the prevalence of these malformations. Additionally, while a few studies have identified differences in birth prevalence by maternal race/ethnicity, maternal age, and infant sex (Best et al., 2012; Caton et al., 2004; Cragan et al., 1993; Cuschieri, 2001; Forrester & Merz, 2004; Torfs et al., 1995; Yoon et al., 1997), (1) most of these studies examine cohorts from the 1990s or earlier, and (2) many of these associations have yet to be confirmed. Therefore, we examined the birth prevalence of biliary atresia, esophageal atresia/tracheoesophageal fistula, rectal and large intestinal atresia/stenosis, and small intestinal atresia/stenosis using 2010–2014 population-based data submitted to the NBDPN.

4. Gastrointestinal Defects Results and Discussion

4.1. Overall prevalence

Pooling data from all participating registries (Table 2), the prevalence estimates were: 0.7 per 10,000 live births for biliary atresia (713 cases); 2.3 per 10,000 live births for esophageal atresia/tracheoesophageal fistula (2,472 cases); 4.2 per 10,000 live births for rectal and large intestinal atresia/stenosis (4,334 cases); and 3.4 per 10,000 live births for small intestinal atresia/stenosis (3,388 cases). While these prevalence estimates are generally consistent with previous assessments (Caton et al., 2004; Cuschieri, 2001, 2002; Harris et al., 1995; Mai et al., 2014; Torfs et al., 1995; Yoon et al., 1997), the birth prevalence was higher for small intestinal atresia/stenosis than reported in the Metropolitan Atlanta Congenital Defects Program (MACDP) for the years 1968–1989 (2.8 per 10,000 in MACDP versus 3.4 per 10,000 in NBDPN) (Cragan et al., 1993). Lower birth prevalence estimates for small intestinal atresia/stenosis have also been reported in other population-based surveillance systems (Best et al., 2012; Takahashi et al., 2014).

4.2. Case ascertainment methodology and pregnancy outcome inclusion

Table 2 also provides prevalence estimates stratified by case-finding ascertainment methodology (active versus passive ascertainment), pregnancy outcome inclusion (live births, live births and stillbirths, and all pregnancy outcomes combined), maternal race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, non-Hispanic Asian/Pacific Islander, and non-Hispanic American Indian/Alaska Native), maternal age (<20, 20–24, 25–

29, 30–34, 35–39, ≥40 years), and infant sex (male or female). For maternal race/ethnicity, maternal age, and infant sex, “other” and/or “unknown” estimates are not presented, but represent less than 6% of total cases. While prevalence estimates for biliary atresia and esophageal atresia/tracheoesophageal fistula were consistent by case-finding ascertainment methodology, there were differences for rectal and large intestinal atresia/stenosis (4.7 per 10,000 for active versus 3.9 per 10,000 for passive) and small intestinal atresia/stenosis (3.1 per 10,000 for active versus 3.6 per 10,000 for passive). Differences were also observed for state “pregnancy outcome inclusion” status, with the largest difference between prevalence estimates for rectal and large intestinal atresia/stenosis in states that ascertain cases among live births only (3.7 per 10,000) compared to states that ascertain cases across all pregnancy outcomes (4.9 per 10,000).

4.3. Maternal race/ethnicity

Variations in birth prevalence were observed for the gastrointestinal defects by racial/ethnic groups; however, many categories had overlapping confidence intervals. When considering differences in birth prevalence by maternal race/ ethnicity, non-Hispanic whites had the lowest prevalence of biliary atresia (0.5 per 10,000 live births) and the highest prevalence of esophageal atresia/tracheoesophageal fistula (2.5 per 10,000 live births). This is consistent with previous reports that suggest certain racial/ethnic groups (e.g., non-Hispanic blacks) are more likely to be diagnosed with biliary atresia compared to non-Hispanic whites (Caton et al., 2004), whereas non-Hispanic whites were more likely to develop esophageal atresia/ tracheoesophageal fistula when compared to other racial/ethnic groups (Carmichael, Shaw, & Kaidarova, 2004; Forrester & Merz, 2005). Hispanics and non-Hispanic American Indians/Alaska Natives had the highest birth prevalence of rectal and large intestinal atresia/ stenosis (4.7 and 5.2 per 10,000 live births, respectively), which has not been reported previously. Finally, non-Hispanic blacks and Hispanics had the highest birth prevalence of small intestinal atresia/stenosis (3.7 and 3.6 per 10,000 live births, respectively). Cragan et al. (1993) also reported higher prevalence among blacks when compared to whites.

4.4. Maternal ages

While the birth prevalence of each gastrointestinal defect was highest among mothers who were ≥40 years of age, there was not a consistent trend in which increasing maternal age was associated with higher prevalence of gastrointestinal defects. In fact, the evidence of an association between advanced maternal age and increased risk of gastrointestinal defects is equivocal and varies by specific malformation. For instance, the birth prevalence of esophageal atresia/tracheoesophageal fistula was highest among mothers who were ≥40 years of age (4.9 per 10,000 live births), which is consistent with data from the National Birth Defects Prevention Study (NBDPS) (Gill et al., 2012), but was not seen in data from Poland (Materna-Kiryluk et al., 2009). Additionally, some reports indicate younger mothers are more likely to have children with rectal and large intestinal atresia/stenosis (Francannet & Robert, 1996), while others report a U-shaped relationship between maternal age and risk of small intestinal atresia/stenosis (Forrester & Merz, 2004).

4.5. Infant sex

Differences in the sex ratio for biliary atresia (0.6 per 10,000 in males versus 0.7 per 10,000 in females) and small intestinal atresia/stenosis (3.3 per 10,000 in males versus 3.5 per 10,000 in females) were unremarkable. The largest sex disparity was for rectal and large intestinal atresia/stenosis (4.6 per 10,000 in males versus 3.8 per 10,000 in females), which has been reported previously (Cuschieri, 2001, 2002; Harris et al., 1995; Hay, 1971).

4.6. Co-occurring birth defects and chromosomal anomalies

A striking feature of gastrointestinal defects is the likelihood of these malformations co-occurring with other major structural birth defects. These birth defects can be: (1) with no apparent developmental relation to the gastrointestinal defect such as esophageal atresia and limb malformations, even if they frequently occur together; or (2) with apparent relation to the gastrointestinal defect such as intestinal atresia and gastroschisis. For each of the gastrointestinal defects, surveillance programs submitted aggregate counts of cases with (1) any co-occurring structural malformation on the NBDPN list (Supporting Information Appendix 1), (2) any co-occurring chromosomal defect on the NBDPN list, (3) co-occurring trisomy 21, and (4) co-occurring gastroschisis. Findings related to co-occurring birth defects were especially notable for esophageal atresia/tracheoesophageal fistula, rectal and large intestinal atresia/stenosis, and small intestinal atresia/ stenosis, where the median percentage of nonisolated cases was 53.9%, 45.5%, and 50.6%, respectively (Table 3). When considering the interquartile range (IQR) for these estimates, our findings are consistent with those reported previously (Best et al., 2012; Cragan et al., 1993; Cuschieri, 2001, 2002; Forrester & Merz, 2005; Torfs et al., 1995). Notably, esophageal atresia/tracheoesophageal fistula, as well as rectal and large intestinal atresia/stenosis, are often part of VACTERL association (Cuschieri, 2001, 2002; Forrester & Merz, 2004; Scott, 2014; Shaw-Smith, 2006). While it is estimated that approximately 15% of children with esophageal atresia/tracheoesophageal fistula or rectal and large intestinal atresia/stenosis also have VACTERL association (Cuschieri, 2002; Forrester & Merz, 2006), it is not possible to determine that in this report, as states do not provide individual-level data on co-occurring birth defects. The median prevalence of co-occurring birth defects is lowest among children with biliary atresia (23.4%, IQR 14.3–36.4%), which is also consistent with the few population-based or multicenter reports exploring this question (Caton et al., 2004; Schwarz et al., 2013). When evaluating the prevalence of co-occurring birth defects, it should be noted that there was variability in case ascertainment methodology and pregnancy outcome inclusion (see Supporting Information Appendices 2a–2b and a more detailed description of a similar figure in Mai et al., 2015). Finally, despite well-established associations, the genetic and/or environmental factors that lead to multiple congenital anomalies that include gastrointestinal defects have yet to be discovered. Exploring the genetic and environmental determinants of multiple co-occurring structural birth defects may yield new clues into their etiologies.

Several previous reports also explored the co-occurrence of chromosomal anomalies among children with gastrointestinal defects (Best et al., 2012; Brosens et al., 2014; Felix et al., 2007; Harris et al., 1995; Hemming & Rankin, 2007; Shaw-Smith, 2006; Takahashi et al., 2014; Torfs et al., 1995). Table 3 also includes the median of the state prevalence estimates of more common chromosomal anomalies (i.e., trisomies 13, 18, and 21, Turner syndrome,

and 22q11.2 deletion syndrome) by gastrointestinal defect. When focusing on trisomy 21, we observed the lowest median prevalence among those with biliary atresia (0.0%, IQR 0.0–0.8%), which has been previously reported (Caton et al., 2004). At the other end of the spectrum, the defect with the highest median prevalence of co-occurring trisomy 21 was small intestinal atresia/stenosis (15.2%, IQR 11.47–18.6%), which is also consistent with previous reports (Best et al., 2012; Cragan et al., 1993; Forrester & Merz, 2004; Takahashi et al., 2014).

Because of the well-established association between trisomy 21 and small intestinal atresia/stenosis (Best et al., 2012; Cragan et al., 1993; Forrester & Merz, 2004; Takahashi et al., 2014), as well as the relatively high prevalence of this chromosomal anomaly among those with small intestinal atresia/stenosis, we explored differences in several demographic characteristics among those with small intestinal atresia/stenosis by presence of trisomy 21 (Table 4). There were significant differences ($p < .05$) in the distributions of maternal race/ethnicity, maternal age, and infant sex by the presence of trisomy 21. Among mothers of small intestinal atresia/stenosis cases with trisomy 21, compared to those without trisomy 21, respectively, 55.5% and 51.7% were white and 25.1% and 2.8% were ≥40 years of age. Finally, there was a higher proportion of male infants with trisomy 21 compared to those without trisomy 21 (53.6% versus 48.6%). To our knowledge, these differences have not been reported previously. This may be informative for future studies evaluating differences in the etiologies between cases of small intestinal atresia/stenosis with and without trisomy 21.

5. Conclusion

The 2017 NBDPN Congenital Malformations Surveillance Report, which includes data from 43 population-based surveillance programs, continues to provide unique and important information to aid in the understanding of the occurrence and public health importance of birth defects in the United States. The focus on gastrointestinal defects in the present report, using pooled surveillance data from 28 states, is intended to provide more detailed information on the occurrence of these serious birth defects. Additionally, the population-based prevalence estimates (overall and by selected characteristics) of biliary atresia, esophageal atresia/tracheoesophageal fistula, rectal and large intestinal atresia/stenosis, and small intestinal atresia/stenosis may provide a foundation for future epidemiologic studies of these particular malformations. The ultimate goal of this work is to guide clinicians, scientists, and public health officials concerned with treatment strategies, research priorities, and prevention efforts for children with gastrointestinal defects.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Birth Defects for the National Birth Defects Prevention Network (NBDPN) Annual Report by Disease Classification Codes

Birth defects	Disease classification codes	
	International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)	Centers for Disease Control and Prevention/ British Pediatric Association Classification of Diseases (CDC/BPA)
Central nervous system		
Anencephaly	740.0–740.1	740.00–740.10
Encephalocele	742.0	742.00–742.09
Holoprosencephaly	742.2	742.26
Spina bifida without anencephaly	741.0, 741.9 without 740.0–740.1	741.00–741.99 without 740.00–740.10
Eye		
Anophthalmia/microphthalmia	743.0, 743.1	743.00–743.10
Congenital cataract	743.30–743.34	743.32
Ear		
Anotia/microtia	744.01, 744.23	744.01, 744.21
Cardiovascular		
Aortic valve stenosis	746.3	746.30
Atrial septal defect	745.5	745.51–745.59
Atrioventricular septal defect (endocardial cushion defect)	745.60, .61, .69	745.60–745.69, 745.487
Coarctation of aorta	747.10	747.10–747.19
Common truncus (truncus arteriosus or TA)	745.0	745.00 (excluding 745.01)
Double outlet right ventricle (DORV)	745.11	745.13–745.15
Ebstein anomaly	746.2	746.20
Hypoplastic left heart syndrome	746.7	746.70
Interrupted aortic arch (IAA)	747.11	747.215–747.217, 747.285
Pulmonary valve atresia and stenosis	746.01, 746.02	746.00, 746.01
Pulmonary valve atresia – for CCHD screening	746.01	746.00
Single ventricle	745.3	745.3
Tetralogy of Fallot (TOF)	745.2	745.20–745.21, 747.31
Transposition of the great arteries (TGA)	745.10, .12, .19	745.10–745.12, 745.18–745.19
Dextro-Transposition of great arteries (d-TGA) – for CCHD screening	745.10	745.10, 745.11, 745.18, 745.19
Total anomalous pulmonary venous connection (TAPVC)	747.41	747.42
Tricuspid valve atresia and stenosis	746.1	746.100, 746.106 (excluding 746.105)
Tricuspid valve atresia– for CCHD screening	746.1	746.100
Ventricular septal defect	745.4	745.40–745.49 (excluding 745.487, 745.498)
Orofacial		

Birth defects	Disease classification codes	
	International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)	Centers for Disease Control and Prevention/ British Pediatric Association Classification of Diseases (CDC/BPA)
Choanal atresia	748.0	748.00
Cleft lip alone (without cleft palate)	749.1	749.10–749.19
Cleft lip with cleft palate	749.20–749.25	749.20–749.29
Cleft palate alone (without cleft lip)	749.0	749.00–749.09
Gastrointestinal		
Biliary atresia	751.61	751.65
Esophageal atresia/tracheoesophageal fistula	750.3	750.30–750.35
Rectal and large intestinal atresia/stenosis	751.2	751.20–751.24
Small intestinal atresia/stenosis	751.1	751.10–751.19
Genitourinary		
Bladder exstrophy	753.5	753.50
Cloacal exstrophy	751.5	751.555
Congenital posterior urethral valves	753.6	753.60
Hypospadias	752.61	752.60–752.62 (excluding 752.61 and 752.621)
Renal agenesis/hypoplasia	753.0	753.00–753.01
Musculoskeletal		
Craniosynostosis	No specific code	756.00–756.03
Clubfoot	754.51, 754.70	754.50, 754.73 (excluding 754.735)
Diaphragmatic hernia	756.6	756.610–756.617
Gastroschisis	756.73 (as of 10/01/09)	756.71
Limb deficiencies (reduction defects)	755.2–755.4	755.20–755.49
Omphaloele	756.72 (as of 10/01/09)	756.70
Chromosomal		
Deletion 22 q11.2	758.32	758.37
Trisomy 13	758.1	758.10–758.19
Trisomy 18	758.2	758.20–758.29
Trisomy 21 (Down syndrome)	758.0	758.00–758.09
Turner syndrome	758.6	758.60–758.69

CCHD: Critical congenital heart defect.

Table 2

Gastrointestinal Defect Counts, Prevalence and 95% Confidence Interval for 28 U.S. State-based Surveillance Programs[a], 2010-2014 (Prevalence per 10,000 Live Births)

	Biliary atresia[b]			Esophageal atresia/ tracheoesophageal fistula			Rectal a nd large intestinal atresia/ stenosis[c]			Small intestinal atresia/stenosis[d]		
Variables	**Count**	**Prev**	**95 % CI**	**Count**	**Prev**	**95 % CI**	**Count**	**Prev**	**95 % CI**	**Count**	**Prev**	**95 % CI**
Total cases	713	0.7	0.6–0.7	2472	2.3	2.2–2.4	4334	4.2	4.1–4.4	3388	3.4	3.3–3.6
Case ascertainment methodology[e]												
Programs with active case finding	259	0.6	0.6–0.7	955	2.3	2.2–2.5	1788	4.7	4.5–5.0	1050	3.1	2.9–3.3
Programs with passive case finding	454	0.7	0.6–0.8	1517	2.3	2.2–2.5	2546	3.9	3.8–4.1	2338	3.6	3.5–3.8
Pregnancy outcome inclusion[f]												
Programs that track live births only	200	0.7	0.6–0.8	646	2.2	2.0–2.4	1084	3.7	3.5–3.9	927	3.3	3.1–3.5
Programs that track live births and stillbirths	317	0.7	0.6–0.8	1112	2.4	2.3–2.6	1723	4.1	3.9–4.3	1506	3.6	3.4–3.8
Programs that track all pregnancy outcomes	196	0.6	0.5–0.7	714	2.3	2.1–2.5	1527	4.9	4.7–5.2	955	3.4	3.2–3.6
Maternal race/ethnicity[g]												
White, non-Hispanic	291	0.5	0.5–0.6	1428	2.5	2.4–2.7	2207	4.0	3.9–4.2	1716	3.3	3.1–3.4
Black, non-Hispanic	151	0.9	0.8–1.1	324	2.0	1.8–2.2	620	3.8	3.5–4.2	553	3.7	3.4–4.0
Hispanic	160	0.6	0.5–0.8	535	2.1	2.0–2.3	1104	4.7	4.4–5.0	840	3.6	3.4–3.9
Asian or Pacific Islander, non-Hispanic	60	1.1	0.8–1.4	95	1.7	1.4–2.1	213	4.0	3.5–4.6	161	3.2	2.7–3.7
American Indian or Alaska Native, non-Hispanic	9	1.1	0.5–2.1	17	2.1	1.2–3.3	31	5.2	3.5–7.4	14	2.5	1.3–4.1
Maternal age (years)[g]												
<20	51	0.6	0.4–0.8	197	2.3	2.0–2.6	392	4.7	4.3–5.2	317	4.0	3.6–4.4
20–24	150	0.6	0.5–0.7	515	2.1	1.9–2.3	1069	4.5	4.2–4.7	782	3.4	3.2–3.7
25–29	212	0.7	0.6–0.8	621	2.1	1.9–2.2	1092	3.8	3.5–4.0	840	3.0	2.8–3.2
30–34	142	0.5	0.4–0.6	583	2.2	2.0–2.4	1000	3.9	3.6–4.1	772	3.1	2.9–3.3
35–39	91	0.7	0.6–0.9	349	2.8	2.5–3.1	525	4.3	4.0–4.7	416	3.6	3.2–3.9
40+	36	1.2	0.8–1.6	151	4.9	4.2–5.8	177	6.0	5.1–6.9	202	7.1	6.1–8.1

Variables	Biliary atresia[b]			Esophageal atresia/ tracheoesophageal fistula			Rectal a nd large intestinal atresia/ stenosis[c]			Small intestinal atresia/stenosis[d]		
	Count	Prev	95 % CI	Count	Prev	95 % CI	Count	Prev	95 % CI	Count	Prev	95 % CI
Infant sex[g]												
Male	311	0.6	0.5–0.6	1366	2.5	2.4–2.7	2383	4.6	4.4–4.7	1651	3.3	3.1–3.4
Female	383	0.7	0.7–0.8	1080	2.1	2.0–2.2	1878	3.8	3.6–4.0	1692	3.5	3.4–3.7

Prev: Prevalence per 10,000 live births; CI: Confidence interval

[a]Programs contributing to the table: Arizona (2010–2013), Arkansas (2010–2013), Delaware, Florida, Georgia (Metropolitan Atlanta Congenital Defects Program), Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Massachusetts, Minnesota, Mississippi, Missouri, Nebraska, Nevada, New Jersey, New York, Oklahoma, Oregon, Rhode Island, South Carolina, Tennessee, Texas, Vermont, West Virginia, and Wisconsin.

[b]Excludes Vermont.

[c]Excludes Arizona.

[d]Excludes Arizona, Minnesota, and South Carolina.

[e]Program primary case-finding methodology: Programs with active case-finding: Arkansas (2010-2013), Arizona (2010-2013), Delaware, Georgia (Metropolitan Atlanta Congenital Defects Program), Iowa, Louisiana, Massachusetts, Minnesota, Oklahoma, South Carolina, and Texas; Programs with passive case-finding: Florida, Illinois, Indiana, Kansas, Kentucky, Missouri, Mississippi, Nebraska, New Jersey, Nevada, New York, Oregon, Rhode Island, Tennessee, Vermont, West Virginia, and Wisconsin.

[f]Program pregnancy outcome inclusion: Programs that track live births only: Louisiana, Minnesota, Florida, Indiana, Mississippi, New Jersey, Nevada, Oregon, and Vermont; Programs that track live births and stillbirths: Arizona (2010–2013), Delaware, Massachusetts, Illinois, Kansas, Kentucky, Missouri, Nebraska, New York, Tennessee, West Virginia, and Wisconsin; Programs that track all pregnancy outcomes: Arkansas (2010–2013), Georgia (Metropolitan Atlanta Congenital Defects Program), Iowa, Oklahoma, South Carolina, Texas, and Rhode Island.

[g]Counts of unknown and/or other are not shown.

Table 3

Median State[a] Reported Percent of Cases that had a Co-occurrence of Other Defects by Gastrointestinal Defects, 2010–2014

	Biliary atresia[b]		Esophage atresia/ tracheoesophageal fistula		Rectal and large intestinal atresia/Stenosis[c]		Small intestinal atresia/stenosis[d]	
Co-occurrence	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**
Co-occurring other defects	23.4	(14.3, 36.4)	53.9	(41.6, 63.1)	45.5	(38.8, 58.7)	50.6	(37.7, 61.7)
Co-occurring trisomies 13, 18, 21, Turner syndrome, and deletion 22q11.2	0.0	(0.0, 6.3)	8.3	(5.0, 11.0)	4.9	(4.1, 6.6)	16.1	(12.8, 19.7)
Co-occurring trisomy 21	0.0	(0.0, 0.8)	3.1	(2.1, 5.2)	3.9	(2.4, 5.2)	15.2	(11.4, 18.6)
Co-occurring gastroschisis[e]	0.0	(0.0, 0.4)	0.0	(0.0, 0.0)	3.2	(1.1, 4.8)	9.7	(7.0, 13.6)

IQR: Interquartile range (25th percentile, 75th percentile).

[a]Programs contributing to the table: Arizona (2010–2013), Arkansas (2010–2013), Delaware, Florida, Georgia (Metropolitan Atlanta Congenital Defects Program), Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Massachusetts, Minnesota, Mississippi, Missouri, Nebraska, Nevada, New Jersey, New York, Oklahoma, Oregon, Rhode Island, South Carolina, Tennessee, Texas, Vermont, West Virginia, and Wisconsin.

[b]Excludes Vermont.

[c]Excludes Arizona.

[d]Excludes Arizona, Minnesota, and South Carolina.

[e]Excludes Mississippi, Nevada, West Virginia (2010–2012), and Wisconsin.

Table 4

Maternal and Infant Characteristics Among Cases of Small Intestinal Atresia/Stenosis with and without Trisomy 21 from 25 U.S. States, 2010–2014[a]

	Cases with trisomy 21		Cases without trisomy 21		
Characteristic	**Count**	**Column percent**	**Count**	**Column percent**	***p*-value**[b]
Maternal race/ethnicity[c]					
White, non-Hispanic	269	55.5	1447	51.7	<0.001
Black, non-Hispanic	38	7.8	515	18.4	
Hispanic	151	31.1	689	24.6	
Asian or Pacific Islander, non-Hispanic	27	5.6	134	4.8	
American Indian or Alaska Native, non-Hispanic	0	0.0	14	0.5	
Maternal age (years)[c]					
<20	16	3.3	301	10.6	<0.001
20–24	61	12.4	721	25.4	
25–29	91	18.6	749	26.4	
30–34	94	19.2	678	23.9	
35–39	105	21.4	311	11.0	
40+	123	25.1	79	2.8	
Infant sex[c]					
Male	265	53.6	1386	48.6	0.040
Female	229	46.4	1463	51.4	

[a]Programs contributing to the table: Arkansas (2010–2013), Delaware, Florida, Georgia (Metropolitan Atlanta Congenital Defects Program), Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Massachusetts, Mississippi, Missouri, Nebraska, Nevada, New Jersey, New York, Oklahoma, Oregon, Rhode Island, Tennessee, Texas, Vermont, West Virginia, and Wisconsin.

[b]Pearson chi-square test was used to perform all tests of proportions.

[c]Counts of other and/or unknown are not shown.