Racial/Ethnic Differences in Survival of United States Children with Birth Defects: A Population-Based Study

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Objectives To examine racial/ethnic-specific survival of children with major birth defects in the US.

Study design We pooled data on live births delivered during 1999-2007 with any of 21 birth defects from 12 population-based birth defects surveillance programs. We used the Kaplan-Meier method to calculate cumulative survival probabilities and Cox proportional hazards models to estimate mortality risk.

Results For most birth defects, there were small-to-moderate differences in neonatal (<28 days) survival among racial/ethnic groups. However, compared with children born to non-Hispanic white mothers, postneonatal infant (28 days to <1 year) mortality risk was significantly greater among children born to non-Hispanic black mothers for 13 of 21 defects (hazard ratios [HRs] 1.3-2.8) and among children born to Hispanic mothers for 10 of 21 defects (HRs 1.3-1.7). Compared with children born to non-Hispanic white mothers, a significantly increased childhood (≤8 years) mortality risk was found among children born to Asian/Pacific Islander mothers for encephalocele (HR 2.6), tetralogy of Fallot, and atrioventricular septal defect (HRs 1.6-1.8) and among children born to American Indian/Alaska Native mothers for encephalocele (HR 2.8), whereas a significantly decreased childhood mortality risk was found among children born to Asian/Pacific Islander mothers for cleft lip with or without cleft palate (HR 0.6).

Conclusion Children with birth defects born to non-Hispanic black and Hispanic mothers carry a greater risk of mortality well into childhood, especially children with congenital heart defect. Understanding survival differences among racial/ethnic groups provides important information for policy development and service planning. *(J Pediatr 2015;166:819-26)*.

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Birth defects are a leading cause of infant death in the US.[1] National vital statistics data are critical to our understanding of infant mortality[2] and child and adult mortality.[3,4] However, compared with population-based birth defects surveillance systems, birth certificates have relatively poor sensitivity and specificity for the reporting of birth defects.[5] Linking population-based birth defects surveillance data to state death certificates and the National Death Index (NDI) can provide high high-quality information on both short- and long-term survival of children with birth defects.

There have been several previous studies on survival of infants with birth defects using statewide[6-14] or regional[15-21] population-based birth defects surveillance data. The use of pooled data from several surveillance systems in the US, however, has been limited to only a few studies of individual defects.[22-24] Previous literature suggests that the mortality and survival experience of children with birth defects differs by specific birth defect phenotype and by demographic factors such as maternal race/ethnicity.[12-14,25-28] Racial/ethnic disparities in infant and child mortality were found among Florida[29] and Texas infants with birth

A/PI	Asian/Pacific Islander
AI/AN	American Indian/Alaska Native
AVSD	Atrioventricular septal defect
HR	Hazard ratio
NDI	National Death Index
NHB	Non-Hispanic black
NHW	Non-Hispanic white

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*List of centers of the National Birth Defects Prevention Network is available at www.jpeds.com (**Appendix**).

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defects[25,27,28] but not among New York children (up to 25 years) with birth defects.[12]

To date, no studies using pooled population-based surveillance data have investigated the survival of children with a broad range of birth defects. A recent study using pooled data from 12 population-based birth defects surveillance programs in the US examined the relationship between race/ethnicity and occurrence of selected major birth defects.[30] Using that study population, in the current study we estimated infant and child survival by birth defect subtype and race/ethnicity among live-born individuals with selected birth defects.

Methods

Information on all live births with any of the selected major birth defects was obtained from 12 participating population-based birth defects surveillance programs: Arizona, Colorado, Florida, Georgia (5 counties of metropolitan Atlanta), Illinois, Massachusetts, Michigan, Nebraska, New Jersey, New York (excludes New York City), North Carolina, and Texas. Surveillance programs matched cases to state birth certificate records to obtain data on maternal race/ethnicity, classified as non-Hispanic white (NHW), non-Hispanic black (NHB), Hispanic, Asian/Pacific Islander (A/PI), and American Indian/Alaska Native (AI/AN). The study protocol was reviewed and approved by the participating states' institutional review boards, as necessary.

The birth defects included in the study were spina bifida without anencephalus; encephalocele; common truncus; transposition of great arteries; tetralogy of Fallot; atrioventricular septal defect (AVSD) (and a subgroup without co-occurring Down syndrome); aortic valve stenosis; hypoplastic left heart syndrome; coarctation of the aorta; cleft palate without cleft lip; cleft lip with or without cleft palate; esophageal atresia/s tracheoesophageal fistula; pyloric stenosis; rectal, anal, and large intestinal atresia/stenosis; upper and lower limb deficiencies; diaphragmatic hernia; gastroschisis; omphalocele; and Down syndrome. States selected cases from their surveillance systems for inclusion in this analysis based on a list of specified *International Classification of Diseases, 9th Revision, Clinical Modification* or Centers for Disease Control and Prevention/British Pediatric Association Classification of Diseases codes that are used for annual reporting by the National Birth Defects Prevention Network.[31] The birth defects included are not mutually exclusive, and infants with multiple defects were included in each relevant birth defect category.

Each state surveillance program linked its case information to the state's death certificate data files to obtain the vital status information of the study cohort. The follow-up period for children in the study ranged from 1 (for those born at the end of 2007 followed through the end of 2008) up to 9 years (for those born in the beginning of 1999 followed through the end of 2008). Illinois and Nebraska programs only provided vital status information for the first year. If a child was deceased, participating programs provided the date of death and duration of life in days. Additional data sources used to obtain vital status information included hospital discharge files (Arizona, Texas), medical records (Arizona, Texas), and the NDI (Georgia, Michigan).

Statistical Analyses

The Kaplan-Meier product limit method was used to calculate survival probabilities (<1 day, <7 days, <28 days, <1 year, <2 years, ≤8 years) for specific defects and by maternal race/ethnicity. Greenwood method was used to calculate 95% CIs. The infant survival analysis was conducted using data from all 12 birth defects surveillance programs. For the analyses of survival beyond infancy, data for those born during 1999-2005 from 10 programs (note: Massachusetts was 2000-2007 and North Carolina was 2003-2007) were analyzed; Illinois and Nebraska were excluded from the analyses of survival beyond infancy because they did not provide vital status data beyond one year of life. Because the birth cohort for one of the participating states (New Jersey) was through 2005 only, 2005 was chosen as the latest birth year to be included for all 10 programs in the analysis. Thus, the longest possible period of follow-up was just under 9 years (infants born in the beginning of 1999 with follow-up though the end of 2008).

Multivariable analyses using Cox proportional hazards models were conducted to estimate the mortality risk, the hazard ratio (HR), for each birth defect, with adjustment for the following covariates: birth weight and gestational age (<37 weeks and <2500 g, <37 weeks and ≥2500 g, ≥37 weeks and <2500 g, and ≥37 weeks and ≥2500 g),[22] maternal age (<35 and ≥35 years), birth period (1999-2000, 2001-2002, 2003-2005, and 2006-2007), and state surveillance program. These variables were selected because bivariate analyses indicated these factors were associated with survival ($P < .1$). Other factors, such as mother's birth country, marital status, insurance status, and method of delivery were excluded from the multivariable models because they were not available from all participating surveillance programs. SAS Version 9.2 (SAS Institute, Cary, North Carolina) was used for all statistical analyses.

Results

The study cohort contained 98 833 children born alive in 1999-2007 with at least 1 of the selected major birth defects and ascertained from the 12 state surveillance programs (**Table I**; available at www.jpeds.com) among approximately 14 million live births (about 39% of all live births in the US during the study period). The study cohort did not include 2007 births from Colorado, Illinois, Michigan, and Nebraska and 2006-2007 births from New Jersey because of unavailability of the vital status data; the earliest available data were 2000 for Massachusetts and 2003 for North Carolina. A total of 9997 deaths were identified in the study cohort, with 8893 (89%) occurring during infancy.

The lowest 1-day and 7-day survival probabilities were found for encephalocele (**Table II**). Children with