DETERMINANT FACTORS OF INFANT CONGENITAL HEART DEFECTS IN NORTH CAROLINA 2003-2016.

by

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ORIGINAL ARTICLE

Determinant factors of infant congenital heart defects in North Carolina 2003-2016.

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BACKGROUND There is limited understanding of how geospatial and socioeconomic variability impacts congenital heart defects at the county level in North Carolina.

METHODS Literature research, data harvesting and analyses.

RESULTS The average percent of infants diagnosed with a CHD was noteably higher in ENC for African Americans (29.33%). Rural counties show significantly increased rates of incidence for American Indians (2.82%). Rates for prenatal care during the first trimester were found to be lower for rural counties (67.04%) and ENC (58.28%) than urban counties (74.11%). ENC indicated lower rates of prenatal care reception during all trimesters of pregnancy compared to other geospatial areas. There was a significant decrease in infant mortality for urban counties (30.1%) and ENC (26.3%) for 2013-2016. A significant negative correlation was determined between rates of prenatal care reception in the second trimester and annual infant mortality rates (R^2=0.60). A similar correlation was observed in the reception of prenatal care in the third trimester and infant mortality rates (R^2=0.64).

CONCLUSION Disproportionate rates of African Americans and Caucasians are diagnosed with CHDs in rural and ENC counties. Second and third trimester prenatal care reception are strong predictors of infant mortality rates. Future studies should investigate disparities in healthcare and prenatal services between rural and urban counties to determine associations with infant mortality and diagnosis.

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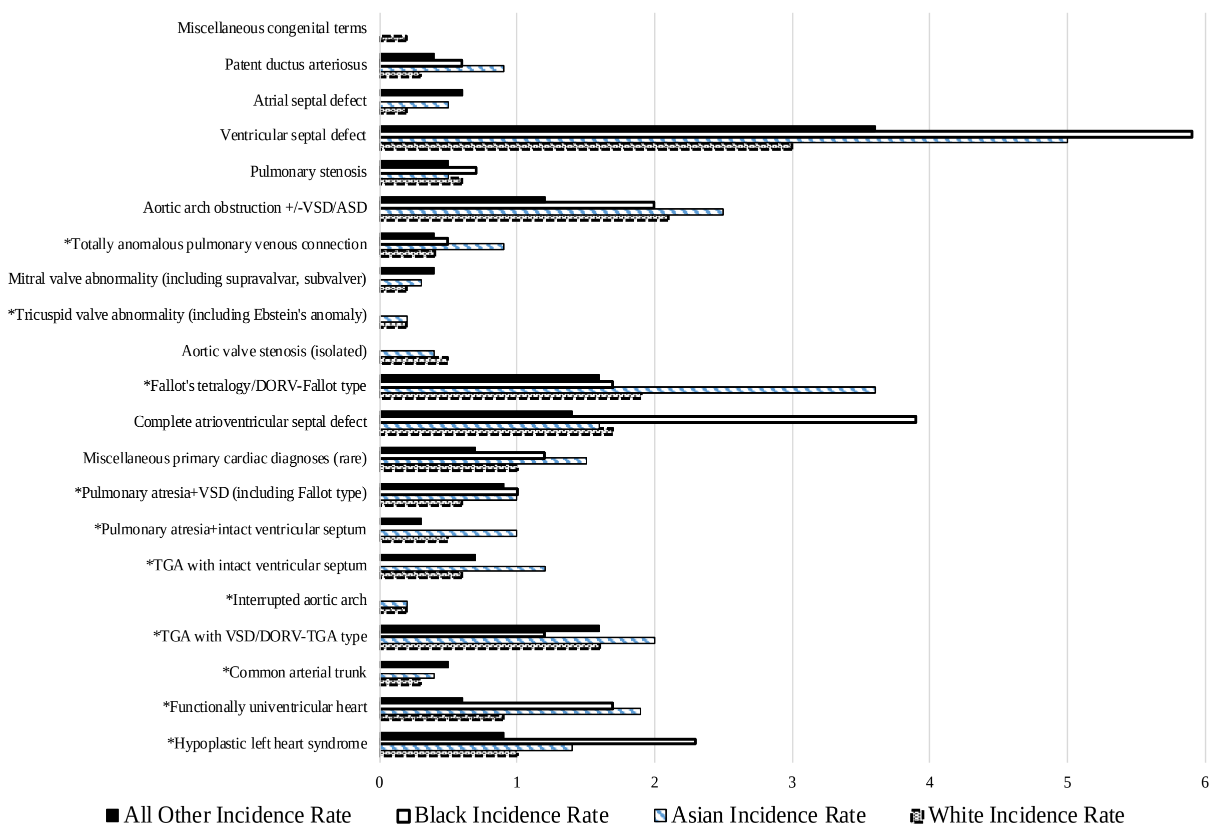
BACKGROUND

Congenital heart defects (CHDs) are structural anomalies resulting from abnormal heart development. Defects range in severity from self-correcting to fatal if interventions are not implemented soon after birth. Critical congenital heart defects (CCHDs) are defined as potentially fatal heart defects requiring immediate treatment within the first days of life[1]. Heart defects are the most common congenital defect and a leading cause of death among infants with birth defects[2]. CHD affects infants of all races. While there are limited studies regarding the role of race, Knowles et al.[3] did identify a higher incidence rate for black British African infants in their study of the United Kingdom (Figure #1).

FIGURE 1. Percent of congenital heart defects treated in first year of life by race of infant in the United Kingdom between 2006-2009.[3]



It is estimated that for every 1,000 live births eight to twelve infants are diagnosed with CHDs around the world[4]. Many countries have reported similar incidence rates of congenital heart defects with few (i.e. China, Russia, South Africa, Spain) showing minor discrepancies among types of heart defects[4]. Cardiac surgeons and other intervention resources have been assessed between continents to determine global availability for CHD interventions[5]. North America and Europe had significantly larger rates of cardiac surgeons per one million people than the other three continents for which data was analyzed[4, 5, 6].

Approximately 1 in 150 adults in the United States are living with a CHD[1]. At least 40,000 infants are expected to be born each year with a CHD in the United States[1]. Twenty-five percent of these will require invasive interventions in their first year of life due to a CCHD[1]. The age demographics of individuals living with CHDs in the United States has gradually shifted due to an increasing adult population living with CHDs[2]. Over 1.4 million adults and 1 million children are estimated to be living with a CHD in the United States[7]. Between 1999 and 2006, CHD mortality rates decreased by 24.1 percent in the United States largely contributing to the growing adult population living with them[8].

The decrease in CHD related mortality rates have largely been attributed to the implementation of newborn screening protocols in 2011 by the American Heart Association after indicating the effectiveness of pulse oximetry screenings in the early detection among newborns[9]. Pulse oximetry screenings are conducted immediately after birth via a blood test to check the oxygen levels of the infant's blood. Low oxygen levels could be an indicator of a CHD[10]. Before the implementation of newborn screenings, CHDs were responsible for 30-50% of all infant mortalities between 1999 and 2006 in the United States[11].

Increasing acceptance of newborn screenings has impacted the early diagnosis of CHDs and allowed for early intervention to minimize mortality risks[11]. Despite implementations of newborn screenings, recent studies have found disparities among mortality rates in urban regions of the United States[10,12,13]. Incidence rates of CHDs have increased due in part to new standards recommending preventative screenings[11].

Limited research has been conducted investigating disparities in CHD rates between rural and urban counties in the United States. The comparison between these geographic variations is a topic of growing interest due to the growing literature of broader health disparities between rural and urban regions[14,15,16,17,18,19]. Previous studies have shown maternal residence as the strongest predictor of reported prenatal diagnosis in CHDs[20,17,21]. One study showed a four-fold difference in geographic location with prenatal diagnosis of CHDs being 60% more prominent in urban regions[20]. Access to facilities equipped with high-quality imaging technology and trained healthcare personnel is believed to play a role in early prenatal detection[20].

Disparities in incidence and mortality rates are often associated with similar patterns in socioeconomic and geographic factors including poverty, healthcare access, and education status[22,15,16,23]. Lack of access to healthcare facilities and specialists decrease the likelihood rural residents attend regular doctor visits and receive proper prenatal care[14]. This increases the probability of late diagnosis and intervention and therefore overall risk for mortality[18,24]. With lower rates of educational attainment, rural counties have higher rates of uninsured due to a larger portion of the population living in a lower socioeconomic status[15,16,22].

This research seeks to advance our understanding of the role geospatial and demographic variability plays regarding CHDs. Specifically, the authors were able to obtain and analyze historical birth certificate data for the state of North Carolina between 2003 and 2016.

Prior works in the United States have been limited to data on CHD mortality and incidence rates at the national and state level. This study fills a research gap by assessing CHD mortality rates and disparities at the county level of North Carolina. It will provide further context by analyzing CHD mortality rates geospatially by comparing data between rural and urban counties. While mortality rates have gradually decreased from 1999 to 2016, annual CHD mortality rates in North Carolina are consistently higher than that of the country[25]. North Carolina was selected for this study because of the optimal diversity in geography and substantial sample size. It is the tenth most populated state in the country and has 100 counties from which to analyze and compare data.

METHODS

Data was obtained from the North Carolina Department of Health and Human Services. A total of 21,952 birth certificates were analyzed for infants diagnosed with a congenital heart defect for years 2003 to 2016. For the purposes of this study, infant mortality was defined as death in the first year of life. Eastern North Carolina (ENC) was defined as the thirty-one easternmost counties in the state. ENC was selected as a regional focus due to its constitution of primarily rural counties and the regional significance for the surrounding community in which this research was conducted. Maternal race, prenatal care reception, and infant mortality were examined in this study. Linear regressions and analysis were used to determine significant correlations and trends.

RESULTS

The average percent of infants diagnosed with a CHD was noteably higher in ENC for African Americans (29.33%). Rural counties show significantly increased rates of incidence for American Indians (2.82%). Both rural counties (9.27%) and ENC (8.43%) have lower rates of hispanic infants diagnosed with CHDs than urban counties (16.22%) in the state.

TABLE 1. Race/ethnicity of mothers with children diagnosed with a congenital heart defect in North Carolina for 2003-2016. Source: North Carolina Department of Health and Human Services (2003-2016).

	African American (%)	White (%)	American Indian (%)	Hispanic (%)	Other (%)
ALL BIRTHS IN NORTH CAROLINA					

NC	**23.53**	**56.22**	**1.35**	**15.34**	**3.56**
ENC	**29.73**	**56.85**	**0.53**	**11.70**	**1.20**
BIRTHS DIAGNOSED WITH CHD IN NORTH CAROLINA					
NC	**26.88**	**53.61**	**1.63**	**15.17**	**2.73**
Rural	**21.81**	**54.12**	**2.82**	**9.27**	**0.84**
Urban	**24.32**	**56.64**	**0.44**	**16.22**	**2.39**
ENC	**29.33**	**38.89**	**0.44**	**8.43**	**0.80**

Rates for prenatal care during the first trimester were found to be lower for rural counties (67.04%) and ENC (58.28%) than urban counties (74.11%). ENC indicated lower rates of prenatal care reception during all trimesters of pregnancy compared to other geospatial areas. Urban counties had the highest rates of mothers receiving prenatal care for all trimesters.

TABLE 2. Percent of mothers whose infants were diagnosed with a congenital heart defect that received prenatal care in North Carolina for 2003-2016. Source: North Carolina Department of Health and Human Services (2003-2016).

	1st Trimester	**2nd Trimester**	**3rd Trimester**	**No Prenatal Care**	**Unknown**
ALL BIRTHS IN NORTH CAROLINA					
NC	**39.46**	**11.50**	**2.63**	**1.36**	**6.80**
ENC	**38.94**	**11.47**	**2.40**	**1.30**	**9.91**
BIRTHS DIAGNOSED WITH CHD IN NORTH CAROLINA					
NC	**74.22**	**17.55**	**4.02**	**2.83**	**1.38**
Rural	**67.04**	**14.59**	**3.61**	**2.17**	**1.53**

Urban	**74.11**	**17.89**	**3.85**	**2.64**	**1.51**
ENC	**58.28**	**13.16**	**3.45**	**1.62**	**1.15**
Note: This data does not include the year 2010 due to changes in reporting on birth certificates.					

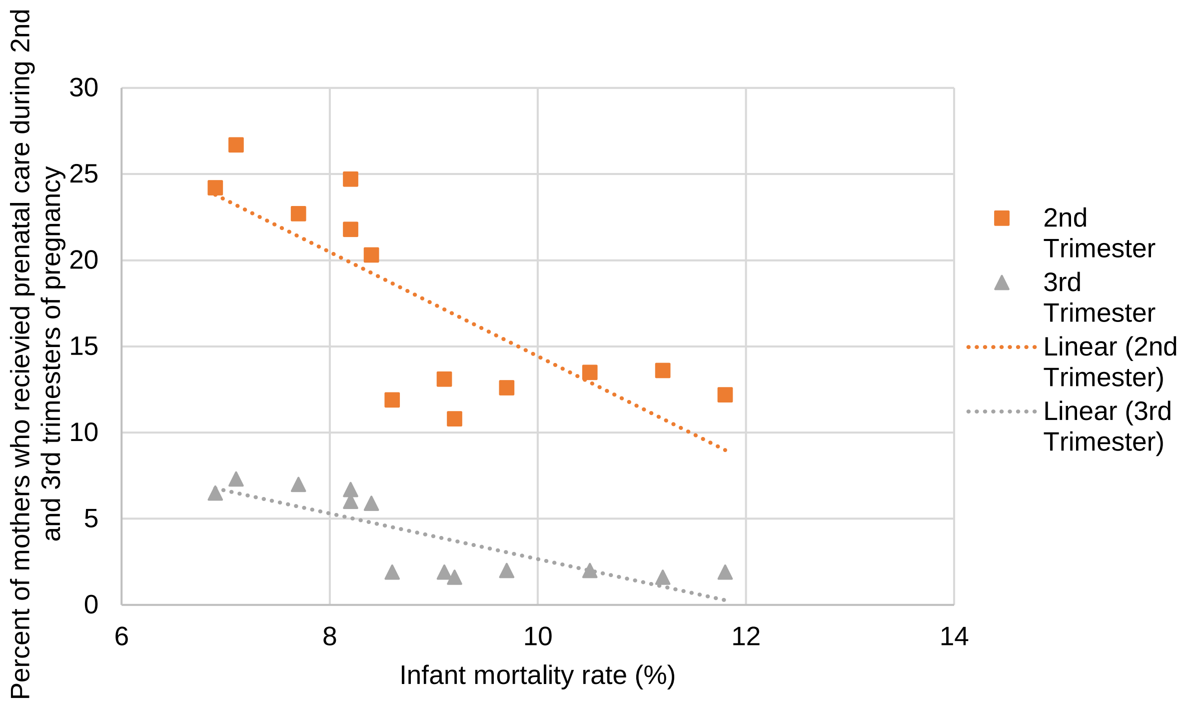
With 2013-2016 being the exception, urban counties indicate higher mortality rates than rural counties and ENC for all reported annual intervals. There was a significant decrease in infant mortality for urban counties (30.1%) and ENC (26.3%) for 2013-2016.

TABLE 3. Infant mortality rate as a percent for infants diagnosed with a congenital heart defect in North Carolina for 2003-2016. Source: North Carolina Department of Health and Human Services (2003-2016).

	Overall Average Mortality Rate (2003-2016)	2003-2007	2008-2012	2013-2016
NC	8.94	10.08	8.96	7.48
Rural	8.05	9.62	7.25	7.10
Urban	8.71	10.13	9.15	6.39
ENC	6.87	7.82	7.19	5.30

Correlations were found between the reception of prenatal care in the second and third trimesters of pregnancy and infant mortality. A significant negative correlation was determined between rates of prenatal care reception in the second trimester and annual infant mortality rates (R^2=0.60). A similar correlation was observed in the reception of prenatal care in the third trimester and infant mortality rates (R^2=0.64).

FIGURE 2. Percent of mothers who received prenatal care in the second and third trimesters of pregnancy for children diagnosed with a congenital heart defect and infant mortality rates in North Carolina for 2003-2016. Source: North Carolina Department of



Note: Figure excludes 2010 data due to a single change in the change in birth certificates.

DISCUSSION

African Americans comprise over a quarter (26.9%) of the population in ENC[26]. This could explain why incidence rates for African American infants are higher in ENC (29.33%) than other geospatial areas. Additionally, American Indians in North Carolina primarily live in rural counties in North Carolina[27]. For this reason, it would be expected infant mortality rates for American Indians would be increased for rural counties in North Carolina (2.82%).

As expected, prenatal care was more scarcely received in rural counties and ENC for all trimesters of pregnancy than urban counties in the state. Urban counties had the highest rates of prenatal care for all year intervals. Prior to this study, it was expected rural counties would have higher infant mortality rates due to a lack of healthcare screenings, specialists, and intervention resources[19,20]. However, urban counties indicated consistently higher mortality rates with the years 2013-2016 being the exception. A potential explanation for this could be in the relocation of families or expectant mothers to be more proximate to resources for prenatal care[19,20]. Infant mortality rates in urban counties significantly decreased by approximately 30%. It is possible this results from an increase in accessibility to prenatal resources and healthcare services in urbanized communities[19,20].

Correlations indicate rates of prenatal care in the second and third trimesters as strong indicators for CHD infant mortality rates (R^2=0.60; R^2=0.64). Congenital abonormalities are often not detected or screened for until the second trimester of pregnancy during which a fetal echocardiography is typically administed for visualization of the fetal heart[28.] Receiving prenatal care during this time increases the likelihood of early diagnosis of CHDs and allows precautions and appropriate interventions to be implemented at birth[28].

Figure 2 and Table 2 could potentially indicate a disparity in prenatal care reception for rural counties and ENC. The decrease in infant mortality rates for urban counties and ENC in recent years could be attributed to the adoption of more strict screening regulations and precautions as the incidence of CHDs increase. Future studies should explore prenatal resources at the county level and compare quality and availability of services across rural and urban counties to further examine this hypothesis. Subsequent studies should also investigate how environmental factors and maternal health behaviors differ in urban and rural counties and how they potentially influence infant mortality rates. It is important researchers continue to explore disparities associated with congenital heart defects at the county level to identify gaps in prenatal care and domains in which to improve infant outcomes and quality of life.

CONCLUSION

Advances made in screening technology and implementation policy have increased diagnosis and overall incidence rates in CHDs[11]. White and African American infants are predominantly at risk for the diagnosis of a congenital heart defect with African Americans specifically having higher rates of diagnosis in ENC. Disparities are evident in prenatal care reception between rural and urban counties and ENC. Receiving prenatal care in the second and third trimesters of pregnancy serve as strong indicators for infant mortality from CHDs. Urban counties have consistently shown higher rates of infant mortality from CHDs until recent years when rates significantly decreased (30.1%). Future studies should strive to identify and compare environmental, behavioral, and resource factors that influence the accessibility and availability of prenatal care in rural and urban counties.

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