



Occupational & Environmental Epidemiology



North Carolina Climate-Related Health Indicators: Human Development

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I. Overview

Climate can impact human development

The National Institute for Environmental Health Sciences (NIEHS) recognizes that climate poses a risk to fetal and child development by altering the level of risk for environmental exposures and pathogens, including carcinogenic chemicals and metals. More frequent extreme weather events such as floods, droughts or storm surges may lead to increased rates of foodborne diseases and food scarcity. In turn, threatened food security may lead to malnutrition among pregnant mothers and their children, putting them more at risk for impaired development.¹ Similarly, more frequent extreme weather events may affect risk for exposure to biotoxins in seafood, agricultural herbicides and pesticides, and harmful chemicals in potable and recreational water. For example, increased groundwater depletion coupled with changes in climate may result in higher concentrations of inorganic arsenic that is naturally present in groundwater. Arsenic is a known human carcinogen and therefore is dangerous at any stage in human development.² Moreover, recent research has demonstrated that extreme summer temperatures and heat stress are positively linked to higher rates of birth defects and preterm births.^{3,4}

This report describes human development health outcomes in North Carolina from 2000 to 2010. These outcomes include infant and early childhood deaths, preterm births, low birthweight births, birth defects, and childhood cancers. In addition, this report presents indicators for maternal and child vulnerability, such as breastfeeding and health care access among North Carolina mothers. Of note, the term “indicators” in this report refers to maternal and child health outcomes, not measurable changes in the climate or environment. The human development health outcomes and maternal and child vulnerability indicators presented in this report have been selected based on the NIEHS report, *A Human Health Perspective on Climate Change*, that provides an overview of the potential affect of climate on human health. These indicators serve as a baseline for future trend analysis regarding climate-related human development in North Carolina.

¹ Portier CJ et al 2010. A Human Health Perspective On Climate Change: A Report Outlining the Research Needs on the Human Health Effects of Climate Change. Research Triangle Park, NC: Environmental Health Perspectives/National Institute of Environmental Health Sciences. doi:10.1289/ehp.1002272. Accessed www.niehs.nih.gov/climatereport 12 Feb 2013.

² CDC, Climate and Health Program. Human Developmental Effects: Impacts on Risk. Accessed http://www.cdc.gov/climateandhealth/effects/human_development.htm 31 Mar 2013.

³ Van Zutphen, A. R., Lin, S., Fletcher, B. A., & Hwang, S. A. (2012). A Population-Based Case–Control Study of Extreme Summer Temperature and Birth Defects. *Environmental Health Perspectives*, 120(10), 1443.

⁴ Carolan-Olah, M., & Frankowska, D. (2013). High environmental temperature and preterm birth: A review of the evidence. *Midwifery*.

II. Health indicators

1. *Infant and early childhood mortality*

As shown in Table 1, child mortality rates in North Carolina decreased from the period of 2000 to 2010. The lowest mortality rate for children ages 0-4 years was observed in 2010, and from 2006-2009 for children ages 1-4 years. In Figure 1, the primary cause for early childhood deaths (excluding infants) is injuries. While weather and climate affect some injuries, such as motor vehicle injuries, it is likely many of these deaths are not affected by either climate or environment.

Between 2006 and 2010, North Carolina experienced an average infant mortality rate of 7.9 per 1,000 live births (Figure 2). During the same time period, the average rate of fetal deaths for the state was 6.6 (the actual formula is fetal deaths/[fetal deaths + live births]), with a maximum of 15.7 in Edgecombe County. Fetal deaths are deaths among infants older than 20 weeks. The state's average rate of neonatal deaths was 5.3 per 1,000 live births, with a maximum rate of 15.1 in Perquimans County. Neonatal deaths are among infants less than 28 days old. North Carolina's average postneonatal death rate during this time was 2.6 deaths per 1,000 infants surviving the neonatal period.⁵ Postneonatal deaths are infant deaths occurring between 28 days and one year. The Healthy North Carolina 2020 Maternal and Infant Health Objective target for infant mortality rate is 6.3 deaths per 1,000 live births.

Figure 2 also reveals substantial racial disparities in infant mortality rates in North Carolina, particularly among African Americans. From 2006-2010, the average death rate among non-Hispanic African American infants (14.7) was more than twice the average death rate among non-Hispanic white infants (5.9) and Hispanic infants (5.8).

Table 1: Selected NC child mortality rates per 1,000 births, 2000-2010⁶

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Child deaths (0-4 years) (n)	1,178	1,138	1,089	1,111	1,190	1,218	1,173	1,251	1,212	1,154	1,007
Rate	21.8	20.4	19.0	19.0	20.0	20.1	19.0	19.6	18.5	17.4	15.9
Child deaths (1-4 years) (n)	144	133	132	144	140	141	140	144	146	148	153
Rate	3.4	3.0	2.9	3.1	2.9	2.9	2.8	2.8	2.8	2.8	3.0

⁵ North Carolina State Center for Health Statistics. 2012 County Health Data Book. North Carolina Community Health Assessment Process. Accessed <http://www.schs.state.nc.us/schs/data/databook/2012> 16 Apr 2013.

⁶ North Carolina State Center for Health Statistics. 2011. Vital Statistics Volume I, 2000-2010 volumes. Accessed <http://www.schs.state.nc.us/SCHS/data/vitalstats.cfm> 21 Mar 2013.

Leading Causes of Death in North Carolina 2010

Location: ALL COUNTIES

Race: all

Gender: both

all (Hispanic, Non-Hispanic, and

Hispanic Origin: Unknown)

Age: 1 - 4 years

Rank	Cause	Number	%
1	All other unintentional injuries	32	20.9
2	Motor vehicle injuries	21	13.7
3	Assault (homicide)	13	8.5
4	Congenital malformations, deformations, and chromosomal abnormalities	12	7.8
5	Cancer	9	5.9
6	Diseases of heart	5	3.3
7	Influenza and pneumonia	4	2.6
	Septicemia	4	2.6
9	Certain conditions originating in the perinatal period	3	2
	In situ neoplasms, benign neoplasms and neoplasms of uncertain or unknown behavior	3	2
	All other causes (Residual)	47	30.7
Total Deaths -- All Causes		153	100

Source: State Center for Health Statistics, North Carolina

Figure 1: Leading cause of death for children 1-4 years in North Carolina, 2010⁷

⁷ North Carolina State Center for Health Statistics. 2012 County Health Data Book. North Carolina Community Health Assessment Process. Accessed <http://www.schs.state.nc.us/schs/data/databook/2012> 16 Apr 2013.

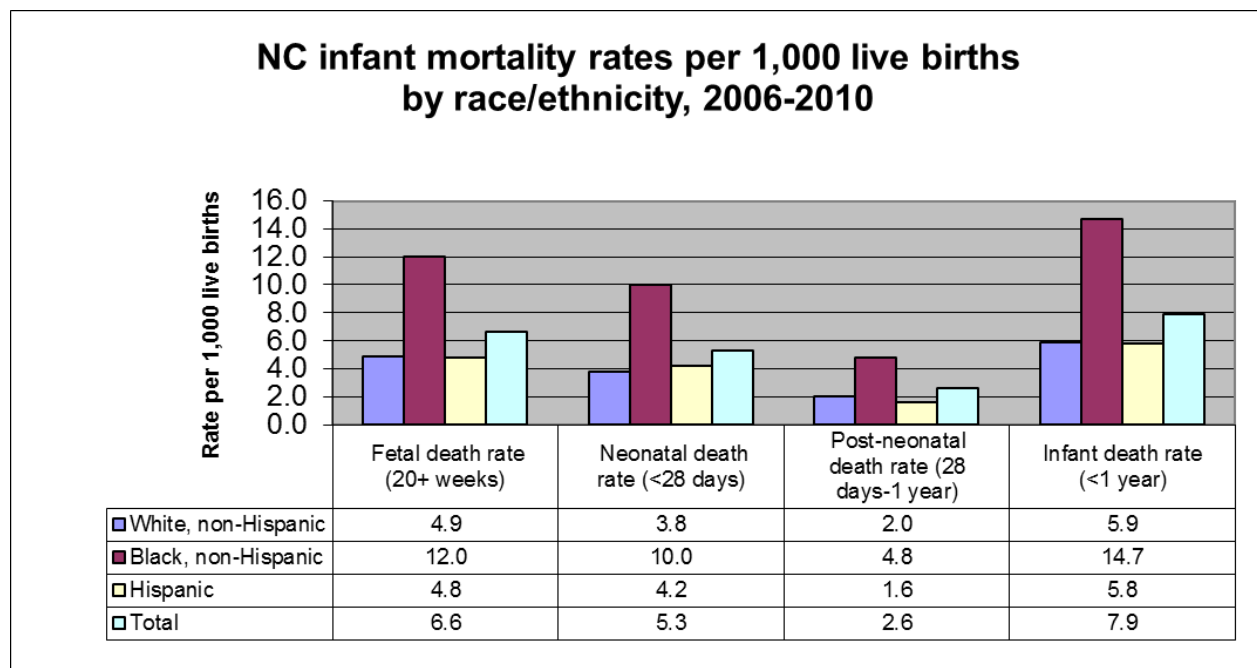


Figure 2: Perinatal and infant average annual mortality rates per 1,000 live births in North Carolina by race, 2006-2010⁸

2. Pre-term births, low birthweight babies, and birth defects

A birth before 37 weeks of gestation is described as “preterm,” while an infant that weighs less than 2,500 grams (~5.5 pounds) at birth is described as “low birthweight.” Both conditions are major risk factors for early death and long-term adverse health outcomes.^{9,10} For instance, infant death rates of low birthweight babies can be up to 40 times the death rates of normal weight babies. Similarly, preterm births are associated with neurologic problems like cerebral palsy, blindness, and deafness.¹¹ In 2010, the rate of preterm births in North Carolina (12.7%) was slightly higher than the national rate (12.0%).¹² The low birthweight rate in North Carolina (9.1%) was also slightly higher than the national rate in 2010 (8.2%).^{13,14}

⁸ North Carolina State Center for Health Statistics. 2012 County Health Data Book. North Carolina Community Health Assessment Process. Accessed <http://www.schs.state.nc.us/schs/data/databook/2012> 16 Apr 2013.

⁹ Martin, J. A., Kirmeyer, S., Osterman, M., & Shepherd, R. A. (2009). Born a bit too early: recent trends in late preterm births. *NCHS data brief*, (24), 1.

¹⁰ Chang, H. H., Larson, J., Blencowe, H., Spong, C. Y., Howson, C. P., Cairns-Smith, S., ... & Lawn, J. E. (2012). Preventing preterm births: analysis of trends and potential reductions with interventions in 39 countries with very high human development index. *The Lancet*.

¹¹ Goldenberg, R. L., & Culhane, J. F. (2007). Low birth weight in the United States. *The American Journal of Clinical Nutrition*, 85(2), 584S-590S.

¹² Martin JA, Hamilton BE, Ventura SJ, et al. Births: Final data for 2010. National vital statistics reports; vol 61 no 1. Hyattsville, MD: National Center for Health Statistics. 2012. Accessed http://www.cdc.gov/nchs/data/nvsr/nvsr61/nvsr61_01.pdf 18 Apr 2013.

Birth defects are another public health concern. Research suggests that one out of every 33 babies are born with a birth defect.^{15,16} In addition, one out of every five infant deaths are attributable to a birth defect.¹⁷ In the United States, approximately 3% of infants have a major structural or genetic birth defect.¹⁸ Every year, an estimated 4,000 babies are born with a birth defect in North Carolina.¹⁹

The incidence rate of low birth weight infants in North Carolina from 2003 to 2010 has increased slightly, while the incidence rate of preterm births has decreased (Table 2).

¹³ Martin JA, Hamilton BE, Ventura SJ, et al. Births: Final data for 2010. National vital statistics reports; vol 61 no 1. Hyattsville, MD: National Center for Health Statistics. 2012. Accessed http://www.cdc.gov/nchs/data/nvsr/nvsr61/nvsr61_01.pdf#table25 11 Apr 2013.

¹⁴ North Carolina State Center for Health Statistics. Selected vital statistics for 2010 and 2006-2010, North Carolina. Accessed <http://www.schs.state.nc.us/schs/vitalstats/volume1/2010/nc.html> 18 Apr 2013.

¹⁵ CDC. Birth Defects: Facts about Birth Defects. Accessed <http://www.cdc.gov/ncbddd/birthdefects/facts.html> 1 Apr 2013.

¹⁶ Update on overall prevalence of major birth defects—Atlanta, Georgia, 1978-2005. *MMWR Morb Mortal Wkly Rep* 2008;57:1-5.

¹⁷ Martin JA, Kung HC, Mathews TJ, et al. Annual summary of vital statistics: 2006. *Pediatrics* 2008;121:788-801.

¹⁸ Update on overall prevalence of major birth defects—Atlanta, Georgia, 1978-2005. *MMWR Morb Mortal Wkly Rep* 2008;57:1-5.

¹⁹ North Carolina State Center for Health Statistics. North Carolina Birth Defects Monitoring Program. Accessed <http://www.schs.state.nc.us/schs/bdmp/qanda.html> 16 Apr 2013.

Table 2: Selected NC birth statistics, 2003-2010²⁰

	2003	2004	2005	2006	2007	2008	2009	2010
Total Live Births	118292	119773	123040	127646	130886	130758	126785	122302
Prevalence of Selected Birth Defects (see note below)								
Number	1022	1073	962	1001	1052	994	1044	1092
Prevalence (per 1,000 live births)	8.6	9.0	7.8	7.8	8.0	7.6	8.2	8.9
Rate of Low Birth Weight Infants (< 2,500 grams)								
Number	10647	10846	11353	11595	12100	11929	11484	11152
Rate (per 1,000 live births)	90.0	90.6	92.3	90.8	92.4	91.2	90.6	91.2
Rate of Singleton Preterm Births (< 37 weeks gestation)								
Number	13517	13536	14313	14823	14653	14131	13905	12905
Rate (per 1,000 live births)	114.3	113.0	116.3	116.1	112.0	108.1	109.7	105.5
NOTE: Birth defect phenotypes included in this table are those monitored by the U.S. Environmental Public Health Tracking Program. They include: anencephaly, spina bifida w/o anencephaly, hypoplastic left heart syndrome, tetralogy of Fallot, transposition of great arteries, cleft lip with or w/o cleft palate, posterior cleft palate w/o cleft lip, gastroschisis, hypospadias, upper and lower limb deficiency defects, and trisomy 21 (Down syndrome).								

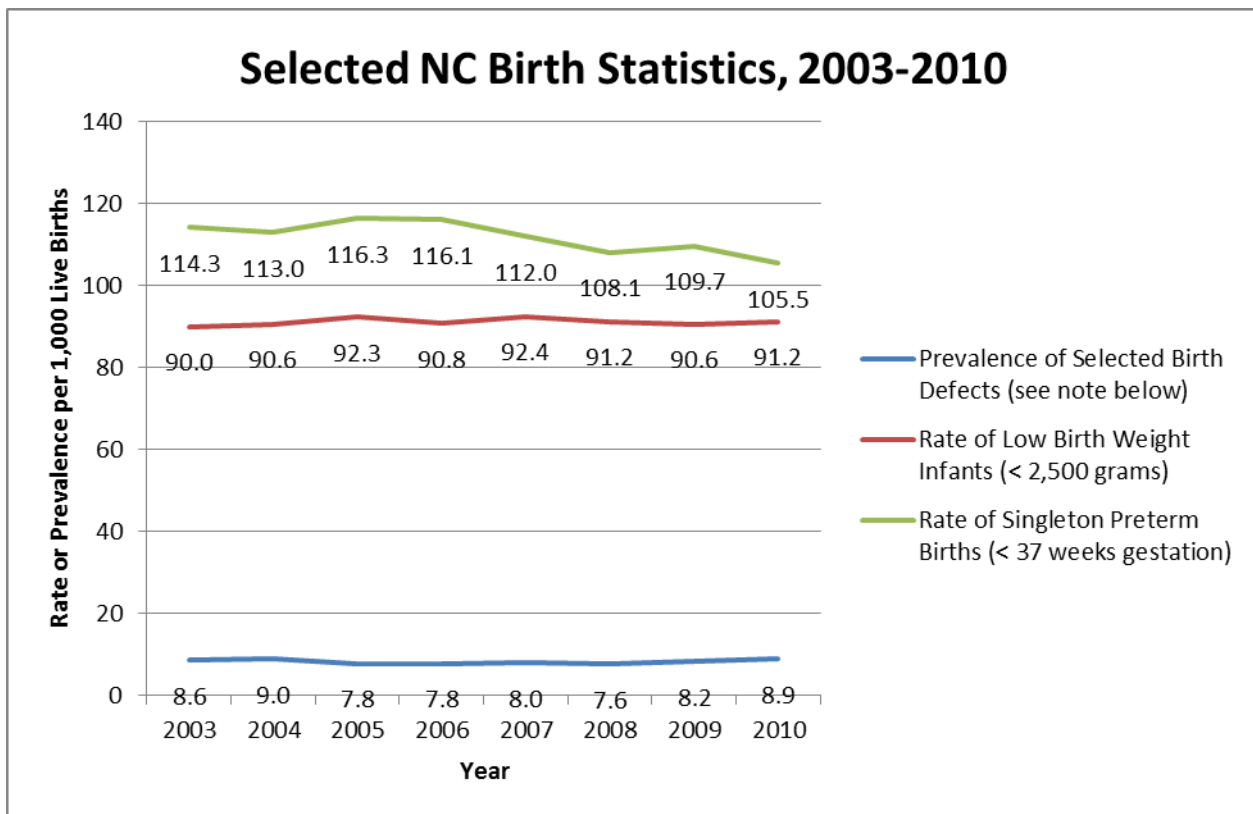


Figure 3: NC preterm, low birth weight, and birth defect rates per 1,000 live births, 2003-2010²¹

²⁰ North Carolina Birth Defects Registry. Obtained 13 August 2013.

²¹ North Carolina Birth Defects Registry. Obtained 13 August 2013. See Table 2.

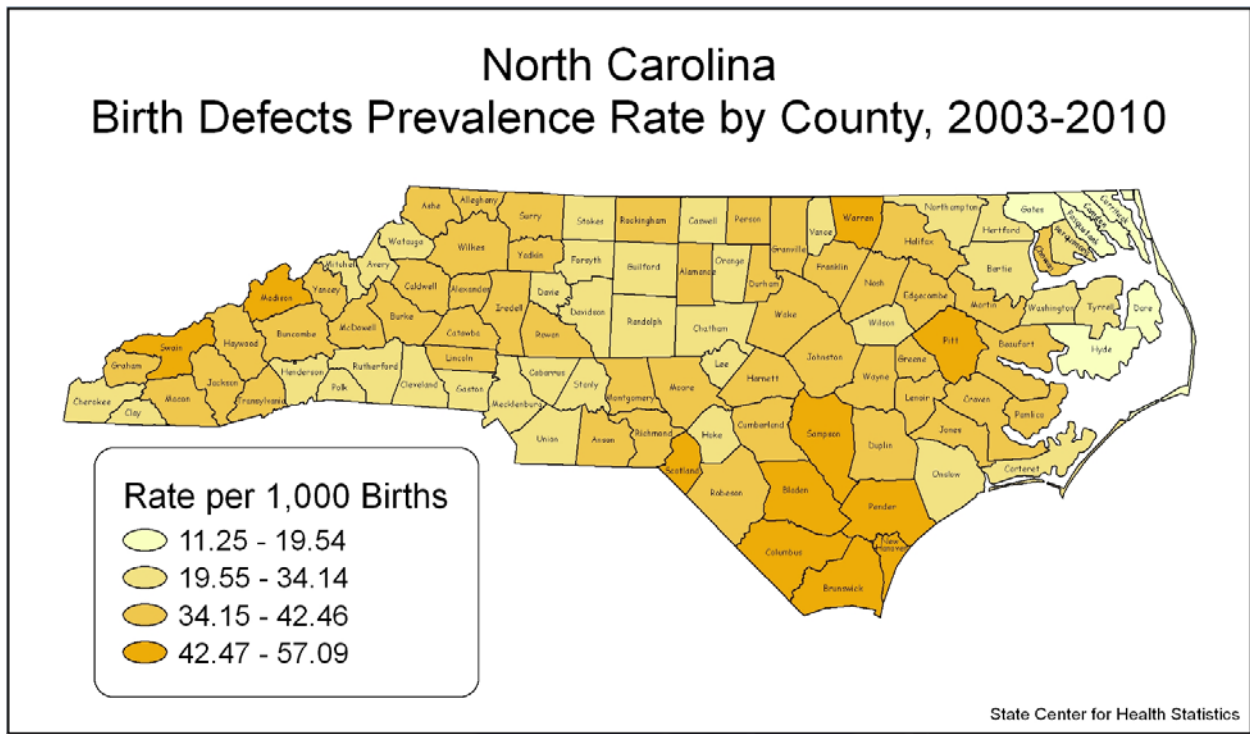


Figure 4: NC average incidence rate of birth defects by county, 2003-2010²²

3. *Childhood cancers*

Between 2005 and 2009, the average incidence and death rates of child cancers in North Carolina were slightly lower than the national average rates (Table 3). The age-adjusted annual incidence rates of childhood cancers among children less than 15 years of age were highest in the Triad, Triangle, and Central Piedmont regions of North Carolina (Figure 5). Among children less than 20 years of age, age-adjusted annual incidence rates of childhood cancers were highest in the Northwest, Central Piedmont regions, and a couple counties in the Southeast and Central Coastal regions (Figure 6). From 2000 to 2008, leukemia was the most common type of child cancer in North Carolina, followed by central nervous system cancer and miscellaneous intracranial and intraspinal neoplasms (Figure 7).

²² State Center for Health Statistics. Birth Defect Search. North Carolina Birth Defects by County. Accessed <http://www.schs.state.nc.us/SCHS/data/bdefects/defectsbycounty.cfm> 12 Feb 2013.

Table 3: NC childhood cancers, 2005-2009²³

	Ages 0-14			Ages 0-19		
	Annual average incidence rate (age-adjusted per 100,000 persons)	95% CI	Average annual count	Annual average incidence rate (age-adjusted per 100,000 persons)	95% CI	Average annual count
NC	15.0	14.2-15.8	280	16.2	15.5-17.0	405
U.S.	15.3	15.2-15.5	N/A	16.9	16.8-17.1	N/A
	Annual average death rate (per 100,000 persons)	95% CI	Average annual count	Annual average death rate (per 100,000 persons)	95% CI	Average annual count
NC	2.0	1.7-2.3	36	2.2	2.0-2.6	53
U.S.	2.2	2.2-2.3	1,376	2.5	2.5-2.6	2,058

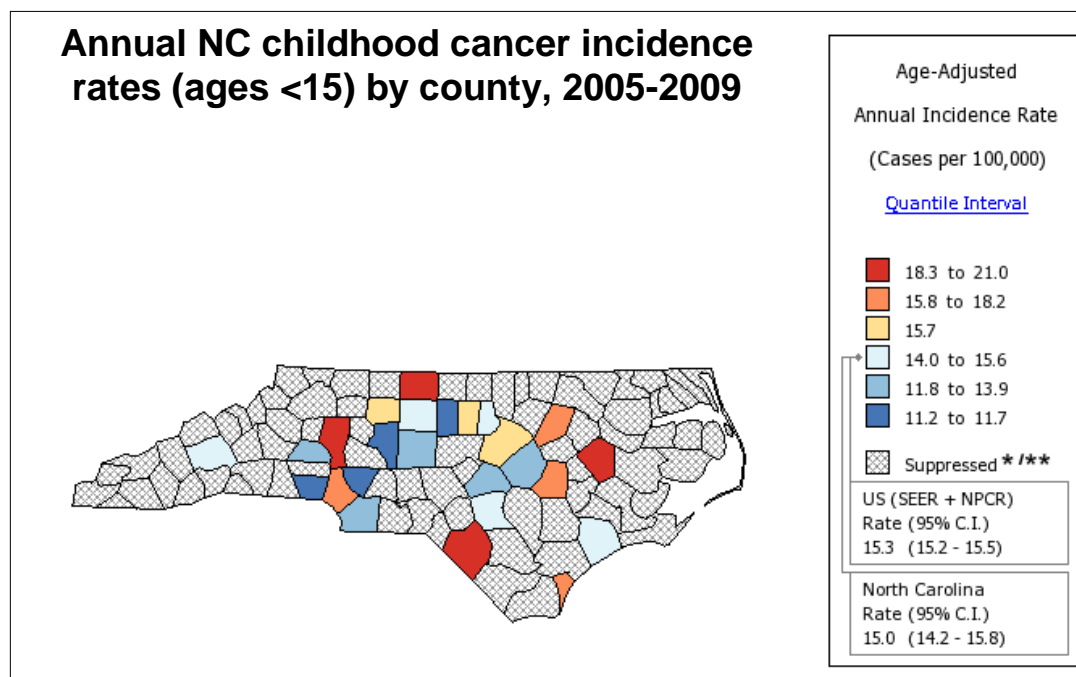


Figure 5: Age-adjusted annual incidence rates for childhood cancers (ages <15, all cancer sites) in North Carolina by county, 2005-2009²⁴

²³ National Cancer Institute, State Cancer Profiles. Accessed <http://statecancerprofiles.cancer.gov/cgi-bin/quickprofiles/profile.pl?37&516#incidence> 31 Mar 2013. U.S. numbers are drawn from SEER + NPCR.

²⁴ National Cancer Institute, State Cancer Profiles. Created by statecancerprofiles.cancer.gov on 3/31/2013. Accessed http://statecancerprofiles.cancer.gov/cgi-bin/quickprofiles/profile.pl?37&516#RT_ForAStateCounty 31 Mar 2013. Incidence rates (cases per 100,000 population) are age-adjusted to the 2000 U.S. Census population.

*Data have been suppressed to ensure confidentiality and stability of rare estimates. Counts are suppressed if fewer than 16 cases were reported in specific area-sex-race category. **Data have been suppressed for states with a population below 50,000 per sex for American Indian/Alaska Native or Asian/Pacific Islanders because of concerns regarding the relatively small size of these populations in some states.

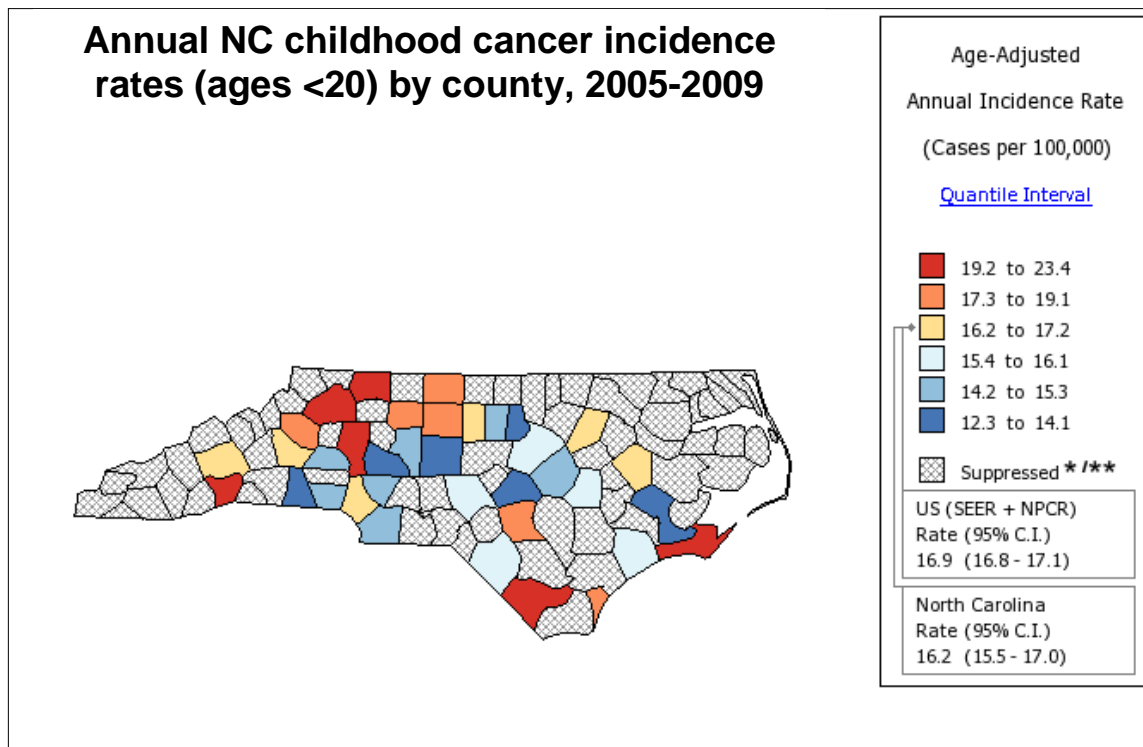


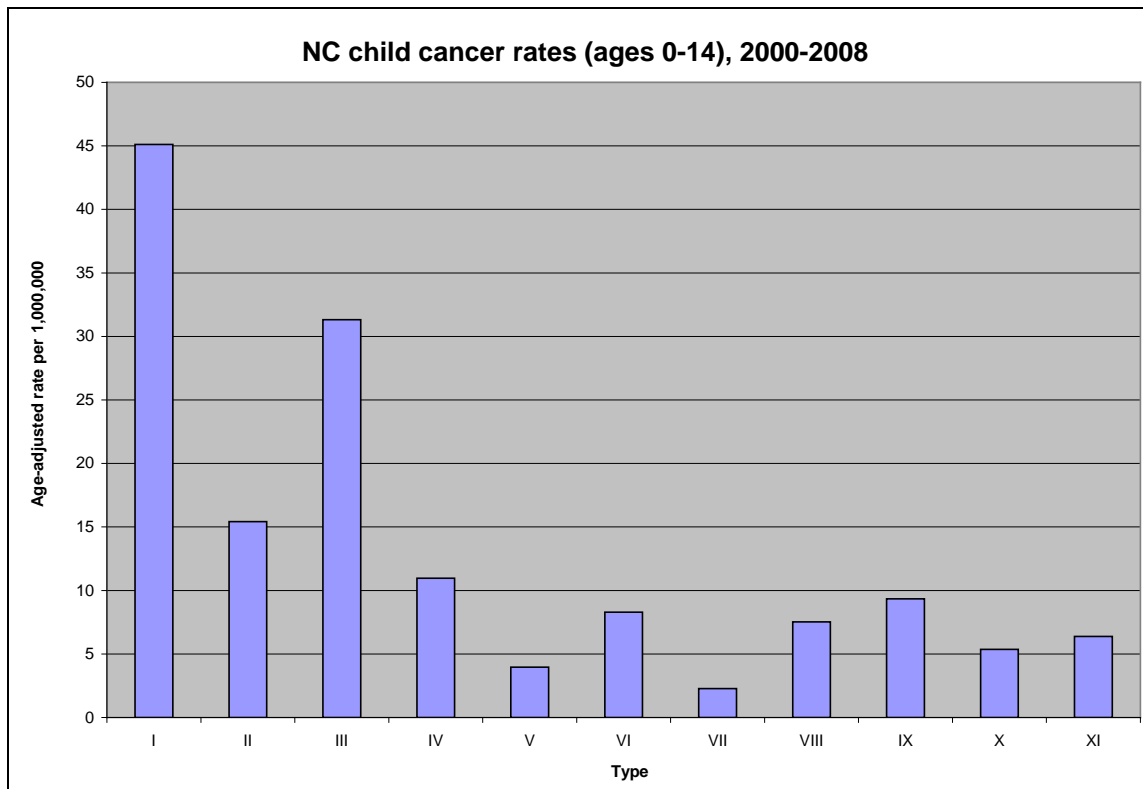
Figure 6: Age-adjusted annual incidence rates for childhood cancers (ages <20, all cancer sites) in North Carolina by county, 2005-2009²⁵

U.S. incidence rates are provided by the National Cancer Institute (NCI)'s Surveillance Epidemiology and End Results (SEER) database (<http://seer.cancer.gov/>) and the CDC's National Program of Cancer Registries (NPCR) (<http://www.cdc.gov/cancer/npcr/>).

²⁵ National Cancer Institute, State Cancer Profiles. Created by statecancerprofiles.cancer.gov on 3/31/2013. Accessed http://statecancerprofiles.cancer.gov/cgi-bin/quickprofiles/profile.pl?37&516#RT_ForAStateCounty 31 Mar 2013. Incidence rates (cases per 100,000 population) are age-adjusted to the 2000 U.S. Census population.

*Data have been suppressed to ensure confidentiality and stability of rare estimates. Counts are suppressed if fewer than 16 cases were reported in specific area-sex-race category. **Data have been suppressed for states with a population below 50,000 per sex for American Indian/Alaska Native or Asian/Pacific Islanders because of concerns regarding the relatively small size of these populations in some states.

U.S. incidence rates are provided by the National Cancer Institute (NCI)'s Surveillance Epidemiology and End Results (SEER) database (<http://seer.cancer.gov/>) and the CDC's National Program of Cancer Registries (NPCR) (<http://www.cdc.gov/cancer/npcr/>).



Type	Name	Age-adjusted rate per 100,000 persons	Lower 95% CI	Upper 95% CI
	ALL	147.41	141.19	153.84
I	Leukemia	45.12	41.71	48.74
II	Lymphoma and reticulo-endothelial neoplasms	15.42	13.43	17.62
III	CNS and misc intracranial & intraspinal neoplasms	31.31	28.47	34.36
IV	Sympathetic nervous system tumors	10.96	9.34	12.79
V	Retinoblastoma	3.96	3.02	5.1
VI	Renal tumors	8.29	6.88	9.91
VII	Hepatic tumor	2.28	1.58	3.2
VIII	Malignant bone tumors	7.53	6.15	9.12
IX	Soft-tissue sarcomas	9.34	7.82	11.07
X	Germ-cell, trophoblastic, & other geonodal neoplasms	5.36	4.24	6.69
XI	Carcinomas & other malignant epithelial neoplasms	6.38	5.13	7.85

Figure 7: NC child cancer rates per 1,000,000 persons by type (ages 0-14), 2000-2008²⁶

4. Maternal and child vulnerability

Healthy fetal growth and development depend on the health of the maternal-child system. Maternal vulnerabilities such as malnutrition and poverty may contribute to poor health

²⁶ United States Cancer Statistics: 1999-2008 Incidence, WONDER Online Database. United States Department of Health and Human Services, Centers for Disease Control and Prevention and National Cancer Institute; 2011. Accessed <http://wonder.cdc.gov/cancer-v2008.html> 24 Feb 2013 at 1:10:13 PM. Incidence rates are adjusted to the 2000 U.S. standard population in millions.

outcomes in the child.²⁷ In 2008, slightly more than half of all births in North Carolina hospitals (52.6%) were paid for by Medicaid (Table 4). About one in five mothers (20.8%) received prenatal care at a health department, and nearly half of mothers (41.8%) were enrolled in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) (Table 4).

Table 4: Socioeconomic and health care access vulnerabilities among NC mothers, 2008²⁸

Hospital births paid by Medicaid	Mothers receiving prenatal care at a health dept.	Mothers receiving WIC
52.6%	20.8%	41.8%

Breastfeeding is another important vulnerability indicator for early child health. Breastfeeding is a proven protective factor against negative health outcomes for both mother and child.²⁹ While the benefits of breastfeeding are well documented, one concern is that environmental and bio-accumulated contaminants such as organic chemicals may also be transmitted through breast milk.³⁰ The percentage of mothers in North Carolina who have ever breastfed their child increased from 2009 to 2010, nearing the Healthy People 2010 goal of 75 percent (Table 5). However, the percentage of mothers who breastfed exclusively through 3 months or 6 months decreased between 2009 and 2010 (Table 5). Results from the 2004-2008 National Immunization Survey found that prevalence rates of breastfeeding initiation and duration to 6 months and 12 months are highest among Hispanics and lowest among African Americans (Table 6).

²⁷ Lobo, I., & Zhaurova, K. (2008). Birth defects: causes and statistics. *Nature Education*, 1(1).

²⁸ North Carolina State Center for Health Statistics. 2009. North Carolina Health Statistics Pocket Guide. Table 7C: Demographic, Economic, and Health Resources Data, Birth and Medicaid Statistics. “2008 –Percent of Births to Medicaid Mothers, WIC Mothers, Health Department Mothers.” Accessed <http://www.schs.state.nc.us/schs/data/pocketguide/2009/PocketGuide.pdf> 13 Feb 2013.

²⁹ U.S. Department of Health and Human Services Office on Women’s Health, womenshealth.gov. Breastfeeding. Accessed <http://www.womenshealth.gov/breastfeeding/why-breastfeeding-is-important/index.html> 11 Apr 2013.

³⁰ CDC. Breastfeeding: Exposure to Environmental Toxins. Accessed http://www.cdc.gov/breastfeeding/disease/environmental_toxins.htm 11 Apr 2013.

Table 5: NC breastfeeding rates 2009-2010³¹

Breastfeeding metric	NC 2009	NC 2010	“Healthy People 2010” Goal
Ever breastfed	67%	74%	75%
Breastfed at 6 months	37%	36%	50%
Breastfed at 1 year	19%	19%	25%
Breastfed exclusively ³² through 3 months	30%	28%	40%
Breastfed exclusively through 6 months	13.1%	8.7%	25%

Table 6: Prevalence of breastfeeding initiation and duration to 6 months and 12 months in North Carolina by race/ethnicity, National Immunization Survey, United States, 2004–2008³³

Race/ethnicity	Number of respondents	Initiation (% confidence interval)	6 months (% confidence interval)	12 months (% confidence interval)
Hispanic	197	84.6% (78.8--90.4)	48.1% (40.3--55.9)	23.3% (16.8--29.8)
White, non-Hispanic	862	72.4% (68.3--76.5)	39.5% (35.6--43.4)	20.1% (17.1--23.1)
Black, non-Hispanic	186	49.8% (41.4--58.2)	19.5% (13.3--25.7)	11.3% (6.3--16.3)

III. Conclusion

Climate may influence patterns of human exposure to environmental factors, that may potentially change population risks in human development.³⁴ North Carolina should be vigilant in monitoring indicators of climate-related developmental health, including rates of infant mortality, preterm births, low birthweight births, birth defects, and childhood cancers. In addition, special consideration should be applied to addressing maternal and early childhood vulnerabilities that may reduce capacity for adaptation to climate-related environmental changes. The information presented in this report provides a baseline assessment whereby changes in the effects of climate can be tracked over time.

A special thank you to Dianne Enright, Bill Furney, Kathleen Jones-Vessey, Sarah McCracken-Cobb, and Robert Meyer for their review.

³¹ CDC Report Card: Promoting, Protecting and Supporting Breastfeeding in NC. Blueprint Status Report, December 2011. NC DHHS. page 1. Accessed <http://www.nutritionnc.com/breastfeeding/PDFS/NCBreastfeedingBlueprintStatusUpdateDecember2011.pdf> 13 Feb 2013.

³² “Exclusive breastfeeding” refers to nourishing a child through breast milk alone (no other food or beverage, including water).

³³ Home, C. D. C. Racial and Ethnic Differences in Breastfeeding Initiation and Duration, by State---National Immunization Survey, United States, 2004--2008. Accessed <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5911a2.htm> 16 Apr 2013. Data were suppressed when sample size was <50.

³⁴ Portier CJ et al 2010. A Human Health Perspective On Climate Change: A Report Outlining the Research Needs on the Human Health Effects of Climate Change. Research Triangle Park, NC: Environmental Health Perspectives/National Institute of Environmental Health Sciences. doi:10.1289/ehp.1002272. Accessed www.niehs.nih.gov/climate-report 12 Feb 2013.