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Asthma deaths in North Carolina: 1999–2016

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ABSTRACT

Introduction: Despite the significant decline in overall death rates in the U.S. over the past decade, many asthma deaths could have been avoided. Eastern North Carolina (N.C.) is an economically challenged region with significant health disparities and a high prevalence of asthma. *Objective:* The primary purpose of this project was to examine trends of asthma deaths across N.C. and identify counties in the state with the highest mortality rates over an 18-year period. *Methods:* CDC WONDER was used to query and evaluate age-adjusted asthma mortality rates from 1999 to 2016 among residents in N.C., greater than 1 year of age. Asthma death data were derived from death certificates using ICD-10 underlying cause-of-death codes J45 (asthma) and J46 (status asthmaticus). The Join point regression program was used to test statistical significance in age-adjusted rates for the U.S. and N.C. over the entire study period. *Results:* N.C. experienced a total of 2,066 decedents assigned as the underlying cause of deaths for an overall death rate of 12.5 per 1,000,000 persons. Death rates were highest among females (14.6 deaths per 1,000,000) and black or African Americans (24.7 per 1,000,000). *Discussion:* Overall asthma mortality rates in N.C. decreased. However, several rural and impoverished counties in eastern N.C. with a large percent of blacks or African-Americans, had the highest asthma death rates in the state. *Conclusion:* Healthcare providers should remain highly cognizant to provide optimal asthma management, education, and follow-up with asthma patients to help avoid unnecessary asthma related deaths.

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Mortality; surveillance; epidemiology; risk

Introduction

Most asthma deaths are considered avoidable [1,2]. However, in 2016, an estimated 3615 or approximately 10 persons per day died in the US of asthma [3]. Adults are four times more likely to die from asthma than children, women are more likely to die than men, and African-Americans are three times more likely to die from asthma than other races [3].

Reported risk factors associated with asthma mortality includes having severe, persistent asthma; large swings in peak expiratory flow, history of respiratory failure due to asthma, hospitalization or emergency room visit for asthma in the past year, recent prednisone dose reduction, excessive use of short-acting beta agonists (SABAs) poor adherence with asthma medications and/or with written action plan, substance abuse, food allergy, access to medical care and, depression or other psychological disorder [2,4–9]. Other studies document high asthma mortality rates attributable to racial disparities particularly among African-Americans, low income and populations with low education levels [10]. Importantly, the vast majority who die from asthma develop progressive symptoms anywhere from 12 h to several weeks before death, a time frame that would have allowed them to seek appropriate medical care.

As healthcare clinicians and researchers that collaborate in a rural, teaching hospital setting and work with a large percent of under served, high-risk patients with asthma, we were interested in asthma mortality trends across our state (North Carolina, NC). Other than few government surveillance reports and information found on the Centers for Disease Control and Prevention website [11], we could not locate any peer-reviewed studies that specifically

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examined asthma mortality in NC. The primary objective of this project was to investigate and document asthma death rates over an 18-year period in NC, while noting significant geographical areas with higher rates of asthma mortality. Results from this surveillance study can be used to inform healthcare providers, policy makers and public health authorities for monitoring asthma mortality trends, allocating resources and targeting increased asthma care, education and awareness.

Methods

This was primarily an epidemiological, surveillance project to evaluate asthma death trends over time. Mortality data were analyzed using CDC WONDER, an interactive, public-use Web-based tool [12]. Data derived from CDC WONDER is supplied by the National Vital Statistics System's (NVSS) information files that contains all resident death certificates filed in the 50 states and District of Columbia (DC). Deaths caused by asthma were defined using *International Classification of Diseases, 10th Revision* underlying cause-of-death codes J45 (asthma) and J46 (status asthmaticus) which asthma was the underlying cause of death listed on the death certificate.

CDC WONDER queries generated numbers of deaths, unadjusted and age-adjusted rates (per 1,000,000 population), with 95% confidence intervals (CIs) and standard errors for groups defined by characteristics including year, gender, age group (1–4, 5–14, 15–24, 25–34, 35–44, 45–54, 55–64, 65–74, 75–84 and 85+), race/ethnicity (White, Black or African American, American Indian/Alaska Native, Asian/Pacific Islander and Hispanic origin). Infant deaths (<1 years) were not included. The number and percentage of deaths that occurred in urban classification (2013) [13], day of week and place of decedent's death were also obtained. We used the National Center for Health Statistics six category urban–rural classification scheme. Age-adjusted and unadjusted mortality rates by age group, gender, race, ethnicity and year were calculated using the direct method (2000 US Census Bureau standard population estimates), 95% CIs and standard errors.

Asthma deaths rates in 1999 and 2016 were compared to determine percent change (either increase or decrease) among gender, race and age groups. Age-adjusted asthma mortality rates were assessed for the US and NC using Joinpoint regression program [14] to test the statistical significance of trends in age-adjusted rates for the period 1999–2016. ArcGIS was used to map county-level unadjusted asthma mortality rates (deaths per 1,000,000) for aggregated years of 1999–2016 for each 100 NC counties.

Results

As shown in Table 1, NC had a total of 2066 decedents asthma or status asthmaticus assigned as the underlying cause of death or a death rate of 12.5 persons per 1,000,000 population (Table 1). Males died at an average age-adjusted death rate of 9.6 (per 1,000,000), while the death rate among females was 14.6 deaths (per 1,000,000). Unadjusted death rates increased with each age group, starting with 2.2 deaths (per 1,000,000), among the youngest (1–4-year-old) age group, to 118.1 deaths among those 85 and older. Among race and ethnicity, blacks or African-Americans had the highest age-adjusted death rate of 24.7 deaths while reported asthma deaths among those of Hispanic origin were 5.5 deaths (per 1,000,000). Among urbanization, higher average death rates in medium metro (34.2%) and micropolitan (22.2%) areas. The highest percent of asthma deaths occurred on a Friday (15.5%) and occurred most frequently in an inpatient medical facility (34.7%) followed by the decedent's home (27.2%). Among asthma deaths, autopsies were reported on 237 or 11.5% of death certificates.

As shown in Figure 1, the overall, age-adjusted mortality rate at the national level decreased from 17.2 deaths in 1999 to 10.1 deaths in 2016. NC experienced a similar decline with an age-adjusted death rate of 17.4 deaths in 1999 to 9.9 deaths in 2016.

As shown in Figure 2, unadjusted rates among white males declined from 7.6 deaths to 4.5 deaths in 2016. Asthma death rates among black males decreased from 23.4 deaths in 1999 to 18.7 in 2002; fluctuated from 2003 to 2015, and then reached the highest rate at 25.0 deaths in 2016.

As shown in Figure 3, unadjusted deaths rates among black females were the highest with 40.3 deaths in 1999, fluctuating across the study period until decreasing to 20.4 deaths in 2016. In comparison with black females, a higher number of asthma deaths were reported among white females. However, the unadjusted rate for white females was considerably lower at 17.4 in 1999, declining to 8.7 deaths in 2016.

When differences of mortality rates were compared between the two years, 1999 and 2016 (Table 2), NC experienced a 43.1% decrease in the overall death rate of asthma deaths. Males saw a decrease in the average

Table 1. Characteristics of asthma deaths in North Carolina, 1999–2016.

Characteristic	No. of deaths (% of asthma deaths)	Average death rate	95% CI	SE
North Carolina	2066 (100.0)	12.5	(11.9–13.0)	0.3
Gender				
Males	717 (34.7)	9.6	(8.9–10.3)	0.4
Females	1349 (65.3)	14.6	(13.8–15.4)	0.4
Age group (yrs.)[a]				
1–4	19 (0.9)	2.2	(1.3–3.5)	0.5
5–14	67 (3.2)	3.1	(2.4–3.9)	0.4
15–24	87 (4.2)	3.8	(3.1–4.7)	0.4
25–34	119 (5.8)	5.3	(4.4–6.3)	0.5
35–44	235 (11.4)	10.0	(8.7–11.2)	0.7
45–54	306 (14.8)	13.3	(11.8–14.8)	0.8
55–64	316 (15.3)	17.1	(15.3–19.0)	1.0
65–74	321 (15.5)	26.4	(23.5–29.3)	1.5
75–84	305 (14.8)	44.5	(39.5–49.5)	2.6
85+	291 (14.1)	118.1	(104.5–131.7)	6.9
Race/ethnicity				
White	1201 (58.1)	9.2	(8.7–9.7)	0.3
Black or African-American	821 (39.7)	24.7	(22.9–26.4)	0.9
American Indian or Alaska Native	30 (1.5)	16.7	(10.8–24.6)	3.3
Asian or Pacific Islander[a]	14 (0.7)	3.7	(2.0 – 6.1)	1.0
Hispanic origin	29 (NS)	5.5	(3.2–8.9)	1.3
Urbanization				
Large Central Metro	249 (12.1)	9.6	(8.4–10.8)	0.6
Large Fringe Metro	206 (10.0)	10.2	(8.8–11.6)	0.7
Medium Metro	707 (34.2)	11.6	(10.8–12.5)	0.4
Small Metro	227 (11.0)	15.2	(13.2–17.2)	1.0
Micropolitan (non-metro)	459 (22.2)	15.7	(14.2–17.1)	0.7
Non-Core (non-metro)	218 (10.6)	17.1	(14.8–19.4)	1.2
Weekday				
Sunday	279 (13.5)	NA	NA	NA
Monday	293 (14.2)	NA	NA	NA
Tuesday	285 (13.8)	NA	NA	NA
Wednesday	308 (14.9)	NA	NA	NA
Thursday	276 (13.4)	NA	NA	NA
Friday	320 (15.5)	NA	NA	NA
Saturday	305 (14.8)	NA	NA	NA
Place of death[b]				
Medical facility – inpatient	716 (34.7)	NA	NA	NA
Medical outpatient or ER	499 (24.2)	NA	NA	NA
Medical DOA	58 (2.8)	NA	NA	NA
Decedent's home	562 (27.2)	NA	NA	NA
Hospice	10 (0.5)	NA	NA	NA
Nursing home/long-term care	154 (7.5)	NA	NA	NA
Other	55 (2.7)	NA	NA	NA
Autopsy				
Yes	237 (11.5)	NA	NA	NA
No	1038 (50.2)	NA	NA	NA
Unknown	791 (38.3)	NA	NA	NA

Source: CDC WONDER (1999–2016).

NA = not available; NS = not stated. Data are suppressed when the data meet the CDC criteria confidentiality constraints. Deaths of persons with Hispanic origin "not stated" are included in "All" counts and rates, but are not distributed among Hispanic Origin groups, so are not included in the Hispanic Origin specific counts and rates.

Decedents include those who had *International Classification of Diseases, 10th Revision* codes J45 (asthma) or J46 (status asthmaticus) assigned as the underlying cause of death (i.e. the disease or injury that initiated the chain of morbid events leading directly to death, or the circumstances of the accident or violence that produced the fatal injury).

[a]Unadjusted rate.

[b]Numbers and percent do not equal 100% because some deaths were suppressed because of confidentiality constraints. Deaths are per 1,000,000 population; Numbers and rates do not include <1 age group. Age-adjusted asthma death rates per 1,000,000 calculated using the 2000 US Census standard population.

age-adjusted death rate of 30.5%, or 13.1 in 1999, to 9.1 deaths in 2016. The average age-adjusted death rate decreased 49% among females, from 20.8 deaths in 1999 to 10.6 deaths in 2016. Age-adjusted rates among blacks were 39.1 deaths in 1999 and declined to 22.8 deaths in 2016, for a 41.7% decrease in the age-adjusted death rate. Whites saw a decrease in death rate from 12.3 in 1999 to 6.3 deaths in 2016, or a 48.8% change. Among age groups, the highest percent change in asthma death rates among adults aged 65 and older was from 71.7 in 1999 to 17.2 deaths in 2016, or a 76.0% decrease.

County-level asthma death rates ranged from 10 or less deaths to 30 or more deaths (per 1,000,000) (Figure 4). NC counties with the highest average asthma mortality rates were in the eastern part of the

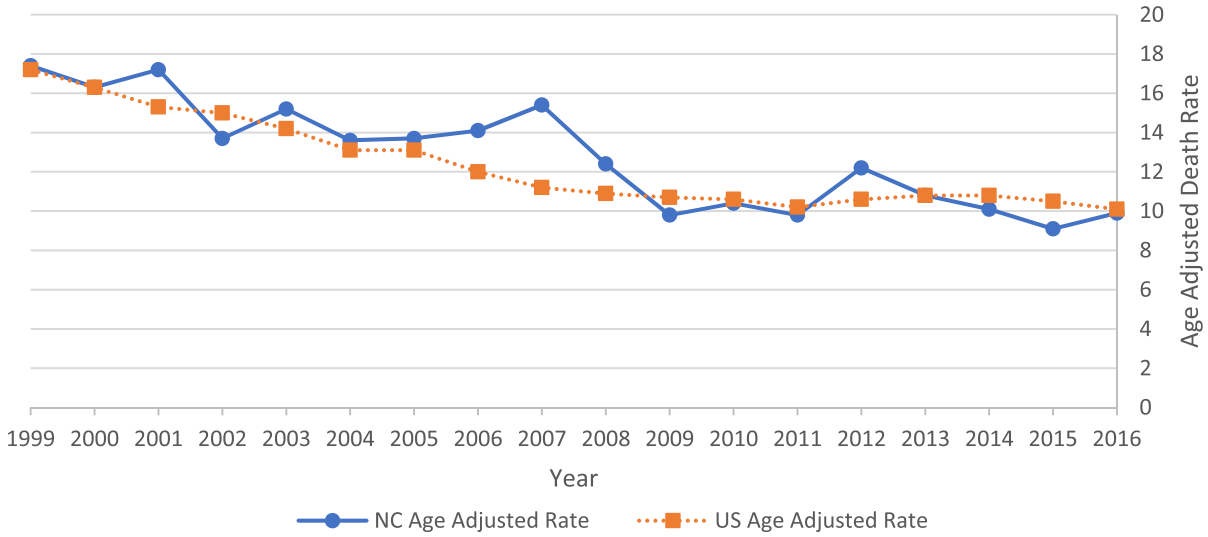


Figure 1. Age-adjusted asthma deaths (per 1,000,000), in North Carolina and the United States, 1999–2016. Note: Joinpoint regression analysis ($p < 0.05$). Source: CDC WONDER (1999–2016).

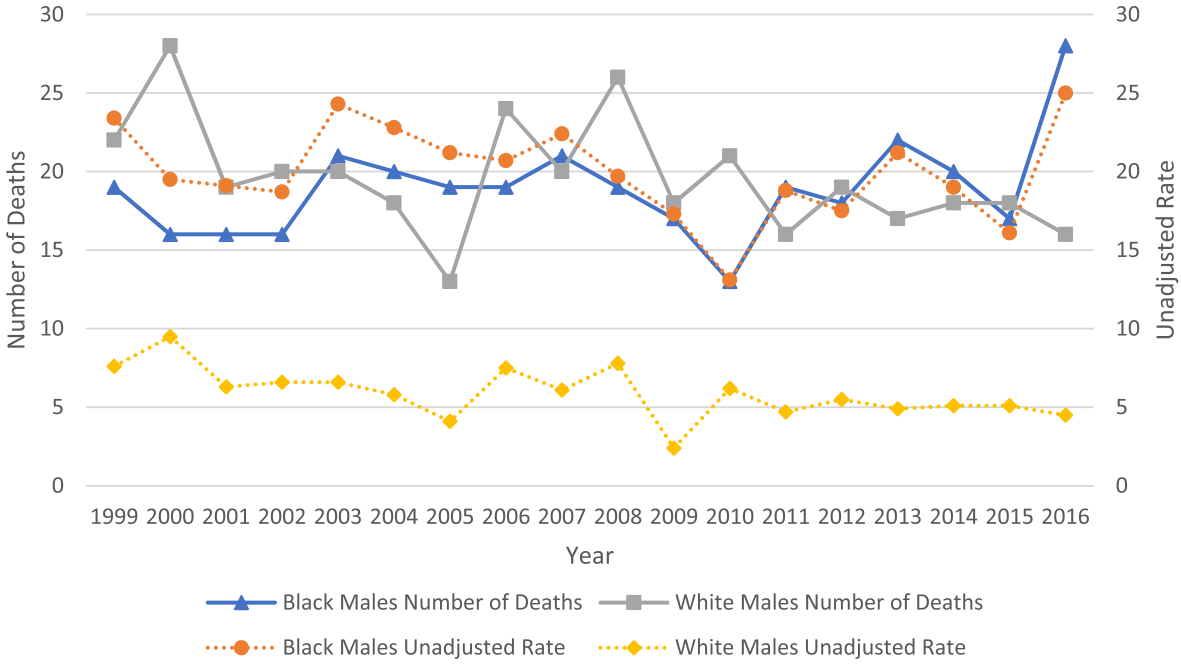


Figure 2. Number of asthma deaths and unadjusted asthma rates among white and black males, North Carolina, 1999–2016. Source: CDC WONDER (1999–2016).

state and included Northampton, Bertie, Beaufort and Pamlico Counties.

Discussion

From 1999 to 2016, NC experienced an overall 43.1% reduction, or an average of 2.4% asthma deaths per year. Considering the prevalence and incidence of asthma and asthma-related ED visits have historically increased among all age sex and racial groups [3], asthma death rates across the US have seen an overall significant decrease. Starting in the mid-1990s, asthma mortality rates at the national level have witnessed an overall decline. From 2001 to 2015, the national asthma death rate fell from 15 deaths to 10.3 deaths (per million population), or approximately by one-third [3,15]. Advances in asthma medication, the wide use of inhaled corticosteroids, improvements in asthma management and effective prevention efforts have played significant roles in this extraordinary decline [15,16].

In this study, we identified higher mortality rates among blacks or African-Americans, females and the elderly in NC. When we compared asthma death rates with the national asthma mortality trends, we found similar results among age-groups, race and gender.

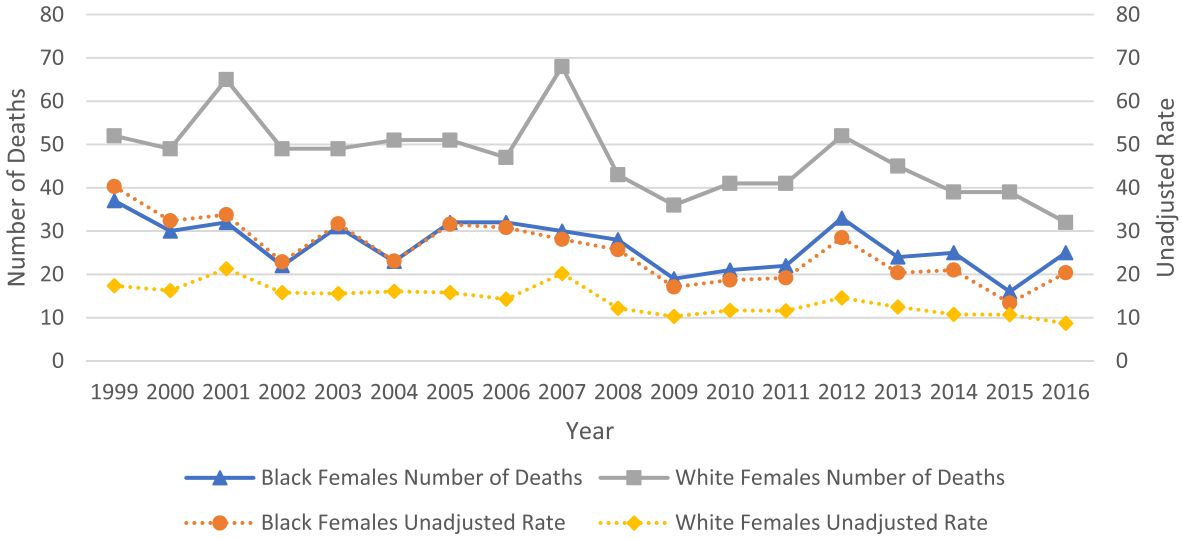


Figure 3. Number of asthma deaths and unadjusted asthma rates among white and black females, North Carolina, 1999–2016. Source: CDC WONDER (1999–2016).

Table 2. Differences in the number of asthma deaths and asthma death rates in North Carolina, 1999–2016.

Characteristic	1999 *N* (%) of deaths	Death rate	(95% CI)	2016 *N* (%) of deaths	Death rate	(95% CI)	% Change from 1999 to 2016
Overall asthma deaths[a]	132 (100)	17.4	(14.2–20.4)	102 (100)	9.9	(7.9–11.8)	−43.1
Gender							
Males	42 (31.8)	13.1	(9.3–17.9)	43 (42.2)	9.1	(6.5–12.4)	−30.5
Females	90 (68.2)	20.8	(16.7–25.7)	59 (57.8)	10.6	(8.0–13.8)	−49.0
Race							
Black or African American	56 (42.4)	39.1	(29.4–51.0)	52 (51.0)	22.8	(16.9–30.2)	−41.7
White	74 (56.0)	12.3	(9.6 – 15.8)	48 (47.1)	6.3	(4.6 – 8.4)	−48.8
Age group[a]							
25–34	NS	NS	NS	12 (11.8)	8.9	(4.6–15.7)	
35–44	16 (12.1)	12.5	(7.1–20.3)	21 (20.6)	16.3	(10.1–24.9)	+30.4
45–54	14 (10.6)	13.3	(7.2–22.2)	12 (11.8)	8.7[4]	(4.5–15.1)	−34.6
55–64	18 (13.6)	25.4	(15.0–40.1)	20 (19.6)	15.4	(9.4–23.7)	−39.4
>65+	69 (52.3)	71.7	(55.8–90.8)	27 (26.5)	17.2	(11.3–25.0)	−76.0

Source: CDC WONDER (1999–2016).

Abbreviations: NA = not available; NS = not stated. Data are suppressed when the data meet the CDC criteria confidentiality constraints. Deaths of persons with Hispanic origin "not stated" are included in "all" counts and rates, but are not distributed among Hispanic Origin groups, so are not included in the Hispanic Origin specific counts and rates.

Deaths are per 1,000,000 population; numbers and rates do not include <1 age group. Age-adjusted asthma death rates per 1,000,000 calculated using the 2000 US Census standard population.

Decedents who had *International Classification of Diseases, 10th Revision* codes J45 (asthma) or J46 (status asthmaticus) assigned as the underlying cause of death (i.e. the disease or injury that initiated the chain of morbid events leading directly to death, or the circumstances of the accident or violence that produced the fatal injury).

[a]Unadjusted rate.

Within this context, studies repeatedly have observed racial differences in asthma mortality rates for African-Americans with death rates approximately four- to five-fold higher than other racial groups [17]. In other studies, individuals of African descent with asthma have been shown to have more severe asthma and morbidity, higher IgE levels, be less responsive to asthma treatment, less access to healthcare [18], and display clinical differences in perception and reporting of asthma symptoms than races of European descent [19,20]. The complexity of asthma makes it difficult to explain why these racial differences exist, although, genetic variation and gene–environment interaction appears to play major roles [20,21].

In addition to black race, women are at higher risk and suffer disproportionally from asthma than men. Women are nearly twice as likely to visit the emergency department for asthma, have higher hospitalization rates [22] and have nearly four times higher death rates as men [23]. Although, it has been difficult to explain why gender differences exist in asthma [24], it is well documented that asthma is more prevalent and severe in young boys [22], but following puberty, switches to females. Research studies suggest genetic and hormonal factors and/or difference in gender-specific responses to environmental or occupational exposures as likely explanations, but no single, direct mechanism has been identified [25,26].

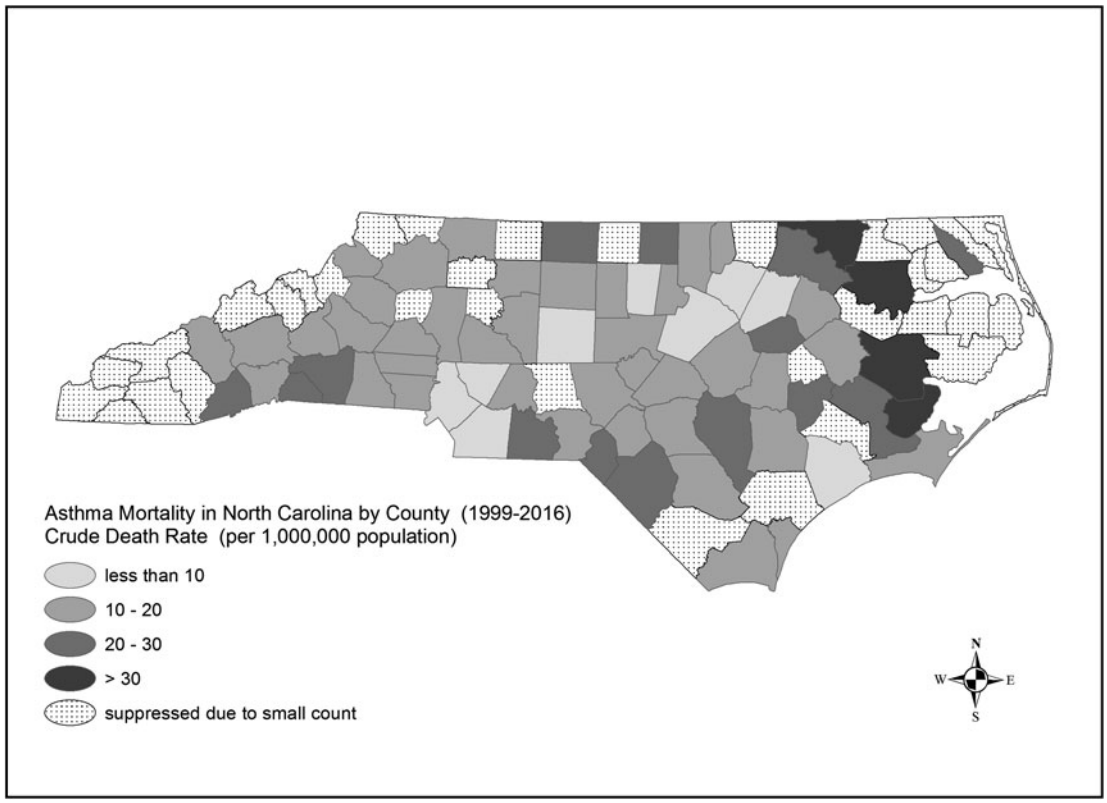


Figure 4. Asthma death rates by county (per 1,000,000), North Carolina, 1999–2016. Source: CDC WONDER (1999–2016).

Although the 65 and older age group had the highest death rates in NC, the same group saw the biggest decrease from 1999 to 2016 in percent change. When we examined the national crude death rates, we found a similar trend, with mortality rates decreasing for those 65 and older from 69.5 deaths (per 1,000,000) in 1999 to 29.2 (deaths per 1,000,000) in 2016, for a 40.3% decrease, or 58% change. Overall, the elderly suffers disproportionately from the burden of asthma and general airway diseases. The reasons are multifaceted, and have been associated with pulmonary changes of aging, perceptions of dyspnea and its meaning to older people, difficulties in asthma diagnosis and the burden of medication and co-morbidities [27]. Socioeconomic factors, lack of access to medical care, physical frailty, self-management and reluctance to seek medical emergency medical care have also been cited [8,27]. Among older adults with asthma, more than half report one or more coexisting health conditions with higher rates among women [28,29].

Given that African-Americans are far greater disproportionally at increased risk for asthma deaths than whites, it was not surprising to find counties in the eastern region (Northampton, Bertie, Beaufort and Pamlico Counties) with the highest percent of black race, with the highest asthma death rates. Nevertheless, it is critical to point out that the same counties we identified with higher asthma mortality, were also counties identified in other studies with a significantly higher prevalence of asthma [30], and higher rates of asthma-related emergency department visits than other counties in the state [31]. We feel that these finding alone arean important contribution to NC asthma surveillance and should be shared with healthcare providers, school nurses and policy makers. We suspect, that in addition to being of black race, that social determinants, including poverty, low education, substandard housing, access to care and having few primary care physicians in these counties are major contributing risk factors for these elevated asthma mortality rates. However, our suspicions require more in-depth investigative research to uncover more precisely why these higher rates are occurring. Until these factors are better established, increased public health efforts should be emphasized and placed on asthma outreach and education in these rural and underserved eastern NC counties to help reduce the asthma burden.

Other risk factors for asthma mortality

In addition to race/ethnicity, gender and age, as described above, other contributing risk factors for

Table 3. Contributing risk factors for death from asthma [15,44–49].

Asthma history and self-management
Severe, persistent asthma
Previous severe exacerbations
Two or more hospitalizations for asthma in the past year
Three or more emergency department visits in the past month
Using >2 canisters of short-acting beta$_2$-agonist per month
Lack of written action plan
Social determinants
Low-SES
Unhealthy residential environments (e.g. poor quality housing)
Poor access to healthcare and delivery
Major psychosocial problems
Comorbidities
Depression or other psychiatric illness
Cardiovascular disease
Other chronic lung disease(s)

asthma mortality have been cited in the literature that broadly includes, asthma history and self-management; comorbidities and social determinants (Table 3). Several published studies and national reports have identified that over-prescription and excessive use of short-acting bronchodilators, under-prescription of preventer medication and inappropriate prescribing of long-acting beta-agonist bronchodilator inhalers as the sole form of treatment have been associated with markedly increased risk of asthma death [2,32,33].

In addition, preventable risk factors have been repeatedly identified in the literature in the majority of asthma deaths. In a case-control study, Abramson and colleagues identified cases of asthma death were significantly less likely to use a peak flow meter and have a written action plan than asthma controls [8]. Interestingly, studies abroad show that over half of those who died from asthma were being treated for mild or moderate asthma at the time suggesting healthcare providers may have underestimated the severity level of their asthma patient [34]. Sherrington and colleagues found that 10% of those with asthma died within one month of discharge from hospital following treatment for asthma and at least 21% had attended an emergency department at least once in the previous year [35]. In the emergency department setting, rapid implementation of evidence-based, multi-disciplinary care has been shown to ensure the best possible outcomes, including that out-going patients stable for discharge receive medications, asthma education, a written asthma action plan and follow-up [36]. Asthma programs, such as Vidant Medical Center's, Pediatric Asthma Program in Greenville, NC, has long served pediatric asthma patients in the region, by helping families gain control of their child's asthma following hospital discharge [37]. Similar programs are needed to target not only children, but adults with asthma, particularly among high risk populations in rural and underserved areas. In more recent years, an area that has gained considerable momentum under the Patient Protection and Affordable Care Act is the implementation of community health workers (CHWs) [38]. CHWs have been shown to be successful for working with individuals with chronic disease management [39] including adults with asthma [40] and continue to show high promise particularly in rural and underserved areas where healthcare shortages exist.

Other factors beyond the control of the individual with asthma, including social determinants have been shown to predict higher levels of asthma mortality for a broad range of conditions including living environments (e.g. indoor air pollution and asthma triggers), and social conditions (e.g. family social support, partner violence) [41,42]. In addition, various types of comorbidities including coronary artery, psychiatric disease and overlap with COPD have been correlated with higher rates of asthma mortality [43].

In general, this study provides an evaluation of asthma mortality trends in NC over an 18-year period. However, the results should be interpreted with caution. Limitations of mortality studies of this nature, often include complications inherent with death certificates. Such concerns include inaccuracies in diagnosis, incorrect coding and measuring mortality with only asthma listed as the primary cause of death on the death certificate, which could underestimate overall total asthma mortality [4]. Another limitation was not having the ability to adjust for population migration which could have influenced the overall estimated rates, including the racial and ethnic disparities. As a note, we used the 2000 US Census Bureau population standard estimates as the default denominator in WONDER for calculating age-adjusted and crude mortality rates. The choice of using "non-standard population" estimates (for each year) was also available as an option in WONDER. However, when we ran the data using both the 2000 standard population estimates and the nonstandard population rates and made comparisons, the differences between death rates among all race, age, etc., between the two were negligible.

Conclusions

Given the increasing burden of chronic health conditions that plague our society and the healthcare system, the noted decreasing trend in asthma deaths is a significant and positive achievement. At the same time, it is important to bear in mind that while

asthma mortality has continued to decline in the US, the majority of asthma deaths are still considered preventable [2,44]. To continue to reduce the asthma mortality trend in NC, it is important that healthcare providers remain highly cognizant to implement optimal asthma diagnosis, management, education, and importantly, patient follow-up. Monitoring population asthma mortality trends can be an important component for identifying geographical areas to target to raise awareness when considering public health asthma awareness campaigns and to help avoid unnecessary asthma deaths.

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Disclosure statement

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