Running the Numbers

A Periodic Feature to Inform North Carolina Health Care Professionals About Current Topics in Health Statistics

County Level Dynamics of Heroin Mortality in North Carolina

In North Carolina, the number of opioid overdose deaths has increased by nearly 800% between 1999 and 2016 [1]. Prior to 2010, over two-thirds of opioid deaths were the result of prescription opioids, but since 2013, prescription opioids have been responsible for less than 45% of opioid overdose deaths, and opioid deaths by illicit drug use have increased dramatically [1].

One goal of North Carolina's Opioid Action Plan from June 2017 is to reduce the number of deaths from opioid overdose by 20% by 2021 [1]. County level mortality trends must be examined to effectively deploy resources to achieve this goal. This analysis characterizes the dynamics of the opioid epidemic with regard to heroin overdose deaths in North Carolina. The purpose of our analysis is to investigate whether there is variation in the pattern of heroin mortality among counties and identify counties within North Carolina that may be used to inform both potential solutions and areas of greatest need.

Calculating Opioid Overdose Mortality

We calculate and report the crude rate of death per 100,000 persons. Opioid poisoning deaths from 1999 to 2016 were obtained from the North Carolina Division of Public Health Injury and Violence Prevention Branch's county level poisoning data [2]. Our analysis primarily focuses on ICD-10 code T40.1 (heroin), but we include a comparison in some models to ICD codes T40.0-T40.4 (which includes methadone, opium, opioids, and other synthetics). Only unintentional deaths were included, which used the code X40—X44. Deaths were counted in county yearly totals with any mention of the above codes, thus it is possible that a single death could be counted multiple times if the medical examiner recorded the presence of multiple opioids.

We use intercensal population estimates from 1999 to 2015 as reported by the Centers for Disease Control (CDC) [3]. For 2016, we use population estimates from the North Carolina Office of State Budget and Management [4]. For our measure of rurality, we use the proportion of the population in a county identified as living in a rural area in 2010 by the US Census Bureau [5]. The US Census Bureau does not report this figure in non-census years. We use annually reported opioid prescriptions per person for each county from 2006 to 2016 obtained from the QuintilesIMS Transactional Data Warehouse [6]. Prescribing rates average 0.94 per person per year, with a range of 0 to 2.25.

Counties categorized as High Intensity Drug Trafficking Areas (HIDTA) are designated by the federal Drug Enforcement Agency due to significant illegal drug productivity, manufacturing, importation, or distribution [7]. All analyses were conducted using R. First, we use logistic models with random county effects (see Table 2). The models adjust for both the reported effects and allow rates in counties to correlate over time. We model trajectories with a discontinuity in 2010. In supplementary analyses, we found associations with certain demographic characteristics for opioid mortality rate (but not heroin mortality rate). We do not include these covariates in reported models because of the risk of ecological fallacy and collider bias [8].

Second, we use finite mixture models to clas-

Electronically published May 7, 2018.

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N C Med J. 2018;79(3):195-200.
0029-2559/2018/79317

TABLE 1.
Descriptive Statistics for County Classifications

Classification	Number of Counties	Proportion of Counties in High Drug Trafficking Area	Proportion of Population Living in Rural Areas	Prescriptions per Person	Mean Unintentional Heroin Mortality Rate	Mean Unintentional Opioid Mortality Rate
High	4	0.25	0.3	1.28	4.48	13.67
Mid-1	27	0.22	0.46	0.94	2.05	9.23
Mid-2	6	0.50	0.17	0.80	1.63	5.87
Mid-3	34	0.12	0.69	0.95	0.98	9.3
Low	29	0.03	0.8	0.93	0.25	9.08

Note: Rates calculated as events per 100,000.

sify counties based on different trajectories of heroin death rates. These models assign counties to classes of similar trajectories. We model crude heroin rates assuming a log-normal distribution with a cubic function for the year effect. Based on the Bayesian Information Criterion method, a 5-class solution is preferred. Differences in county level trajectories of heroin rates are identified in Figure 1b and the most probable class assignment by county is depicted in Figure 1a.

Changes in Heroin Mortality Rate

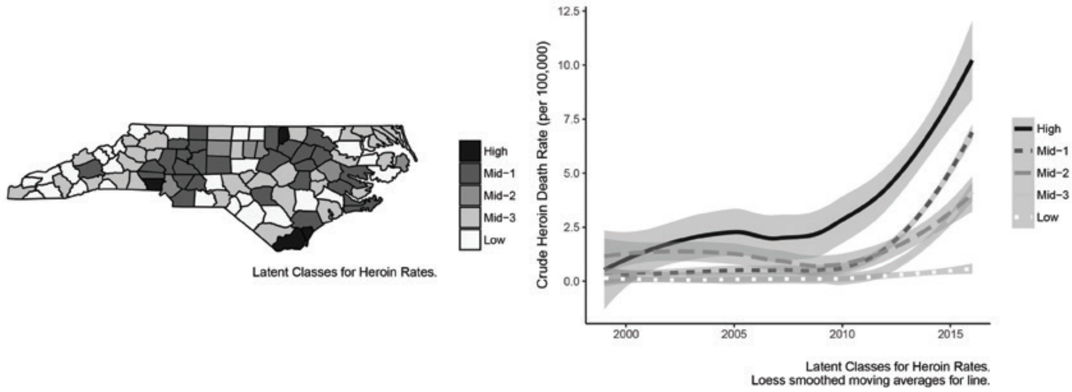
Figure 1 shows the 5-class solution from a latent class mixture analysis. Counties are matched to classes with the most similar trajectories of heroin death rates between 1999 and 2016. Four counties (Brunswick, Gaston, New Hanover, and Vance) have the highest and most quickly increasing heroin rates. These counties, while geographically varied, display distinct patterns in the changes in heroin mortality rate from 2010 to 2016. Conversely, 29 counties (29%) have stable and low rates of heroin death. The rest of the counties have experienced increasing numbers of heroin death rates beginning in 2010 (see Figure 1). Refer to Table 1 for the descriptive statistics for each classification group and to the Supplementary Table for the names of counties listed in each group.

TABLE 2.
Multivariable Associations of County-Level Characteristics with Heroin and Opioid Mortality Rates

	Unintentional Heroin Mortality Rate		Unintentional Opioid Mortality Rate	
	Odds Ratio	95% Confidence Interval	Odds Ratio	95% Confidence Interval
High Drug Trafficking Area	1.00	0.68 – 1.47	1.17	0.81 – 1.70
Proportion of Population Living in Rural Areas	0.23***	0.12 – 0.42	0.85	0.65 – 1.11
Prescriptions per Person	0.97	0.65 – 1.43	1.22*	1.01 – 1.47
Selected Years (relative to 2010)				
2006	1.19	0.79 – 1.60	0.98	0.89 – 1.08
2010 (reference)	1.00	–	1.00	–
2016	9.58***	5.02 – 14.13	1.71	1.22 - 2.20

**P* value < 0.1, ***P* < 0.05, ****P* < 0.01

FIGURE 1.
Classification of Counties by Changes in Unintentional Heroin Overdose Rate



Note: See text and Supplementary Table: Figure 1a shows the geographic distribution of each group across the state and Figure 1b shows the smoothed unintentional heroin mortality rate for each group, 1999 to 2016. The high and low groups have persistently different heroin rates. In contrast, the start and speed of increase in heroin mortality distinguishes each of the three middle groups, with Mid - 1 having the earliest increase in heroin mortality and Mid-3 having the latest rise in heroin mortality.

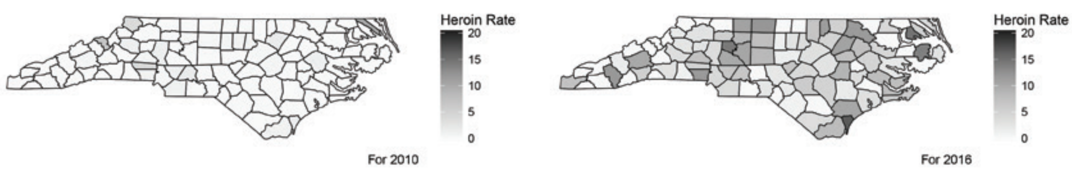
Unlike commonly prescribed opioids, which are available and legal in every county, heroin and other illicit drugs may not be present in every county. Figure 2 shows the relative change in the heroin death rate by county in North Carolina. While the overall heroin death rate in the state has increased over 1000% since 2010, there are 29 counties where the rate of heroin deaths remained constant or decreased. On the other hand, there are 15 counties where the rate of heroin deaths increased by over 10 per 100,000 persons during this same time period.

In multivariate analysis, the county level increase in heroin mortality rate is significantly and inversely associated with rural population proportions (OR=0.23, CI=0.12-0.42). In other words, heroin mortality rate is growing fastest in the most urban areas of our state. The results from our logistic model with random effects are reported in Table 2. In contrast to the statistically significant association with rural population proportions, we do not find evidence of a relationship with prescription opioids per person or High Intensity Drug Trafficking Areas. This contrasts with the broader category of opioid death rates, where there is no association with rurality, and a positive association with prescription rates (OR=1.22, 95% CI=1.01 – 1.47).

Results

Across North Carolina, heroin death rates have increased 10-fold, but our analysis shows that the temporal dynamics and composition of these heroin death rates vary significantly from county to county. In addition, county level variation in unintentional heroin mortality rate is different from trends associated with other opioids. Unintentional

FIGURE 2.
Unintentional Heroin Mortality Rates by County in 2010 and 2016



Note: This figure displays a side-by-side comparison of unintentional heroin mortality rates by county in 2010 and 2016. The unintentional heroin mortality rate is reported per 100,000 persons. Overall in 2010, there were very few heroin deaths relative to 2016.

SUPPLEMENTARY TABLE.
Descriptive Statistics for County Classifications

High (N = 4)	Mid-1 (N = 27)	Mid-2 (N = 6)	Mid-3 (N = 34)	Low (N = 29)
Brunswick	Beaufort	Dare	Alamance	Anson
Gaston	Buncombe	Durham	Alexander	Ashe
New Hanover	Cabarrus	Guilford	Alleghany	Avery
Vance	Carteret	Mecklenburg	Burke	Bertie
	Catawba	Orange	Caldwell	Bladen
	Craven	Pitt	Camden	Caswell
	Cumberland		Cherokee	Chatham
	Davidson		Cleveland	Chowan
	Davie		Columbus	Clay
	Edgecombe		Currituck	Duplin
	Forsyth		Gates	Graham
	Franklin		Greene	Haywood
	Granville		Harnett	Hoke
	Halifax		Henderson	Hyde
	Iredell		Hertford	Jones
	Lincoln		Jackson	Macon
	Nash		Johnston	McDowell
	Pender		Lee	Mitchell
	Randolph		Lenoir	Montgomery
	Rowan		Madison	Northampton
	Stanly		Martin	Person
	Stokes		Moore	Polk
	Union		Onslow	Robeson
	Wake		Pamlico	Scotland
	Wayne		Pasquotank	Surry
	Wilson		Perquimans	Swain
	Yadkin		Richmond	Transylvania
			Rockingham	Washington
			Rutherford	Yancey
			Sampson	
			Tyrrell	
			Warren	
			Watauga	
			Wilkes	

heroin mortality rates show a significant relationship with areas of high population density, and an extremely rapid increase in rate.

The rapid increase in unintentional heroin mortality is consistent with national trends and reported through other data sources in North Carolina [9, 10]. Further, Dasgupta and colleagues analyzed the growing number of deaths from heroin overdose from 2007 to 2013 in North Carolina and found similar associations with urbanity as well as with age and race [10]. Identifying the causes for the increase in heroin mortality and geographic distribution requires further analysis. Previous research shows that during this time period, heroin supply has increased nationally and price is at an all-time low [11]. These factors, along with the increase of fentanyl and fentanyl analogues in the heroin supply, could be strong contributors to the observed increase in mortality. Since 2013, the CDC reported that half of the increase in heroin-involved deaths is attributable to increases in deaths involving use of both heroin and fentanyl [12].

The results of our study should be read in light of a few limitations. First, the data are aggregated from death certificates and are not mutually exclusive. Both individual-level data and data regarding burdens of the opioid crisis other than death (such as variations in emergency department visits, hospitalizations, and secondary problems from unsafe injection practices) could provide a more comprehensive picture of county level differences.

Despite these limitations, our analysis demonstrates the variation in the dynamics of unintentional heroin mortality patterns and suggests that interventions should be tailored to areas of need throughout the state. For example, in areas of high heroin mortality, resources related to safe injection practices and needle exchanges could help alleviate the spread of infections from Hepatitis C virus, human immunodeficiency virus (HIV), and from bacterial infections like endocarditis [13]. In all counties, however, there are treatment and harm reduction interventions that can be implemented regardless of the cause of the opioid overdose, such as increasing access to naloxone and evidence-based addiction treatment.

Conclusion

As a state, North Carolina has observed a 10-fold increase in unintentional heroin deaths from 2010 to 2016. Within this same time period, there were 4 counties in which the number of heroin deaths increased 13-fold. On the other end of the spectrum, however, more than a quarter of the counties showed close to 0 unintentional heroin deaths and no increases throughout the time period. We hope these findings spur future conversations about the factors that contribute to variation in county level mortality rates in order to identify the most appropriate protective interventions. NCMJ

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Acknowledgments

We thank the NC Injury and Violence Prevention Branch of the Division of Public Health for sharing data.

Financial support. Funding was provided through Duke University's Bass Connections in Brain & Society.

Potential conflicts of interest. All authors have no relevant conflicts of interest.

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