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The Use of Vital Statistics Data for Research of Consequence: Birth Outcomes and Population Health in a Rural Region

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Abstract

Objective: The Affordable Care Act (ACA) has influenced increasing interests in population health and population health outcomes. The purpose of this study was to exemplify the importance of using existing vital statistics data for understanding and monitoring health outcomes and consequentially health disparities at the population level. Data from birth records for two geographic regions from 2009-2014 were compared; low birth weight (LBW) and preterm delivery (PD) were used as surrogates for population health outcomes.

Methods: A population-based, multi-year, cross-sectional study design using a pooled dataset of birth records from Tennessee (TN) was the framework for the analyses. A sub-population from North East TN (NE TN) was compared to TN. Logistic regression was used to estimate odds ratios. Attributable risks were calculated to translate the findings from conditional associations to population-level associations to help inform public health policy decision-making.

Results: Using birth records (vital statistics), we demonstrated that the period prevalence of cigarette smoking before and during pregnancy remained unchanged with approximately one in three women in NE TN (from 37% in 2009 to 32% in 2014) and one in five women in TN (from 23% in 2009 to 20% in 2014) reporting smoking pre-pregnancy. Multivariate analyses demonstrated that mothers who were at each end of the age spectrum, of very low household income level and reported cigarette smoking pre-pregnancy or during pregnancy had increased risk of a LBW or PD infant. During the years of observation, 39 to 50% of the total incidence of LBW in the group of women who smoked cigarettes prior to pregnancy was attributable to smoking cigarettes.

Conclusions: Existing data, such as vital statistics data, should be used routinely to identify geographic areas for which programs or policies can be implemented to reach large portions of populations. Reducing prenatal smoking, for example, has the potential to reduce a large fraction of adverse birth outcomes such as LBW and PD. For the geographic area we evaluated, 39 to 50% of LBW could be prevented by devising population-based smoking cessation programs or policies for women of child-bearing age. With recent emphasis on prevention and well-baby care in the ACA, there is potential to increase attention to this problem, implement evidence-based prevention programs and monitor program effectiveness with existing birth record data. Following this model, we can attain population health goals and address health disparities.

Keywords: Adverse birth outcomes; Population Health; Attributable Risk

Introduction

The Affordable Care Act has influenced increasing interests in population health and population health outcomes [1]. Population health was defined by Kindig and Stoddart in 2003 as “the health outcomes of a group of individuals, including the distributions of such outcomes within the group” [2]. Although there have been various embellishments upon the definition, population health is an approach to health that aims to improve the health of an entire population. A current goal for population health is to define policies with the potential to alter the health of a population. As noted by Farley, even with the volumes of research published weekly, public health professionals find a shortage of studies that offer practical solutions to our biggest public health problems [3].

A necessary component of population health monitoring is measurement. Reliable and valid data must be continuously available for the population of interest. We used the Tennessee (TN) vital statistics birth record data as our measurement platform. Understanding data surrounding live births can affect practice and policies made by communities. In the U.S., the first standard certificates for the registration of live births were developed in 1900 by the Bureau of the Census. The use of a standardized birth certificate was not uniformly adopted by all states until the 1930s. The birth certificate then became a legal document, proof of citizenship, as well as an important source for perinatal epidemiology. Through the work of the National Center for Health Statistics, there is a common national standard birth certificate. Over the years, health-related items have been added, such as maternal and paternal education, maternal cigarette smoking and source of payment for delivery. The quality of birth certificate data has been questioned [4–5]; however, vital statistics remain a pillar for public and population health monitoring.

As population health interventions are sought, increasing attention is also being drawn to the variation in health across geographic regions [6] as local contexts may influence the prevalence of risk factors and thus the incidence of health outcomes above and beyond the influence of individual-level characteristics [7]. This field of study highlights the need for the development of ‘upstream’ health interventions geared toward social and environmental determinants of health. Upstream interventions (population interventions) have the potential to impact a larger proportion of the population. Galea et al. found that the estimated number of deaths attributable to social factors (population level factors) in the U.S. is comparable to the number attributed to individual-level causes [8]. A similar and needed evaluation does not exist for adverse birth outcomes. For example, cigarette smoking during pregnancy is linked to many adverse birth outcomes [9–10]. And, this risk factor is influenced by the local context of a community, i.e., a rural region.

The purpose of this study was to demonstrate and reinforce the importance of the use of vital statistics data for monitoring public health issues. We used birth record data to compare two geographical regions to highlight differences in risk factor prevalence and subsequently demonstrate their effects at the population level. Such analyses conducted on a continuous basis can subsequently be used to monitor the success and/or failure of policy-based population interventions and public health policies.

Methods

Study Design

A population-based, multi-year, cross-sectional study analysis

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that utilized a pooled dataset of birth records from 2009 through 2014 was performed. The study sample consisted of 482,681 live births.

Study Population

Birth record data were obtained from the Office of Vital Statistics, TN Department of Health via a research agreement. We were particularly interested in the North East TN (NE TN) region as it is characterized by several population health challenges and thus would serve as a robust example for our model. The TN Department of Health designates NE TN as a contiguous area consisting of seven counties (Carter, Greene, Hancock, Hawkins, Johnson, Unicoi and Washington). The total population of this area in 2014 was 351,322. The area is widely rural and is entirely located within the Appalachian Mountains. The communities in this region have limited resources and their religious and cultural values are largely traditional. The health disparities match the socioeconomic disparities. Residents in Appalachia are at an increased risk for heart disease, cancer, diabetes and obesity compared with other ethnic groups or those living in nonrural areas [11].

Analyses compared the NE TN region to all counties in TN. The study protocol was reviewed and approved by the human subject committee of the East Tennessee State University as well as the Tennessee Department of Health.

Data Quality Measures

TN participates in the Vital Statistics Cooperative Program Contract. This contract calls for TN to send birth data to the National Center for Health Statistics which is part of the Centers for Disease Control. The Office of Vital Statistics, TN Department of Health, trains birth facilities in accurate filing of birth certificates. A record review is conducted to make sure that each record has valid values in each field and combination of fields. The record review also looks at errors in the combination of records in the file. For example, multiple records with the same Social Security Number those are not for the same person show an error. The trend review looks at the entire file and creates a percentage for each value in each field. The Inter-Jurisdictional Exchange Agreement allows jurisdiction to exchange data. TN receives birth certificate data from other jurisdictions for residents of TN who give birth in a non-TN location.

Measures

Dependent Variables: Low birth weight (LBW) and preterm delivery (PD) were the primary outcomes in the analyses. LBW was defined using the standard birth weight of < 2500 grams recorded in the birth record. PD was defined using the standard < 37 weeks gestation recorded in the birth record.

Independent Variables: We selected variables recorded in the birth record that were indicated in previous literature to be in the path of the primary outcomes, covariates or potential confounders. Mother's characteristics included the following categorical variables: age at birth of infant (< 20; 20–24; 25–29 and > 29 years); education level (< 12; 12–15 and > 15 years); and, marital status (married and not married). Mother's behavioral variables included: cigarette smoking (yes/no) and recorded for pre-pregnancy and first, second and third trimester time points and initiation of prenatal care by first trimester (yes/no). Cigarette smoking was further categorized, using the Minnesota Adult Tobacco Survey method, as light (≤ 15 Cigarettes/day), moderate (16–24 Cigarettes/day) and heavy (> 24 Cigarettes/day) [12]. An individual-level poverty variable was created using categories of reported household income (< $15,000; $15,000–49,999 and ≥ $50,000).

Statistical Analyses

Proportions were used to assess LBW and PD at each year (2009–2014) for TN and the NE TN region. We used simple and multiple logistic regression to estimate the crude odds ratios (ORs) and adjusted odds ratios (AORs) and 95% confidence intervals (CIs) comparing the outcomes of women exposed and not exposed to pre-pregnancy cigarette smoking, and similarly to low education and poverty. Covariates associated with outcomes at a p-value ≤ 0.1 in bivariate analyses were included in the multivariate analyses. The variables race, ethnicity, place of delivery and insurance status were not included in the multivariate analyses due to the homogeneity of these variables in NE TN. A *p*-value of < 0.05 was the cut-point for statistical significance. Finally, we calculated the attributable risk (incidence in exposed group – incidence in non-exposed group/ incidence in exposed group) of cigarette smoking to estimate the potential for prevention if the exposure could in fact be eliminated.

Results

Demographics

The number of live births by year remained stable for both TN groups from 2009 through 2014 (Table 1).LBW ranged from 7.4 to 9.7% and PD from 8.9 to 11.7%. Demographic and birth characteristics are presented for the NE TN region and TN (Table 2). The percentage of teenage mothers decreased over time for both TN groups, however a larger percentage of teenage mothers in NE TN compared to TN was consistent over time(P = 0.06, 0.46, 0.002, 0.002, 0.25, 0.04 for 2009 thru 2014, respectively). In addition, a larger percentage of TN mothers did not have high school degree or General Education Development (GED), a test that provides certification that the test taker has American high school-level academic skills, compared to NE TN mothers (P < 0.0001 for each

Child's Year of Birth	NE TN			TN		
	Births N	LBW N (%)	Premature N (%)	Births N	LBW N (%)	Premature N (%)
2009	3,666	348 (9.5)	382 (10.5)	82,109	7412 (9.0)	9137 (11.2)
2010	3,434	331 (9.7)	392 (11.5)	79,345	7086 (8.9)	8906 (11.3)
2011	3,431	305 (8.9)	398 (11.7)	79,462	7082 (8.9)	8629 (11.0)
2012	3,463	287 (8.3)	357 (10.4)	80,202	7265 (9.1)	8856 (11.1)
2013	3,366	282 (8.4)	325 (9.7)	79,954	7201 (9.0)	8730 (11.0)*
2014	3,426	252 (7.4)	303 (8.9)	81,609	7192 (8.8)**	8680 (10.7)***
Total	20,786			482,681		

Table 1: Number of Live Births and Birth Outcomes by Year by Region of Tennessee. The proportion of LBW in NETN region is significantly different from that in TN in the year 2014 (P < 0.01). The proportion of premature births in NETN region is significantly different from that in TN in the year 2013 (P < 0.05) and 2014 (P < 0.001). (P-value: ***<.001, **<0.01, *<0.05)

Child's Year of Birth			2009	2010	2011	2012	2013	2014
Mother's characteristics								
Mother's Age Birth of Infant N (%)	NE TN	≤ 19	505 (13.8)	419 (12.2)	429 (12.5)	412 (11.9)	322 (9.6)	321 (9.4)
		20–24	1,134 (31.0)	1,102 (32.1)	1,022 (29.8)	1,043 (30.1)	1,035 (30.8)	1,049 (30.6)
		25–29	1,012 (27.7)	990 (28.9)	979 (28.6)	1,003 29.0)	1,010 (30.0)	1,063 (31.0)
		> 29	1,003 (27.5)	920 (26.8)	995 (29.1)	1,002 (29.0)	999 (29.7)	993 (29.0)
	TN	≤ 19	10,482 (12.8)	9,356 (11.8)	8,589 (10.8)	7,978 (10.0)	7,189 (9.0)	6,833 (8.4)
		20–24	24,027 (29.3)	22,758 (28.7)	22,695 (28.6)	23,153 (28.9)	22,544 (28.2)	22,474 (27.5)
		25-29	23,216 (28.3)	22,815 (28.8)	23,051 (29.0)	23,139 (28.9)	23,435 (29.3)	24,137 (29.6)
		> 29	24,349 (29.7)	24,389 (30.8)	25,096 (31.6)	25,912 (32.3)	26,782 (33.5)	28,154 (34.5)
Mother's Education Level N (%)	NE TN	< 12 yrs	647 (17.7)	556 (16.2)	479 (14.0)	459 (13.3)	420 (12.5)	395 (11.6)
		12-15 yrs	2,302 (63.0)	2,134 (62.3)	2,206 (64.3)	2,206 (63.8)	2184 (64.9)	2265 (66.3)
		> 15 yrs	708 (19.4)	734 (21.4)	744 (21.7)	793 (22.9)	760 (22.6)	755 (22.1)
	TN	< 12 yrs	17,230 (21.0)	15,515 (19.6)	14,369 (18.1)	13,630 (17.1)	12,702 (15.9)	12,119 (14.9)
		12-15 yrs	46,733 (57.1)	45,444 (57.5)	46,013 (58.1)	46,905 (58.7)	47,088 (59.1)	48,377 (59.5)
		> 15 yrs	17,915 (21.9)	18,141 (22.9)	18,810 (23.8)	19,396 (24.3)	19,895 (25.0)	20,775 (25.6)
Previous preterm Births N (%)	NE TN		48 (1.3)	61 (1.8)	111 (3.2)	111 (3.2)	105 (3.1)	115 (3.4)
	TN		2,407 (2.9)	2,138 (2.7)	2,346 (3.0)	2,409 (3.0)	2,321 (2.9)	2,595 (3.2)
Mother's Marital Status N (%)	NE TN	Married	2,209 (60.3)	2,079 (60.5)	2,034 (59.3)	2,030 (58.6)	1,938 (57.6)	1,980 (57.8)
		Other	1,457 (39.7)	1,355 (39.5)	1,397 (40.7)	1,433 (41.4)	1,428 (42.4)	1,446 (42.2)
	TN	Married	45,534 (55.5)	44,326 (55.9)	44,416 (55.9)	44,775 (55.8)	44,740 (56.0)	45,679 (56.0)
		Other	36,575 (44.5)	35,019 (44.1)	35,046 (44.1)	35,427 (44.2)	35,214 (44.0)	35,930 (44.0)
Reported Household Income	NE TN	< $15,000	1,061 (36.1)	947 (33.5)	994 (35.3)	969 (34.0)	929 (33.4)	953 (33.5)
		$15,000 -49,999	1,121 (38.1)	1,135 (40.2)	1,088 (38.6)	1,138 (39.9)	1,075 (38.6)	1,158 (40.7)
		≥ $50,000	761 (25.9)	743 (26.3)	734 (26.1)	747 (26.2)	779 (28.0)	737 (25.9)
	TN	< $15,000	21,908 (35.8)	21,528 (35.5)	21,853 (35.5)	21,806 (34.9)	21,326 (33.9)	20,702 (32.4)
		$15,000 -49,999	20,763 (33.9)	20,759 (34.3)	20,870 (33.9)	21,480 (34.4)	21,606 (34.3)	22,400 (35.1)
		≥ $50,000	18,559 (30.3)	18,299 (30.2)	18,798 (30.6)	19,239 (30.8)	20,044 (31.8)	20,790 (32.5)
Mother's behavioral variables								
Prenatal Care by First Trimester N (%)	NE TN		3,619 (98.9)	3,399 (99.1)	3,395 (99.0)	3,415 (98.8)	3,318 (98.9)	3,384 (99.2)
	TN		79,156 (97.5)	77,034 (97.9)	77,156 (98.1)	77,894 (98.0)	78,168 (98.2)	79,738 (98.3)
Pre-pregnancy Cigarette Smoking N (%)	NE TN		1,356 (37.1)	1,142 (33.3)	1,125 (32.8)	1,119 (32.5)	1,111 (33.3)	1,084 (31.9)
	TN		18,772 (22.9)	17,517 (22.1)	17,167 (21.7)	16,781 (21.0)	16,519 (20.8)	15,887 (19.6)
First Trimester Cigarette Smoking N (%)	NE TN		1,131 (30.9)	950 (27.7)	916 (26.7)	866 (25.1)	909 (27.3)	871 (25.7)
	TN		14,602 (17.8)	13,456 (17.0)	13,084 (16.5)	12,620 (15.8)	12,388 (15.6)	11,780 (14.5)
Second Trimester Cigarette Smoking N (%)	NE TN		1,029 (28.1)	851 (24.8)	818 (23.9)	783 (22.7)	820 (24.6)	771 (22.7)
	TN		12,900 (15.8)	11,896 (15.0)	11,493 (14.5)	11,044 (13.8)	10,902 (13.7)	10,225 (12.6)
Third Trimester Cigarette Smoking N (%)	NE TN		989 (27.0)	813 (23.7)	785 (22.9)	765 (22.2)	799 (24.0)	740 (21.8)
	TN		12,257 (15.0)	11,260 (14.2)	10,782 (13.6)	10,433 (13.1)	10,265 (12.9)	9,565 (11.8)

Table 2: Demographic and Birth Characteristics for North East Tennessee (NE TN) and Tennessee (TN).

year). A larger percentage of NE TN mothers were married at the time of birth of the infant compared to TN mothers ($P < 0.0001$ for 2009, 2010, 2011, $P = 0.001$ for 2012, $P = 0.06$ for 2013, $P = 0.04$ for 2014). The distribution of the income variable is skewed to the left for the women of NE TN indicating a greater proportion in poverty. Overall, the women in NE TN were significantly younger and poorer than their TN counterparts. However, they were more likely to be married ($P < 0.0001$).

Behavior

Over 98% of all mothers received prenatal care during the first trimester of their pregnancy. Over the six-year period, an average of 34% of women of NE TN smoked during the 3 months prior to pregnancy versus an average of 21% for the TN mothers ($P < 0.0001$). This pattern of percentage of cigarette smokers continued through the third trimester with an average of 24% of NE TN mothers reporting cigarette smoking compared to 13% of TN mothers ($P < 0.0001$).

Multivariate Considerations

Tables 3 and 4 present, for the NE TN and TN groups separately, the crude and adjusted Odds Ratios for the outcomes LBW and PD, respectively. For LBW, the risk profile includes the following characteristics: age < 19 years and age > 29 years ($P < 0.0001$), no high school degree/GED($P < 0.0001$), very low household income level ($P < 0.0001$), and all categories of pre-pregnancy cigarette smoking($P < 0.0001$). For PD, the risk profile is similar, however, perhaps not as pronounced. The striking contrast between NE TN and TN groups is the higher increased risk of LBW among women of NE TN who reported pre-pregnancy smoking compared to TN women ($P < 0.0001$).Even after control for covariates, cigarette smoking remained a clear indicator of adverse birth outcomes.

Attributable Risk (AR) for the Exposed Group

Tables 5 and 6 present the proportion of LBW and PD, among pre-pregnancy cigarette smokers respectively, attributable to smoking. The AR is strikingly high for LBW in NE TN (38–50%) compared to TN. The ARs for PD are less pronounced. In addition, the smaller proportion of smokers in 2012 and 2014 resulted in a non-stable trend.

	NETN		TN	
	Crude OR (CI^)	Adjusted OR (CI)	Crude OR (CI)	Adjusted OR (CI)
Mother's Age				
20-24 vs. ≤19	0.98 (0.83, 1.15)	0.90 (0.73, 1.09)	0.90 (0.87, 0.93)***	0.93 (0.89, 0.97)**
25-29 vs. ≤19	0.88 (0.74, 1.04)	1.02 (0.84, 1.26)	0.79 (0.76, 0.81)***	0.99 (0.95, 1.04)
>29 vs. ≤19	0.95 (0.80, 1.12)	1.27 (1.03, 1.57)*	0.85 (0.82, 0.88)***	1.24 (1.18, 1.30)***
Mother's Education				
12-15 yrs vs. <12 yrs	0.71 (0.63, 0.81)***	0.78 (0.67, 0.91)**	0.85 (0.83, 0.87)***	0.97 (0.94, .997)*
>15 yrs vs. <12 yrs	0.44 (0.37, 0.52)***	0.64 (0.51, 0.81)***	0.59 (0.57, 0.61)***	0.87 (0.83, 0.91)***
Household Income				
$15,000–49,999 vs. <15,000	0.65 (0.58, 0.74)***	0.79 (0.70, 0.91)***	0.64 (0.63, 0.66)***	0.66 (0.64, 0.67)***
≥ $50,000 vs. <15,000	0.56 (0.49, 0.65)***	0.84 (0.69, 1.01)	0.53 (0.52, 0.55)***	0.56 (0.53, 0.58)***
Pre-pregnancy Smoking				
Light vs. No	1.56 (1.35, 1.80)***	1.52 (1.28, 1.81)***	1.44 (1.40, 1.49)***	1.26 (1.21, 1.30)***
Moderate vs. No	2.27 (2.02,2.56)***	2.29 (1.98, 2.65)***	1.58 (1.53, 1.63)***	1.43 (1.38, 1.49)***
Heavy vs. No	2.74 (2.27, 3.30)***	2.55 (2.04, 3.18)***	1.82 (1.72, 1.93)***	1.62 (1.52 1.72)***

Table 3: Low Birth Weight unadjusted and ∞adjusted Odds Ratios North East Tennessee (NE TN) and Tennessee (TN), Odds Ratio Estimates Low Birth Weight (<2500 grams), (^: 95% confidence interval; P-value: ***<.001, **<0.01, *<0.05), **∞Adjusted:** Adjusting for mother's demographic variables; age, education years and reported household income and mother's behavioral characteristics; pre-pregnancy cigarette smoking.

Odds Ratio Estimates Preterm Delivery (<37 Weeks)				
	NETN		TN	
	Crude OR (CI^)	Adjusted OR (CI)	Crude OR (95% CI)	Adjusted OR (CI)
Mother's Age				
20-24 vs. ≤19	1.01 (0.87, 1.18)	0.95 (0.79, 1.15)	0.96 (0.93, 0.99)*	1.00 (0.96, 1.05)
25-29 vs. ≤19	0.95 (0.82, 1.12)	1.10 (0.91, 1.33)	0.93 (0.90, 0.96)***	1.12 (1.07, 1.16)***
>29 vs. ≤19	1.10 (0.94, 1.29)	1.38 (1.14, 1.68)**	1.05 (1.02, 1.08)**	1.38 (1.32, 1.44)***
Mother's Education				
12-15 yrs vs. <12 yrs	0.82 (0.72, 0.92)***	0.83 (0.71, 0.96)*	0.93 (0.91, 0.95)***	0.99 (0.96, 1.02)
>15 yrs vs. <12 yrs	0.60 (0.52, 0.70)***	0.61 (0.50, 0.75)***	0.73 (0.71, 0.75)***	0.83 (0.80, 0.87)***
Household Income				
$15000 -49999 vs. <15000	0.81 (0.72, 0.91)***	0.86 (0.76, 0.98)*	0.76 (0.74, 0.77)***	0.75 (0.73, 0.77)***
≥ $50000<15000	0.75 (0.66, 0.85)***	0.86 (0.73, 1.02)	0.70 (0.68, 0.72)***	0.70 (0.67, 0.72)***
Pre-pregnancy Smoking				
Light vs. No	1.11 (0.97, 1.27)	1.06 (0.90, 1.24)	1.17(1.14, 1.21)***	1.08 (1.04, 1.12)***
Moderate vs. No	1.37 (1.22, 1.54)***	1.27 (1.10, 1.46)***	1.19 (1.16, 1.23)***	1.12 (1.08, 1.16)***
Heavy vs. No	1.31 (1.07, 1.61)**	1.26 (.996, 1.59)	1.23 (1.16, 1.30)***	1.16 (1.08, 1.23)***

Table 4: Preterm Births unadjusted and ∞adjusted Odds Ratios North East Tennessee (NE TN) and Tennessee (TN). ^: 95% confidence interval P-value: ***<.001, **<0.01, *<0.05 (**∞Adjusted:** Adjusting for mother's demographic variables; age, education years and reported household income and mother's behavioral characteristics; pre-pregnancy cigarette smoking.)

Attributable Risk Estimates of LBW to Pre-pregnancy Smoking by Child's Year of Birth NETN vs. TN						
	NETN			TN		
	Smokers N (%)	Non-smokers N (%)	Attributable Risk	Smokers N (%)	Non-smokers N (%)	Attributable Risk
2009	188 (13.86)	159 (6.93)	50.00	2224 (11.86)	5166 (8.20)	30.86***
2010	149 (13.05)	182 (7.98)	38.85	2083 (11.90)	4981 (8.10)	31.93***
2011	162 (14.43)	142 (6.17)	57.24	2064 (12.04)	4995 (8.06)	33.06***
2012	137 (12.29)	150 (6.45)	47.52	2058 (12.29)	5187 (8.23)	33.03***
2013	137 (12.39)	145 (6.53)	47.30	2012 (12.20)	5150 (8.19)	32.87***
2014	113 (10.45)	138 (6.00)	42.58	1873 (11.83)	5272 (8.10)	31.53***

Table 5: Attributable Risk of LBW to Smoking. P-value: ***<.001, **<0.01, *<0.05. The attributable risk for LBW related to smoking in NETN region is significantly higher than that in TN in each year ($P < 0.001$)

Attributable Risk Estimates of Preterm Delivery to Pre-pregnancy Smoking by Child's Year of Birth NETN vs TN						
	NETN			TN		
	Smokers N (%)	Non-smokers N (%)	Attributable Risk %	Smokers N (%)	Non-smokers N (%)	Attributable Risk %
2009	171 (12.64)	211 (9.19)	27.29	2337 (12.54)	6787 (10.86)	13.40***
2010	144 (12.66)	248 (10.90)	13.90	2166 (12.44)	6718 (11.00)	11.58***
2011	163 (14.66)	234 (10.27)	29.95	2133 (12.52)	6479 (10.55)	15.73***
2012	120 (10.81)	236 (10.17)	5.92	2105 (12.63)	6722 (10.73)	15.04***
2013	126 (11.45)	199 (8.98)	21.57	2056 (12.52)	6632 (10.58)	15.50***
2014	100 (9.28)	202 (8.79)	5.28	1871 (11.84)	6749 (10.38)	12.33***

Table 5: Attributable Risk of LBW to Smoking. P-value: ***<.001, **<0.01, *<0.05. The attributable risk for LBW related to smoking in NETN region is significantly higher than that in TN in each year ($P < 0.001$)

Discussion

During 2009 to 2014, the overall aggregated prevalence of cigarette smoking before and during pregnancy remained unchanged with approximately one in three women in NE TN (from 37% in 2009 to 32% in 2014) and one in five women in TN (from 23% in 2009 to 20% in 2014) reporting smoking pre-pregnancy. This finding suggests that current efforts to prevent smoking and increase cessation among female smokers before becoming pregnant have not been effective. Our results are similar to the findings of a 2009 report of 31 sites in the U.S. where the aggregated prevalence of smoking over six years remained unchanged [13]. And, as we observed, adverse birth outcomes related to smoking also remain prevalent in our study population. Finally, we found that 39 to 50% of LBW could be attributed to cigarette smoking. Of consequence, however, is that this risk factor is modifiable. Our focus on a specific geographic region also resulted in the identification of covariates that can further influence the creation of effective smoking cessation interventions that should take into consideration the environment, as broadly defined. Although our results are not of new etiologic significance, they do highlight the fact that knowledge is not enough; we must continue our vigilance to use knowledge to maintain healthy populations.

Commonly used smoking interventions for women of child-bearing ages are individual-based. Text4baby [14], Smoking Cessation and Reduction in Pregnancy Treatment (SCRIPT) [15], and Text2Quit [16] involve individual in-person interactions costing hundreds or thousands of dollars per person reached. In the realm of smoking during pregnancy they have not been brought to scale and never will. Intervention success is contingent upon local factors such as public and political will, cultural differences and other social and environmental variables [17]. Farley challenges researchers to instead focus on minimalist interventions that can be scaled to reach large fractions of the population. Interventions with population potential cost less per person reached [3].

We have identified a gap in population health through the use and analysis of existing vital statistics data. Our findings suggest that efforts in TN to prevent smoking and increase cessation among female smokers before becoming pregnant have not been effective, particularly in the rural region of South Central Appalachia (NE TN). Our findings highlight the importance of continuous monitoring of vital statistics data to assist the targeting of population intervention efforts. In the case presented in this manuscript, LBW and PD are important first measures of health; they are leading factors for infant mortality and for subsequent child mortality [18]. LBW and PD are also predictors of health and socioeconomic status over the life course and generations [19].

Although our study provides important population-based statistics on birth outcomes it is not without limitations. First, the primary source of the data was the birth record. Prior research has indicated that birth record classification errors and incomplete information may potentially lead to incorrect inferences. Since our analyses did not include selection but used all births, any errors should be independent. Cigarette smoking history was based on self-report; self-report is prone to bias, such as social desirability bias. This method, however, is the most feasible for large epidemiologic studies. The birth record also had no information on age at cigarette smoking initiation or the presence of second-hand smoke. Finally, the restriction of births to NE TN resulted in the loss of power due to a relatively small sample size. We, however, pooled the data for six years to increase power.

In summary, reducing prenatal smoking has the potential to reduce adverse birth outcomes, which have important long-term implications. These smoking-attributable outcomes continue to disproportionately affect a specific geographic region of TN. With recent emphasis on prevention and well-baby care in the Affordable Care Act, there is potential to increase attention to this problem and to effectively monitor population-based efforts.

As expressed by Aizer and Currie, "increasing knowledge about determinants of infant health and how to protect it along with public policies that put this knowledge into practice", are needed for health at birth [20]. Health at birth is an important factor related to long-term outcomes including education, income and disability.

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