

Infant Mortality within Cleveland: An In-Depth Analysis (2012 – 2015)

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Executive Summary

Main Findings

- Infant mortality in Cleveland is double the national average (12.9 vs. 6.0)
- Infant mortality is higher among Blacks than Whites or Hispanics (16.0 vs. 9.3 & 10.3)
- Infant mortality rates differ significantly by neighborhoods
 - Buckeye Woodhill 3.8 per 1,000 live births
 - Lee-Harvard 34.6 per 1,000 live births
- Preterm infants are 5 times more likely to have died compared to full-term births
- Low birth weight infants are 9 times more likely to have died compared to normal weight

Infant mortality is one of the greatest indicators of a community's health. The United States' infant mortality rate has been consistently decreasing over the past few decades with a 2013 rate of 6.0 infant deaths per 1,000 live births. Ohio, Cuyahoga County, and the City of Cleveland all have greater infant mortality rates than the US. Cleveland had the greatest infant mortality rate of 12.9 infant deaths per 1,000 live births on average double that of the national rate.

Within the City of Cleveland, infant mortality rates are significantly different among races. Blacks have a significantly greater infant mortality rate than Whites or Hispanics. Blacks, on average, have a rate of 16.0 per 1,000 live births while White and Hispanics have rates of 9.3 and 10.3 per 1,000 live births respectively.

Health disparities exist with stark contrast geographically across the city. Cleveland as a whole has experienced less-than-optimal infant health outcomes; however, when analyzed on a neighborhood level, health disparities become apparent. Some of Cleveland's neighborhoods are doing exceptionally well in regards to infant health, however, others are not. Between the years of 2012 and 2015, the Buckeye-Woodhill neighborhood had the lowest overall infant mortality rate of 3.9 infant deaths per 1,000 live births. During the same time period, the neighborhood with the highest overall infant mortality rate was Lee-Harvard, with a rate of 34.4 infant deaths per 1,000 live births. These neighborhoods lie approximately 3 miles from each other and yet infants born in Lee-Harvard die at nearly 9 times the rate as infants born in Buckeye-Woodhill.

Preterm birth is overwhelmingly associated with infant mortality. Preterm birth occurs when an infant is born with less than 37 weeks of gestation, as opposed to a full, 40 week (9 month), pregnancy. Preterm births account for 81% of all infant deaths. On average, Cleveland infants born preterm are 5 times more likely to die than full term infants. Since preterm birth is so strongly associated with infant mortality, city and neighborhood percentages were calculated. Cleveland's overall preterm birth rate is 17.3%, or, 17 out of every 100 infants born in the City of Cleveland are born preterm. For comparison, the US, Ohio, and Cuyahoga county preterm birth percentages are 11.4%, 12.1%, and 14.1%. The Kamm's Corners neighborhood had the lowest overall preterm birth percent, 11.3%, while Lee-Harvard had the highest preterm birth percent, 23.1%. Significant

factors associated with preterm birth include mother's BMI, mother's age, the mother having hypertension or diabetes, smoking, mother's education, and mother's history of prior preterm birth.

Infant mortality is strongly associated with the birth weight of the infant. Low birth weight infants are 9 times more likely to die than normal weight infants. Prenatal care is strongly associated with an infant's birth weight. Each prenatal care visit adds 0.5 ounces to an infant's birth weight. Neighborhoods were significantly different in terms of the percentage of low birth weight infants. Kamm's Corners had the lowest percentage of low birth weight infants (8.1%) while St. Clair-Superior had the highest percentage of low birth weight infants (19.1%). Overall, neighborhoods on the west side of Cleveland have lower percentages of low birth weight infants than east side neighborhoods.

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Conflict of Interest

The authors declare no conflict of interest.

Introduction

Cleveland has gained recent notoriety for experiencing high rates of infant mortality since the publication of its last infant mortality report in 2014 (CDPH, 2014). The purpose of this report is to provide a comprehensive neighborhood level analysis of infant mortality and the major associated risk factors. Relationships examined between infant mortality and various demographic, health, and socioeconomic factors include age of the mother, race, residence of the mother, total gestation length, medical history, and insurance status. Findings should be used to identify areas of need and create targeted, evidenced based public health interventions.

The United States' infant mortality rate of 5.9 infant deaths per 1,000 live births ranked 58th out of 224 countries in 2015, compared to Japan which had one of the lowest infant mortality rates, among conventional countries, of 2.1 per 1,000 live births (CIA, 2016). The United Kingdom was ranked 38th (4.4 per 1,000); Canada was ranked 46th (4.7 per 1,000) (CIA, 2016). Croatia had a slightly lower infant mortality rate than the United States (5.8 per 1,000) (CIA, 2016). Ohio ranked 46th among all US states in infant mortality in 2013 (CDC, 2015).

Healthy People 2020 (2016) objective MICH-1.3 states to “reduce the rate of all infant deaths (within 1 year) to 6.0 per 1,000 live births”. The baseline used is the 2006 U.S. infant mortality rate of 6.7 per 1,000 live births (HP, 2016). The CDC recently reported that the 2013 infant mortality rate was 6.0 per 1,000 live births, meeting the Healthy People 2020 objective (CDC, 2016). Overall, the infant mortality rate has been decreasing since 2005 across all races (CDC, 2013).

The leading causes of infant mortality in 2013 were congenital malformations, disorders related to short gestation and low birth weight, maternal complications, sudden infant death syndrome, and accidents (CDC, 2016). Preterm birth is defined as a birth occurring with less than 37 weeks of gestation completed (Kramer, 2000). Kramer et al. (2000) found that preterm infants had a significant risk of death. Rush (1976) suggests that preventing preterm labor would significantly reduce infant mortality.

The United States', Ohio's, and Cuyahoga County's infant mortality rate during 2013 was 6.0, 7.3, and 9.4 per 1,000 live births respectively (CDC, 2013; ODH, 2013). The infant mortality rate in Ohio has been trending downward since 1990 (OHD, 2014).

In 2013, the US preterm birth percent was 11.4% (CDC, 2015). Ohio's 2013 preterm birth percent was approximately 12.1% (March of Dimes, 2015). Cuyahoga County's preterm birth percent was approximately 14.1% for the 3-year period of 2008-2010; more recent data is not available. (CCBH, 2014)

The Office of Communicable Disease and Epidemiology works in cooperation with the Cleveland Department of Public Health's Moms First program. Moms First is one of over 100 federal Healthy Start grantees to address disparities in infant mortality experienced by minority populations across the United States. The MomsFirst Project is a community based intervention to reduce the significant disparities in perinatal health experienced by African-Americans in Cleveland. MomsFirst seeks out pregnant women that are at high risk for a poor birth outcome, such as low

birth weight. MomsFirst uses a home visiting model with Community Health Workers providing guidance, peer-to-peer education, and referrals to outside community agencies. The scope of service to families is from pregnancy through the first two years of an infant’s life. (Moms First, 2016).

Infant Mortality Rates by Neighborhoods and Wards

Infant mortality rate is the measure of deaths occurring among live births in infants less than one year old. This statistic is presented per 1,000 live births. The Healthy People 2020 (2016) objective MICH-1.3 is to reduce the rate of all infant deaths (within 1 year) to 6.0 per 1,000 live births.

Background

Between the years 2012-2015, there were 22,504 live births in the City of Cleveland. The majority of births in Cleveland were Black (57.04%), White (25.41%), or Hispanic (10.79%). Yearly infant mortality and preterm birth rates are presented in Table 1. Cleveland experienced 290 infant fatalities and 3,900 preterm births during that time period.

City, County, and Moms First year specific rates are presented in Figure 1 and Table 2.

The overall infant mortality rate was 12.9 per 1,000 live births between the years of 2012 and 2015. Cleveland’s infant mortality rate was 12.8, 12.6, 10.4, and 15.9 per 1,000 live births in 2012, 2013, 2014, and 2015 respectively, see Table 1. 2015 had the highest city-wide infant mortality rate since 1999 (CDPH, 2014). Infant mortality rates had been on the decline between the years 1999 to 2014; however, 2015 saw a substantial spike in infant mortality cases (CDPH, 2014). In 2015, the City of Cleveland had an overall infant mortality rate of 15.9 per 1,000, which would have earned a rank of 125th among all other countries (CIA, 2016).

Year	# of Live Births	# of Infant Deaths	Infant Mortality Rate	# of Preterm Births	% of Preterm Births	Ratio of Preterm Births to Deaths
2012	5,694	73	12.8	1,003	17.6%	13.7
2013	5,775	73	12.6	972	16.8%	13.3
2014	5,744	60	10.4	990	17.2%	16.5
2015	5,291	84	15.9	935	17.7%	11.1
Overall	22,504	290	12.9	3,900	17.3%	13.4

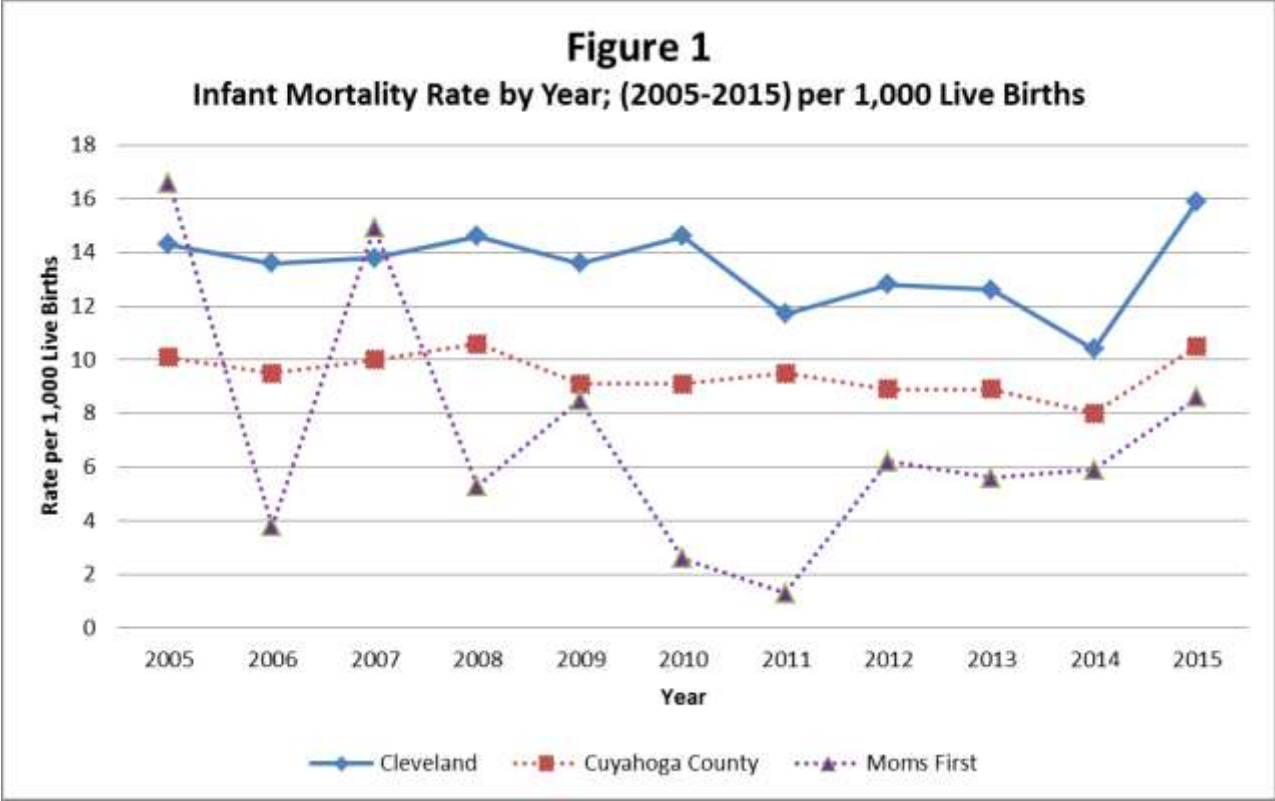


Table 2: Infant Mortality Rate per 1,000 Live Births by City, County, & Moms First Program; (2005 - 2015)

Year	Cleveland	Cuyahoga County	Moms First
2005	14.3	10.1	16.6
2006	13.6	9.5	3.8
2007	13.8	10.0	14.9
2008	14.6	10.6	5.3
2009	13.6	9.1	8.5
2010	14.6	9.1	2.6
2011	11.7	9.5	1.3
2012	12.8	8.9	6.2
2013	12.6	8.9	5.6
2014	10.4	8.0	5.9
2015	15.9	10.5	8.6

City of Cleveland Neighborhood Data

Significant differences exist between neighborhoods (Table 3). Lee-Harvard had the highest infant mortality rate, 34.4 per 1,000 live births, with a total of 12 infant deaths. Glenville had the greatest total number of infant deaths, 23, with an infant mortality rate of 15.0 per 1,000 live births. Buckeye-Woodhill had the lowest rate with 3.9 per 1,000 live births; 2 infant fatalities occurred within the 4 year span, with a total of 513 births. The rates for the neighborhoods of Riverside, also known as Hopkins, and Cuyahoga Valley were not able to be calculated due to their insufficient sample size.

Comparisons were made between Cleveland neighborhoods and US, Ohio, and Cuyahoga County infant mortality rates. Few neighborhoods experienced low rates in comparison. Edgewater, Detroit Shoreway, Clark-Fulton, University, and Buckeye-Shaker Square all experienced rates less than the national infant mortality rate of 6.0 per 1,000. Bellaire-Puritas experienced a rate lower than the Ohio infant mortality rate of 7.4 per 1,000. Old Brooklyn and Hough experienced rates lower than the Cuyahoga County rate of 8.9 per 1,000. All other neighborhoods had a rate greater than 8.9 per 1,000 live births. U.S., Ohio, and Cuyahoga rates are for the year 2013. Individual neighborhood infant mortality frequencies and rates are expressed in Table 3. Neighborhood level rate and rate comparison maps are presented in Figure 2 and Figure 3 to illustrate the geographic distribution of infant mortality within the city.

City of Cleveland Neighborhoods (See Appendix A for More Details)

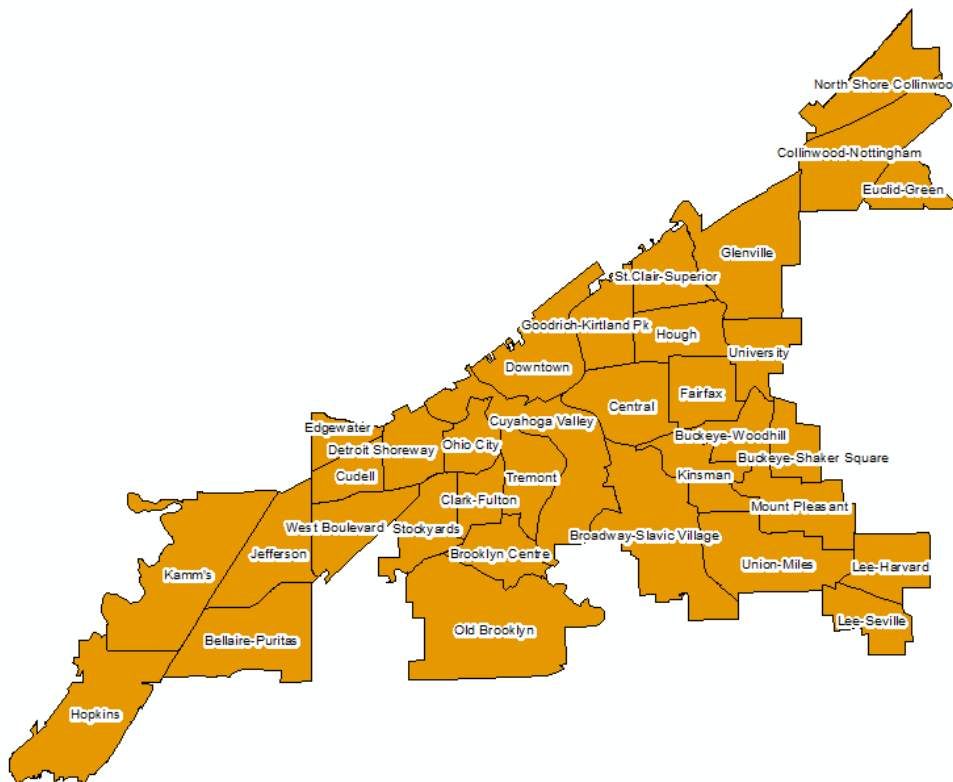


Figure 2:

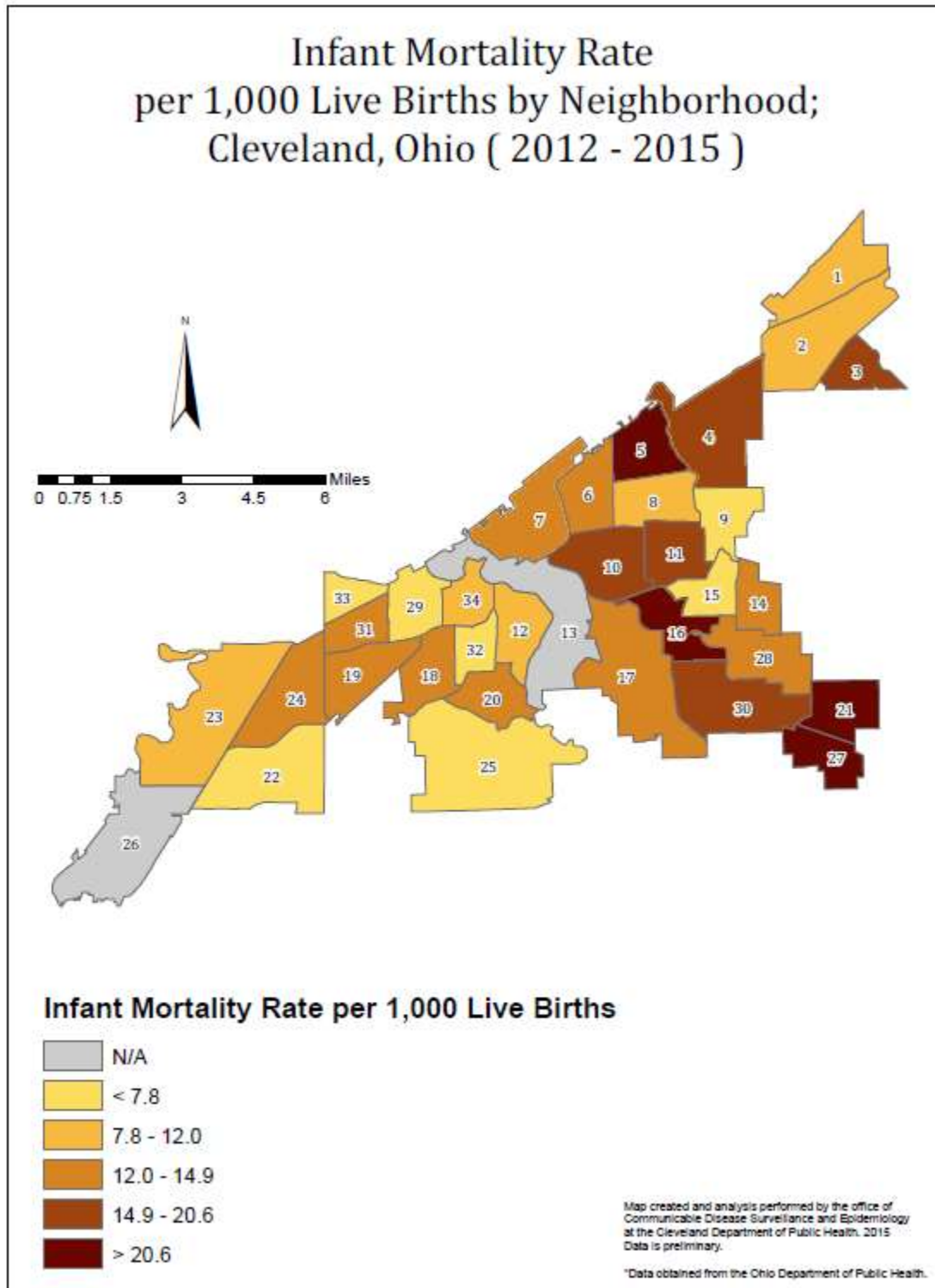


Figure 3:

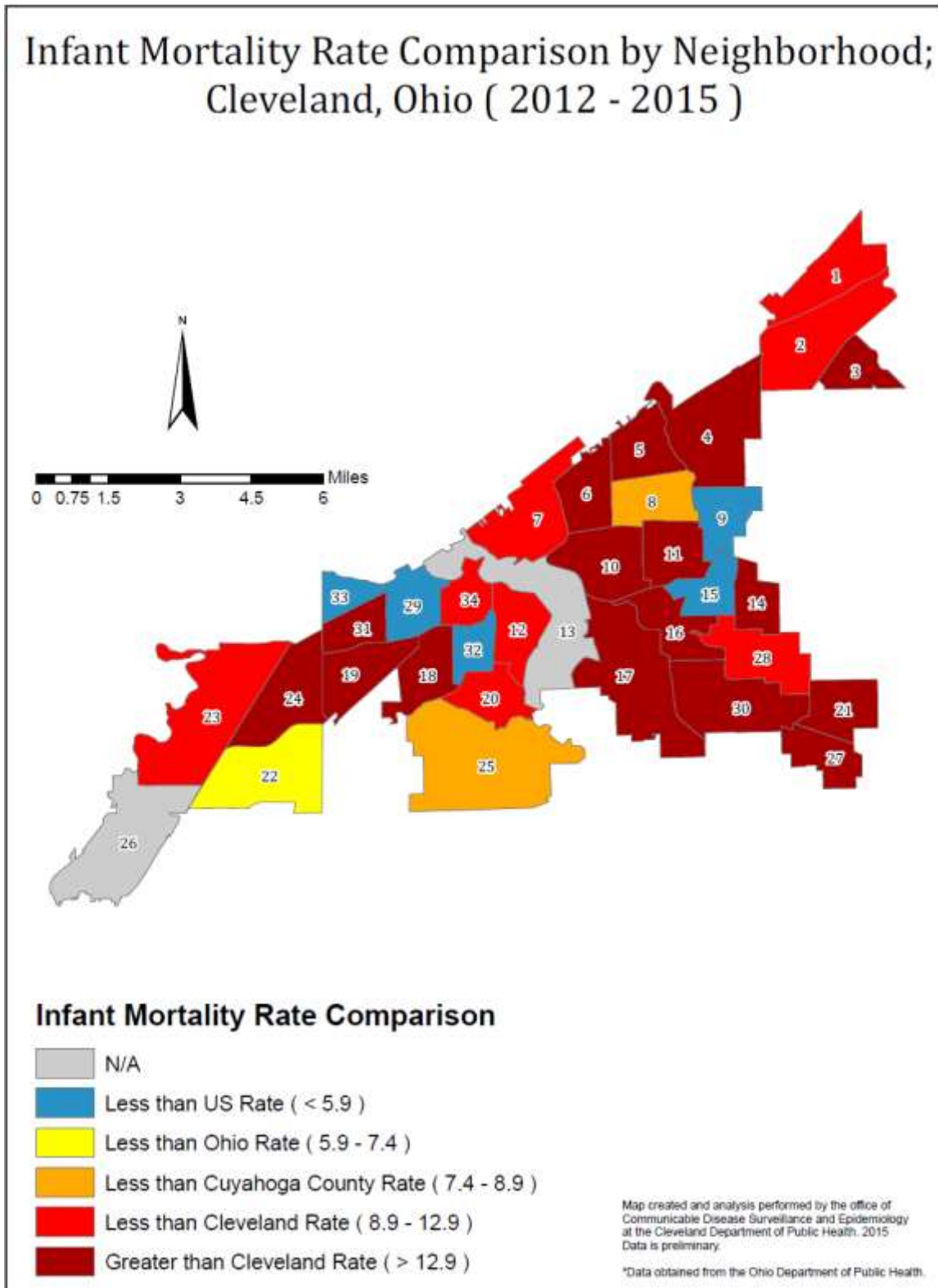


Table 3: Infant Fatalities and Mortality Rate by Neighborhood (2012-2015)			
Geographic Area	# of Live Births	# of Fatalities	Rate per 1,000 Live Births
United States*	3,932,181	23446	6.0
State of Ohio*	139,035	1024	7.4
Cuyahoga County*	14,920	132	8.8
City of Cleveland	22,504	290	12.9
Neighborhood Name (#)			
Bellaire-Puritas (22)	695	5	7.2
Broadway-Slavic Village (17)	1,355	20	14.8
Brooklyn Centre (20)	639	8	12.5
Buckeye-Shaker Square (14)	660	9	13.6
Buckeye-Woodhill (15)	513	2	3.9
Central (10)	1,214	20	16.5
Clark-Fulton (32)	642	3	4.7
Collinwood-Nottingham (2)	651	7	10.8
Cudell (31)	612	8	13.1
Cuyahoga Valley (13)	12	1	**
Detroit Shoreway (29)	705	4	5.7
Downtown (7)	331	4	12.1
Edgewater (33)	232	1	4.3
Euclid-Green (3)	304	5	16.4
Fairfax (11)	362	6	16.6
Glenville (4)	1,533	23	15.0
Goodrich-Kirtland Park (6)	217	3	13.8
Hopkins (26)	9	0	**
Hough (8)	681	6	8.8
Jefferson (24)	939	14	14.9
Kamm's Corners (23)	1,288	12	9.3
Kinsman (16)	529	11	20.8
Lee-Harvard (21)	347	12	34.6
Lee-Seville (27)	204	5	24.5
Mount Pleasant (28)	971	12	12.4
North Shore Collinwood (1)	728	8	11.0
Ohio City (34)	542	6	11.1
Old Brooklyn (25)	1,664	13	7.8
St. Clair-Superior (5)	410	10	24.4
Stockyards (18)	692	10	14.5
Tremont (12)	454	5	11.0
Union-Miles (30)	980	20	20.4
University (9)	172	1	5.8
West Boulevard (19)	1,208	16	13.2
* Frequencies and rates are from 2013 only			
** Statistics could not be calculated due to insufficient sample size			

City of Cleveland Ward Data

Infant mortality rates differ between Cleveland political wards. There are 17 different wards in Cleveland. Wards in Cleveland are administrative divisions represented by a City of Cleveland Councilmember in order to provide direct political representation. Ward 1 experienced the highest 4-year rate of 26.3 (16.1, 36.4; 95% CI) infant fatalities per 1,000 live births. Ward 15 experienced the lowest 4-year rate of 7.6 (3.1, 12.1; 95% CI) infant fatalities per 1,000 live births. All wards experienced a similar amount of live births during this time period (Table 4). Ward level rate and rate comparison maps are presented in Figure 4 and Figure 5 to illustrate the geographic distribution of infant mortality within the city.

City of Cleveland Ward Map

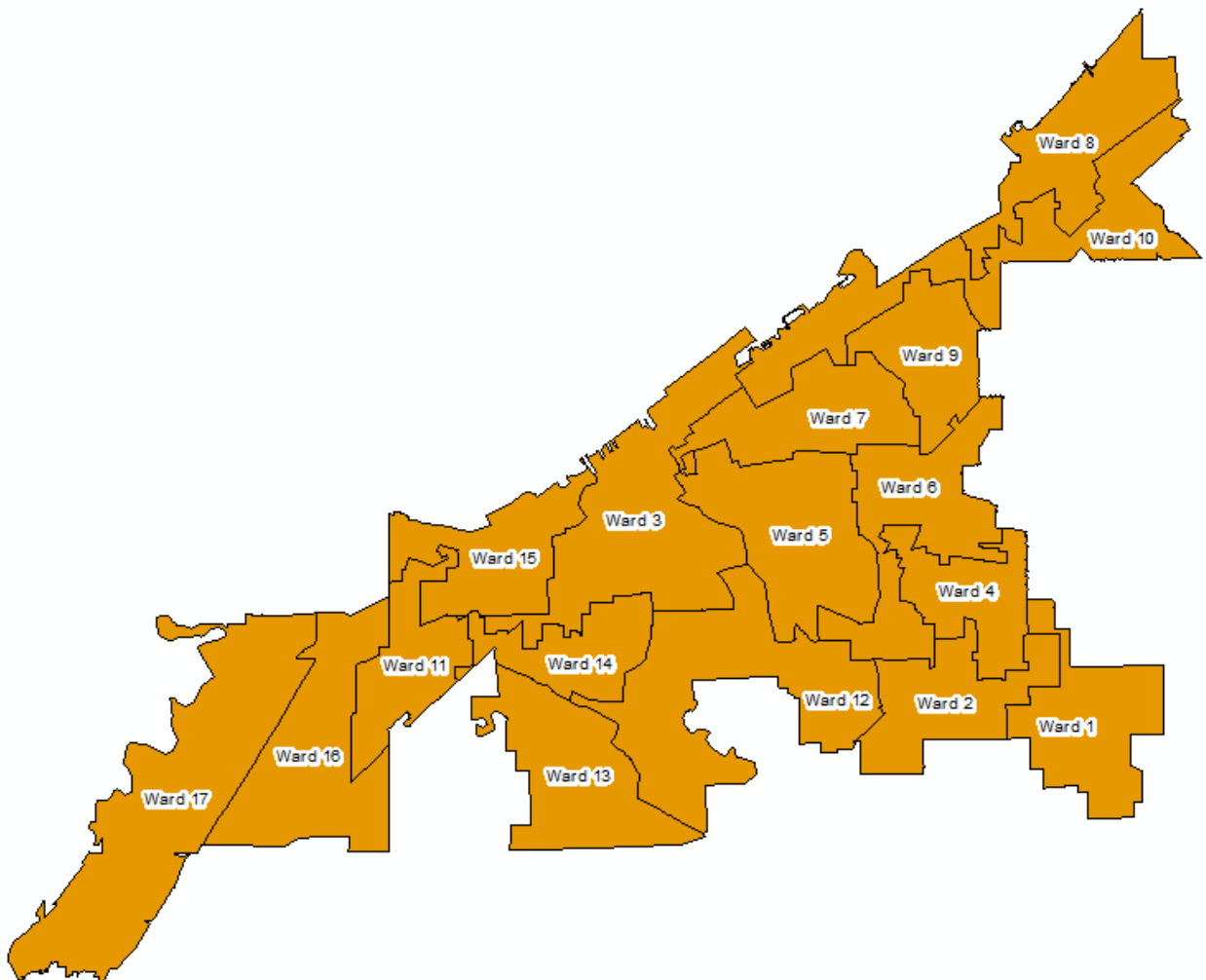


Figure 4:

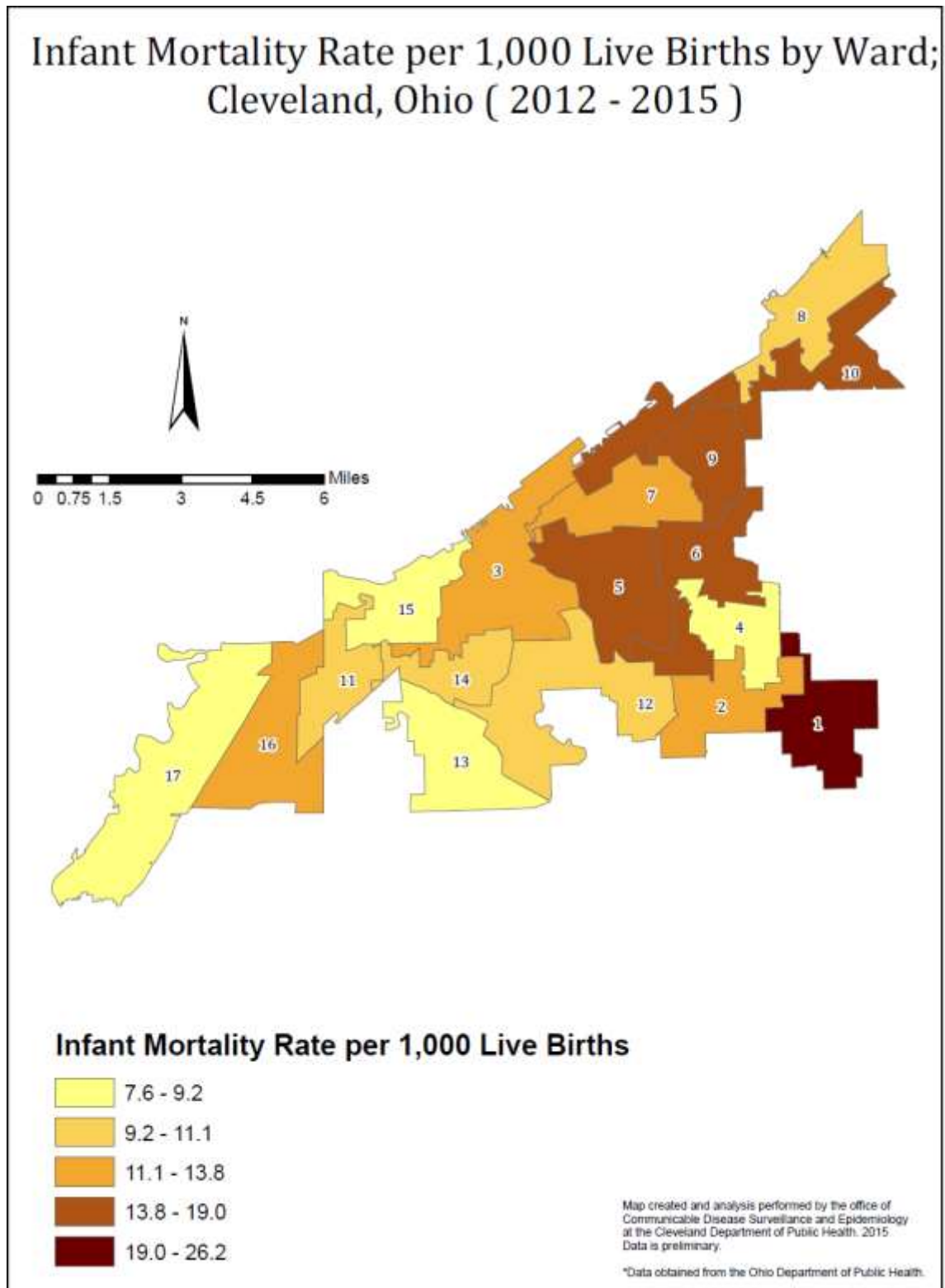


Figure 5:

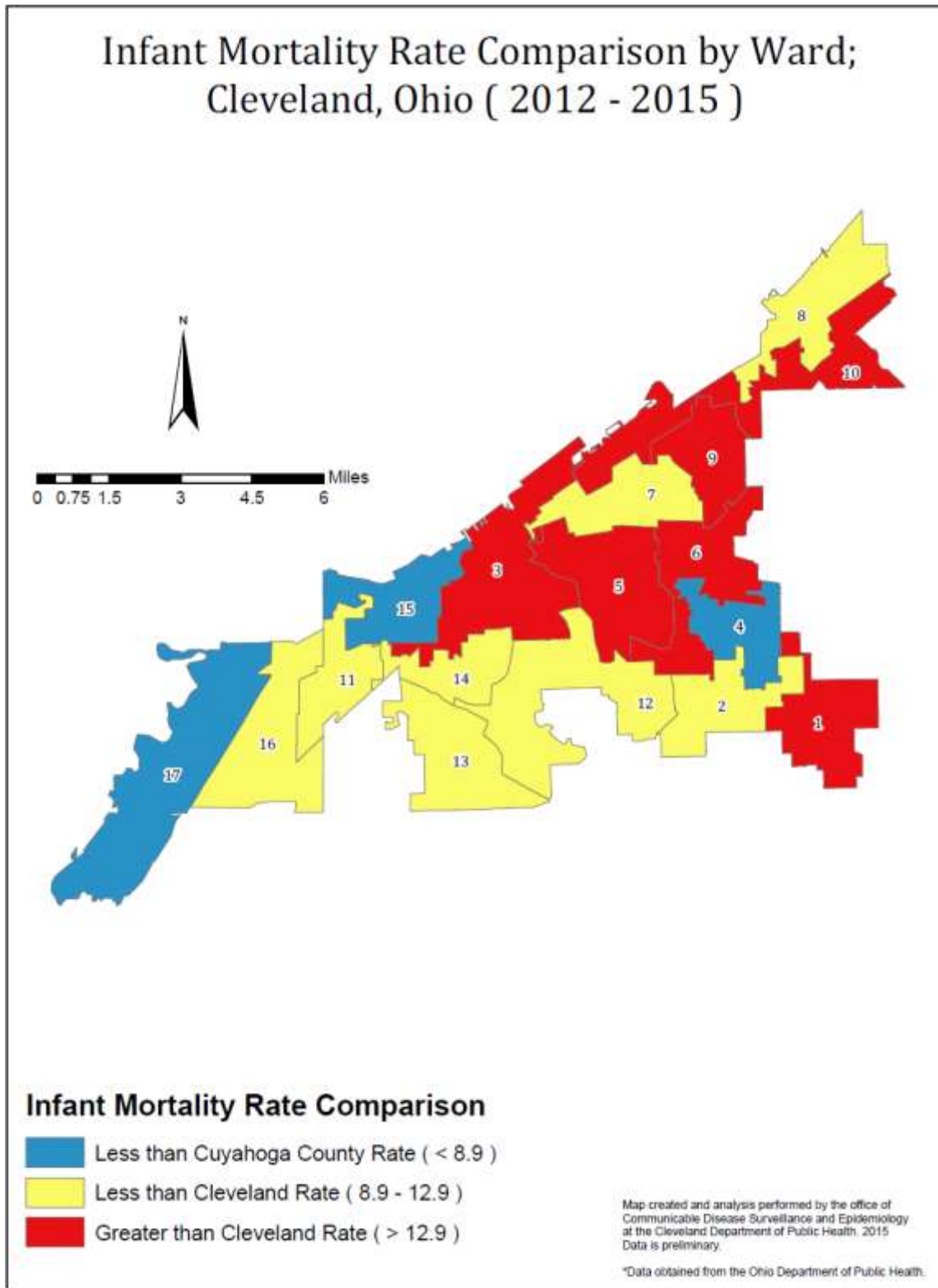


Table 4: Infant Fatalities and Mortality Rate by Ward (2012-2015)

Geographic Area	# of Live Births	# of Infant Fatalities	Rate per 1,000 Live Births
United States*	3,932,181	23,446	6.0
State of Ohio*	139,035	1,024	7.4
Cuyahoga County*	14,920	132	8.9
City of Cleveland	22,504	290	12.9
Ward 1	949	25	26.3
Ward 2	1,273	16	12.6
Ward 3	1,302	18	13.8
Ward 4	1,162	10	8.6
Ward 5	1,936	37	19.1
Ward 6	1,217	20	16.4
Ward 7	1,262	16	12.7
Ward 8	1,105	11	10.0
Ward 9	1,230	19	15.4
Ward 10	1,208	20	16.6
Ward 11	1,441	16	11.1
Ward 12	1,447	15	10.4
Ward 13	1,305	12	9.2
Ward 14	1,680	17	10.1
Ward 15	1,447	11	7.6
Ward 16	1,329	17	12.8
Ward 17	1,210	10	8.3

* Frequencies and rates are from 2013 only

Racial and Ethnic Disparity of Infant Mortality Rates

Nationally, in 2013, the infant mortality among Blacks, (11.1 per 1,000 live births), was more than twice that among Whites, (5.1 per 1,000 live births), and Hispanics (5.0 per 1,000 live births) (Lorenz, 2016).

Between the years of 2012 to 2015, 53 cases of infant fatalities were from Non-Hispanic White mothers, 206 cases were from Non-Hispanic Black mothers, and 25 cases were from Hispanic mothers, see Figure 6. The 6 remaining cases were from either mixed or unknown race and not illustrated in Figure 6.

Differences in infant mortality rates among races are apparent (Figure 6). Between the years 2012-2015, Whites, Blacks, and Hispanics had infant mortality rates of 9.3 (6.8, 11.8; 95% CI), 16.0 (13.8, 18.2; 95% CI), and 10.3 (6.3, 14.3; 95% CI) per 1,000 live births respectively (Table 5). The

differences between groups can be seen by confidence intervals that do not overlap between Blacks and Whites. This means that these two racial groups experience a significantly different infant mortality rate with 95% confidence. Blacks experience a significantly higher infant mortality rate than Whites within the City of Cleveland.

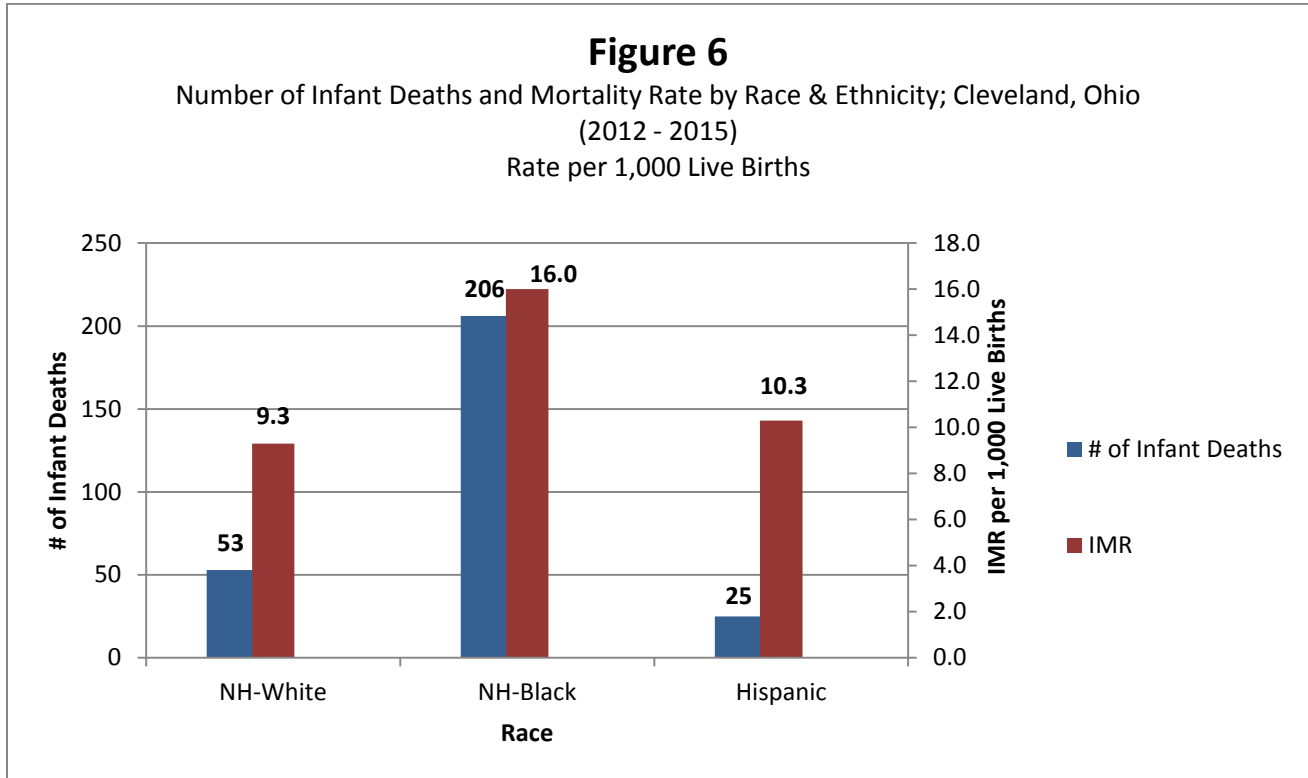


Table 5: Infant Mortality Rates by Race, Ethnicity and Year of Death (2012-2015, Cleveland, Ohio)

Race/Ethnicity	Year of Death				Overall IMR
	2012	2013	2014	2015	
White	9.5	8.7	5.3	13.9	9.3
Black	15.4	15.0	14.6	19.3	16.0
Hispanic	12.4	14.9	4.6	9.8	10.3
Overall	12.8	12.6	10.4	15.9	12.9

Preterm Birth Percentages by Neighborhoods and Wards

The city-wide preterm birth percentage for 2012-2015 was 17.3%. The US preterm birth percentage for 2013 was 11.4% (CDC, 2015). Cleveland's preterm birth percentage has remained relatively constant throughout the 4 year period, with a low of 16.8% in 2013 and a high of 17.7% in 2015. Neighborhood level percentages are presented in Table 6. The Lee-Harvard and Lee-Seville neighborhoods experienced the highest preterm birth percentages, 23.1% and 20.6% respectively. Kamm's Corners and Bellaire-Puritas experienced the lowest preterm birth percentages of 11.3% and 11.7% respectively. Preterm percentages in the Union-Miles neighborhood have been increasing; up from 14.3% in 2012 to 24.1% in 2015 with a 4 year percentage of 19.9%.

Overall, percentages do not change significantly from year to year, but percentages vary greatly from neighborhood to neighborhood. The neighborhoods of Jefferson and Mount Pleasant, both of which had similar numbers of live births, 940 and 968, had significantly different preterm birth percentages. Jefferson's percentage is 14.8% (12.5%, 17.1%; 95% CI), while Mount Pleasant's percentage is 21.6% (19.1%, 24.3%; 95% CI). Glenville and Old Brooklyn also have significantly different preterm birth percentages with 1,533, 1,664 live births respectively. Glenville experienced a percentage of 17.5% (15.6%, 19.4%; 95% CI), while Old Brooklyn experienced a percentage of 13.8% (12.2, 15.5; 95% CI). The confidence intervals in these two neighborhoods do not overlap, indicating that there is a statistically significant difference between the two neighborhood's preterm birth percentages. Neighborhoods are significantly different ($F = 18.18$) ($p < 0.0001$) with respect to gestation length, meaning that different neighborhoods experience significantly different average gestation lengths. Neighborhood level preterm birth percentage and comparisons are presented in Figures 7 and 8.

Differences in preterm birth percentages are apparent between wards (Table 7). Ward 1 had the highest preterm birth percent of 23.2% (20.6, 25.9; 95% CI). Ward 17 had the lowest percentage of 11.5% per 1,000 (9.7%, 13.3%; 95% CI). Ward preterm birth percentages and comparisons are presented in Figure 9 and 10.

Figure 7:

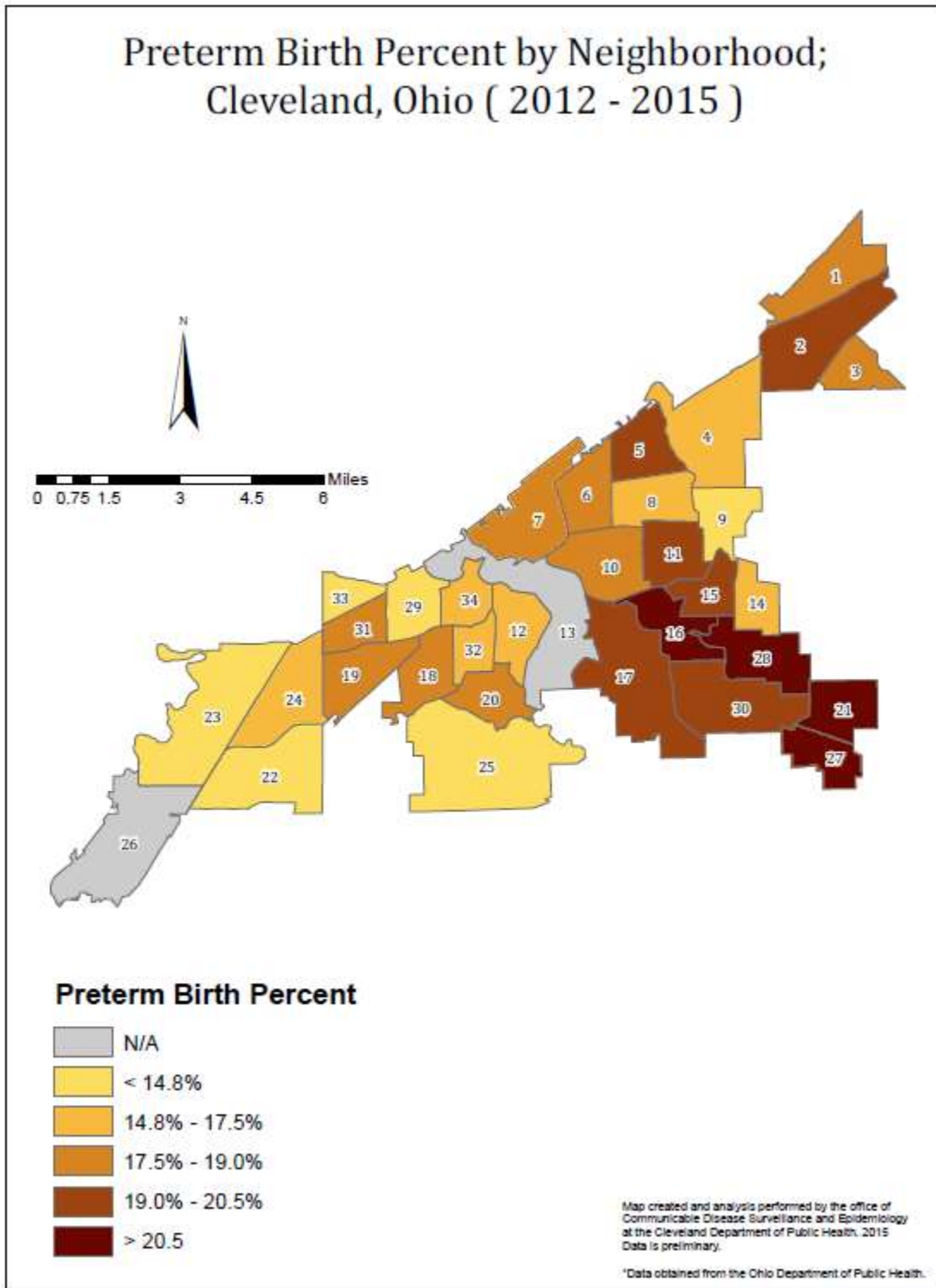


Figure 8:

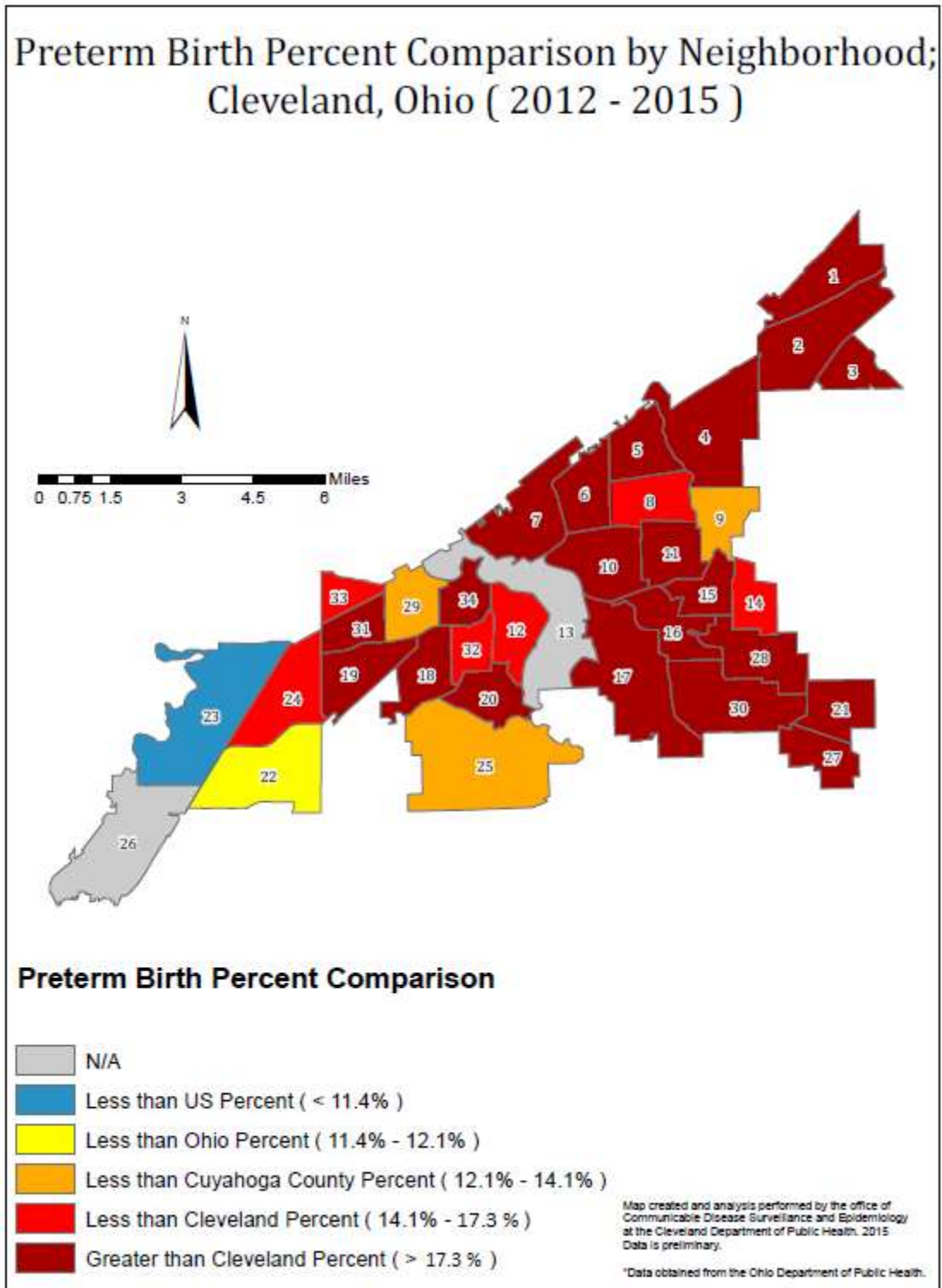


Table 6: Preterm Births and Preterm Birth Percentage by Neighborhood (2012-2015)		
Geographic Area	# of Preterm Births	Preterm Birth Percent
United States*		11.4%
State of Ohio*		12.1%
Cuyahoga County\$		14.1%
City of Cleveland	3,900	17.3%
Neighborhood (#)		
Bellaire-Puritas (22)	81	11.7%
Broadway-Slavic Village (17)	271	20.0%
Brooklyn Centre (20)	115	18.0%
Buckeye-Shaker Square (14)	111	16.8%
Buckeye-Woodhill (15)	103	20.1%
Central (10)	230	18.9%
Clark-Fulton (32)	104	16.1%
Collinwood-Nottingham (2)	125	19.2%
Cudell (31)	111	18.1%
Cuyahoga Valley (13)	2	**
Detroit Shoreway (29)	88	12.5%
Downtown (7)	58	17.5%
Edgewater (33)	33	14.2%
Euclid-Green (3)	56	18.4%
Fairfax (11)	73	20.2%
Glenville (4)	268	17.5%
Goodrich-Kirtland Park (6)	39	18.0%
Hopkins (26)	3	**
Hough (8)	116	17.1%
Jefferson (24)	139	14.8%
Kamm's Corners (23)	145	11.3%
Kinsman (16)	116	21.9%
Lee-Harvard (21)	80	23.1%
Lee-Seville (27)	42	20.6%
Mount Pleasant (28)	210	21.6%
North Shore Collinwood (1)	137	18.8%
Ohio City (34)	94	17.3%
Old Brooklyn (25)	230	13.8%
St. Clair-Superior (5)	83	20.2%
Stockyards (18)	126	18.2%
Tremont (12)	70	15.4%
Union-Miles (30)	195	19.9%
University (9)	24	14.0%
West Boulevard (19)	219	18.1%
* Frequencies and Percentages are from 2013 only		
\$ Frequencies and Percentages are from 2008-2010		
** Statistics could not be calculated due to insufficient sample size		

Figure 9:

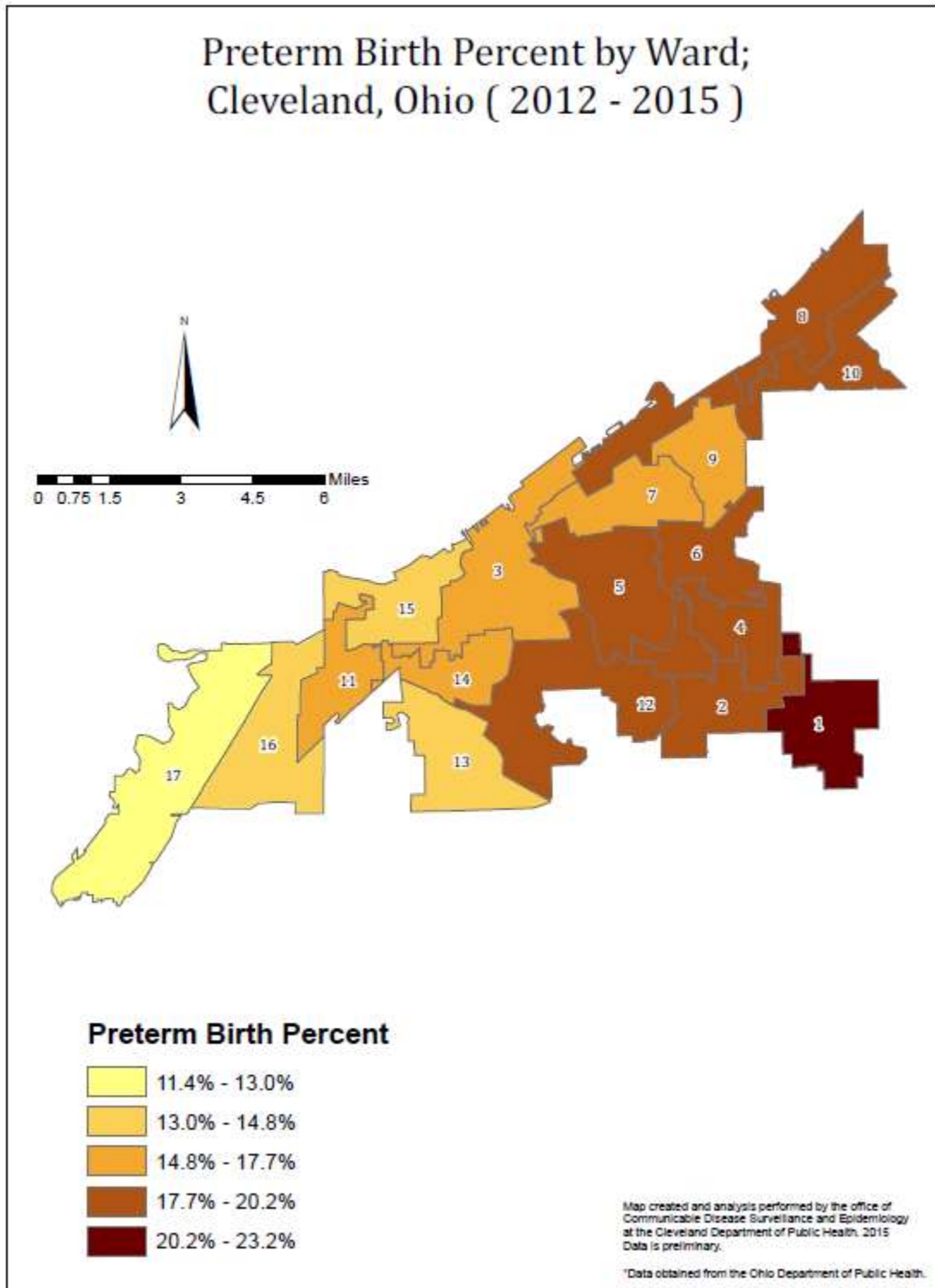
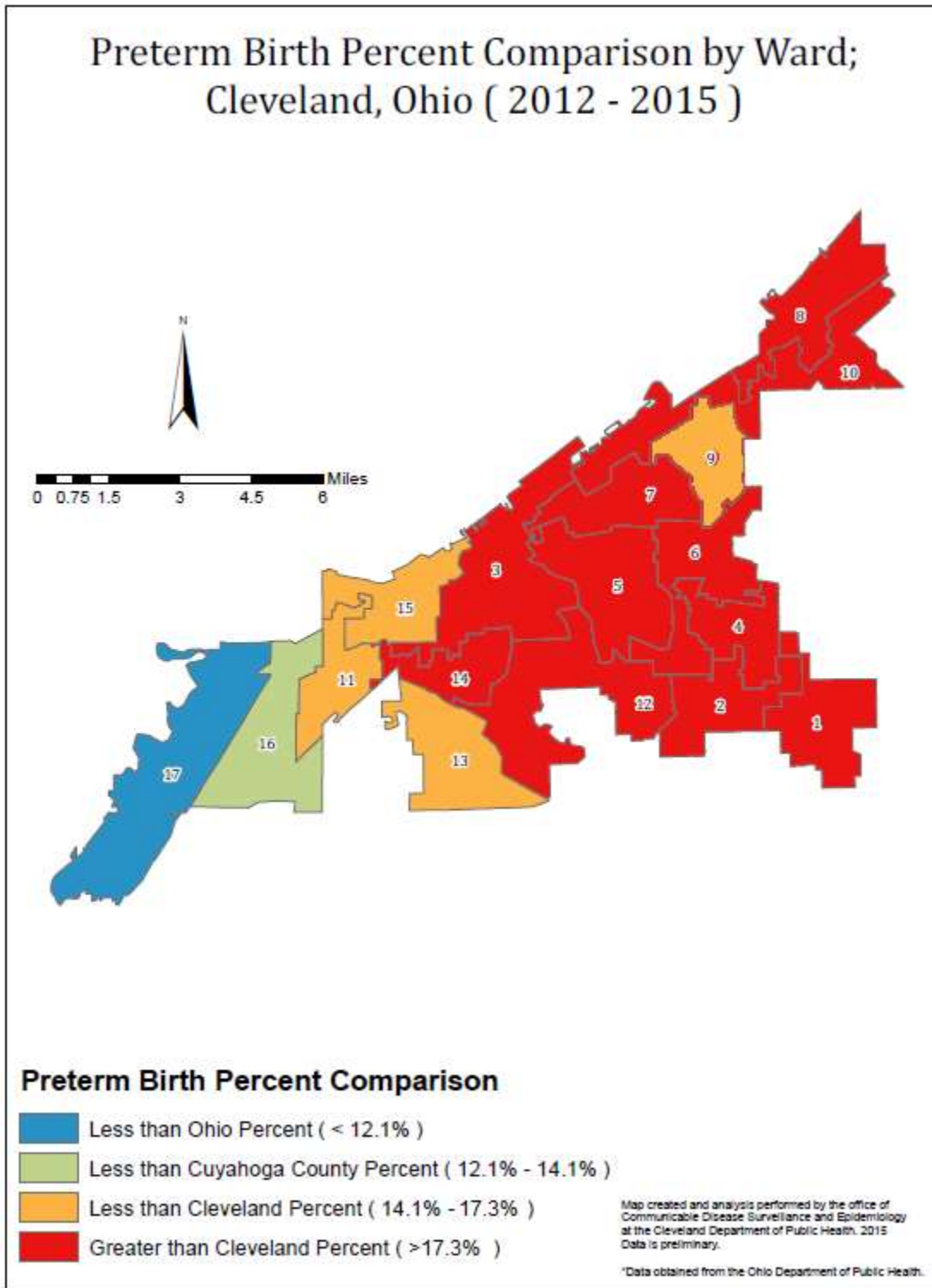


Figure 10:



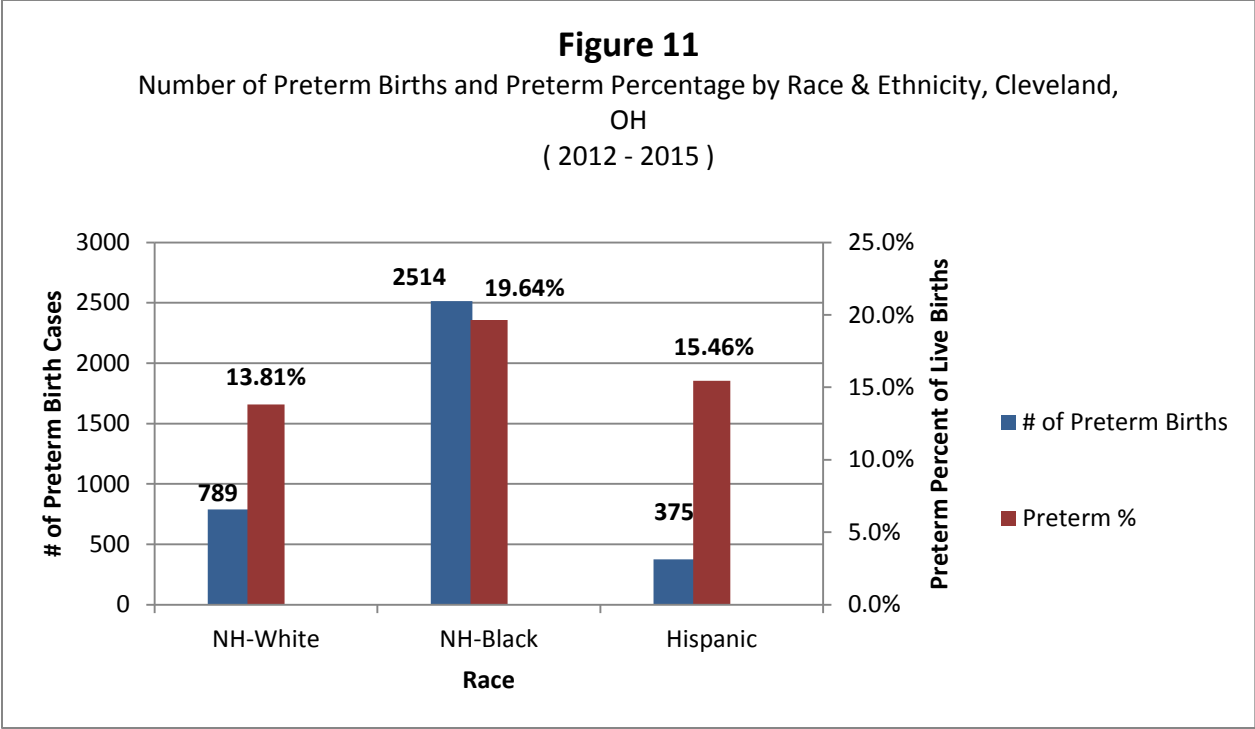
Geographic Area	# of Preterm Births	Preterm Birth Percent
City of Cleveland	3,900	17.3%
Ward 1	220	23.2%
Ward 2	247	19.4%
Ward 3	220	16.9%
Ward 4	215	18.5%
Ward 5	390	20.1%
Ward 6	221	18.2%
Ward 7	223	17.7%
Ward 8	207	18.7%
Ward 9	210	17.1%
Ward 10	231	19.1%
Ward 11	243	16.9%
Ward 12	266	18.4%
Ward 13	189	14.5%
Ward 14	292	17.4%
Ward 15	214	14.8%
Ward 16	173	13.0%
Ward 17	139	11.5%

Racial and Ethnic Disparity of Preterm Birth Percentages

Nationally, in 2014, the preterm birth percentage among Blacks was 13.2%, compared to 8.9% among Whites, and 9.0% among Hispanics (Lorenz, 2016).

The City of Cleveland experienced 3,900 preterm births between the years of 2012 and 2015. Of these, 789 cases of preterm birth were from Non-Hispanic White mothers, 2514 cases were from Non-Hispanic Black mothers, and 375 cases were from Hispanic mothers, see Figure 11. The 222 remaining cases were from either mixed or unknown race and not illustrated in Figure 11.

Preterm birth percentages among races were significantly different from each other. Whites in Cleveland experienced a preterm birth percentage of 13.81% (12.9%, 14.7%; 95% CI). Blacks in Cleveland experienced a preterm birth percentage of 19.64% per 1,000 live births (19.0%, 20.3%; 95% CI). Hispanics in Cleveland experienced a percentage of 15.46% (14.0%, 16.9%; 95% CI). The differences between groups can be seen with the lack of confidence interval overlap between Blacks and Whites or Hispanics. This means that these groups experience a significantly different preterm birth percentage with 95% confidence.



Causes of Death

Figure 12 illustrates the distribution of causes of death among Cleveland infants between the years of 2012 and 2015. Of the 290 total infant deaths, only 217 had complete data on manner of death. A large majority of infant deaths were due to natural death, 175 of 217 (80.65%). 24 (11.06%) infant fatalities did not have a determined cause of death (CND); accidents accounted for 12 (5.53%) infant fatalities. Homicides accounted for 2.30%, 5 total deaths. One death is currently pending investigation (0.46%). Figure 13 illustrates the proportion of infant mortality cases by gestation length. Preterm birth is defined as a gestation length of less than 37 weeks while full term birth is defined as a gestation length of 37 weeks or greater. Preterm births accounted for 195, (80.58%) deaths while full term births accounted for 47 (19.42%) of deaths.

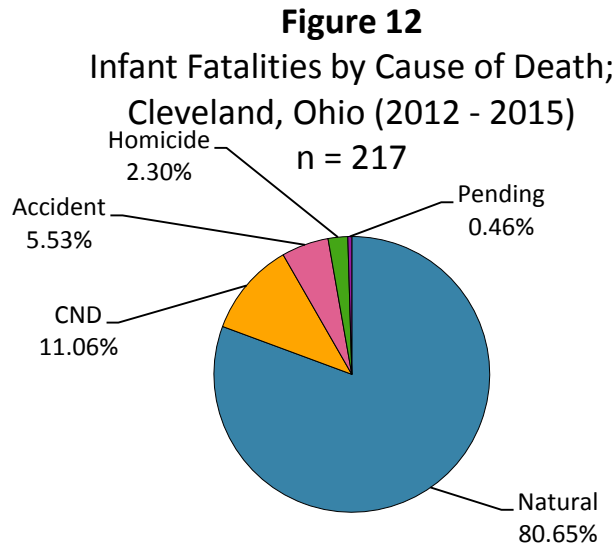
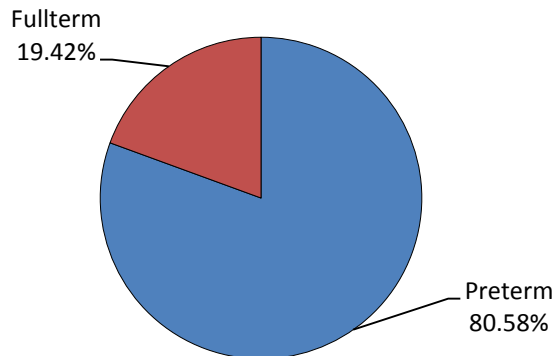


Figure 13
Gestation Length of Infant Mortality
Cases; Cleveland, Ohio (2012 - 2015)
 n = 242



Predictive Factors

Gestation length is the single greatest determining factor of infant mortality in the City of Cleveland ($p < 0.0001$). Unadjusted odds of infant mortality given preterm birth as the predictor is 20.7 (15.1, 28.6; 95% CI), meaning that an infant born before 37 weeks of gestation is 20.7 times more likely to die than a full term infant. After adjusting for confounding of low birth weight, odds of infant mortality given preterm birth are 5.0 times (3.4, 7.4; 95% CI).

Mothers who experienced a preterm birth, had 8 (7.53) prenatal care visits on average. Mothers who had a full-term birth, had 10 (10.19) prenatal care visits on average. Payment type is a significant predictor of the number of prenatal care visits ($p < 0.0001$). Mothers who self-pay

had, on average, 9 (8.80) prenatal care visits, while mothers with private insurance had 12 (11.78) prenatal care visits. Mothers on Medicaid had 9 (9.14) prenatal care visits.

Logistic regression was performed in order to calculate odds of preterm birth. The probability of preterm birth was modeled as the outcome. Significant predictive factors include diabetes status prior to pregnancy, gestational diabetes, hypertension status prior to pregnancy, gestational hypertension, mother's education level, mother's age, a previous occurrence of preterm birth, smoking status, and BMI. Odds are the statistical probability of how much more likely an event will occur given a predictor.

When controlling for all other significant risk factors, mothers who had pre-pregnancy diabetes were 1.6 (1.2, 2.0 95% CI) times more likely to experience a preterm birth. Mothers who had pre-pregnancy hypertension were 1.5 (1.3, 1.9 95% CI) times more likely to experience a preterm birth.

Mothers who experienced either gestational diabetes or gestational hypertension were 1.3 (1.1, 1.5 95% CI) and 1.9 (1.7, 2.2 95% CI) times more likely to experience preterm birth respectively. Mothers who experienced a previous preterm birth were 3.4 (3.0, 3.7 95% CI) times more likely to experience another preterm birth.

Mother's age was a significant predictor of preterm birth. Mothers aged 35 years and older were 1.4 (1.2, 1.6 95% CI) times more likely to experience a preterm birth compared to mothers less than 35 years of age. Mothers who smoked during or three months prior to pregnancy were 1.1 (1.0, 1.2 95% CI) times more likely to experience preterm birth. Mothers who were classified as underweight (<18.5 kg/m² BMI) were 1.3 (1.0, 1.5 95% CI) times more likely to experience preterm birth.

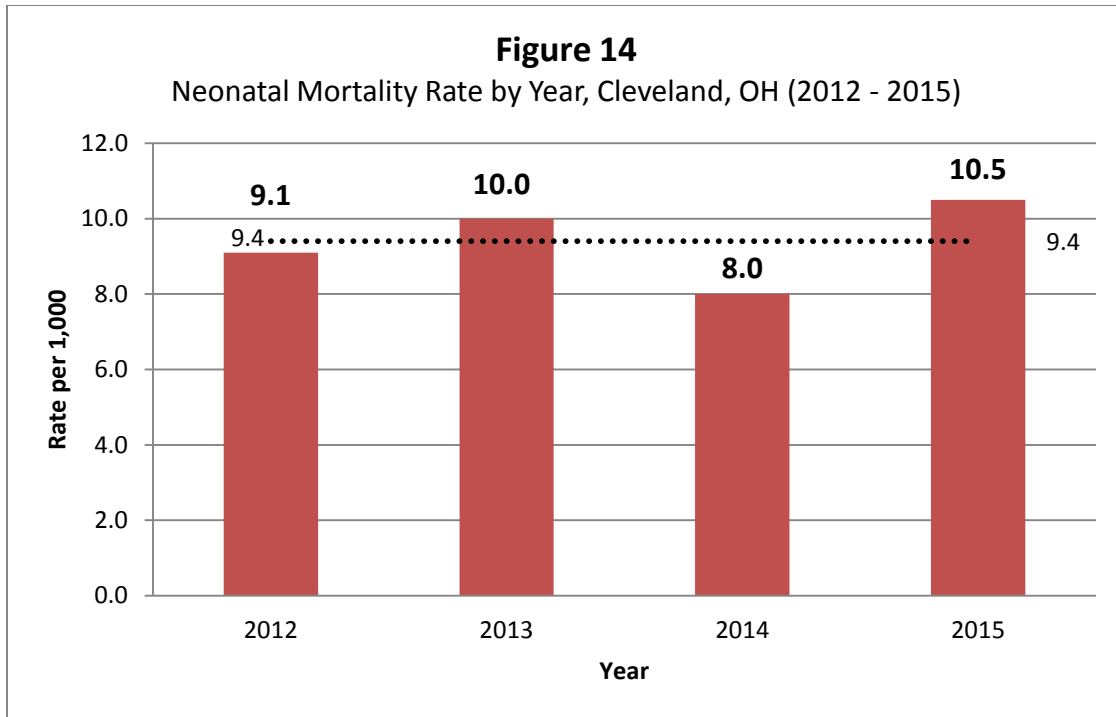
Mother's education level was significantly associated with preterm birth among mothers who have not received a college education. Mothers with less than an 8th grade education were 1.5 (1.2, 1.9 95% CI) times more likely to experience a preterm birth. Mothers that did not graduate high school were at 1.3 (1.2, 1.5 95% CI) odds. Mothers who either graduated high school or received their GED were at 1.3 (1.2, 1.4 95% CI) odds when compared to mothers who went to college. Mothers who previously experienced a preterm birth were at 3.4 (3.0, 3.8 95% CI) times. Odds ratio estimates and 95% confidence intervals are presented in Table 8.

Table 8: Estimated Odds of Preterm Birth and 95% Confidence Intervals; (2012-2015)		
	Odds Estimate	95% Confidence Interval
Gestational Diabetes	1.256	(1.070 - 1.474)
Gestational Hypertension	1.948	(1.734 - 2.188)
Pre-pregnancy Diabetes	1.546	(1.169 - 2.044)
Pre-pregnancy Hypertension	1.584	(1.343 - 1.869)
Age >= 35	1.379	(1.220 - 1.559)
8th grade or less	1.546	(1.234 - 1.937)
9th through 12th grade; no diploma	1.340	(1.218 - 1.475)
High School Graduate or GED Completed	1.282	(1.173 - 1.401)
Previous Preterm Birth	3.366	(3.029 - 3.740)
Smoking Status	1.101	(1.006 - 1.205)
Underweight (BMI < 18.5 kg/m ²)	1.255	(1.047 - 1.502)

Neonatal Mortality Rates

Neonatal mortality rate is the measure of the number of live infants born who die within the first 28 days of life. The Healthy People 2020 objective is to reduce the neonatal mortality rate to 4.1 per 1,000 live births (HP, 2016). This goal was set from the 2006 national baseline rate of 4.5 per 1,000 live births; a goal of a 10% reduction (HP, 2016). Yearly rates are illustrated in Figure 6.

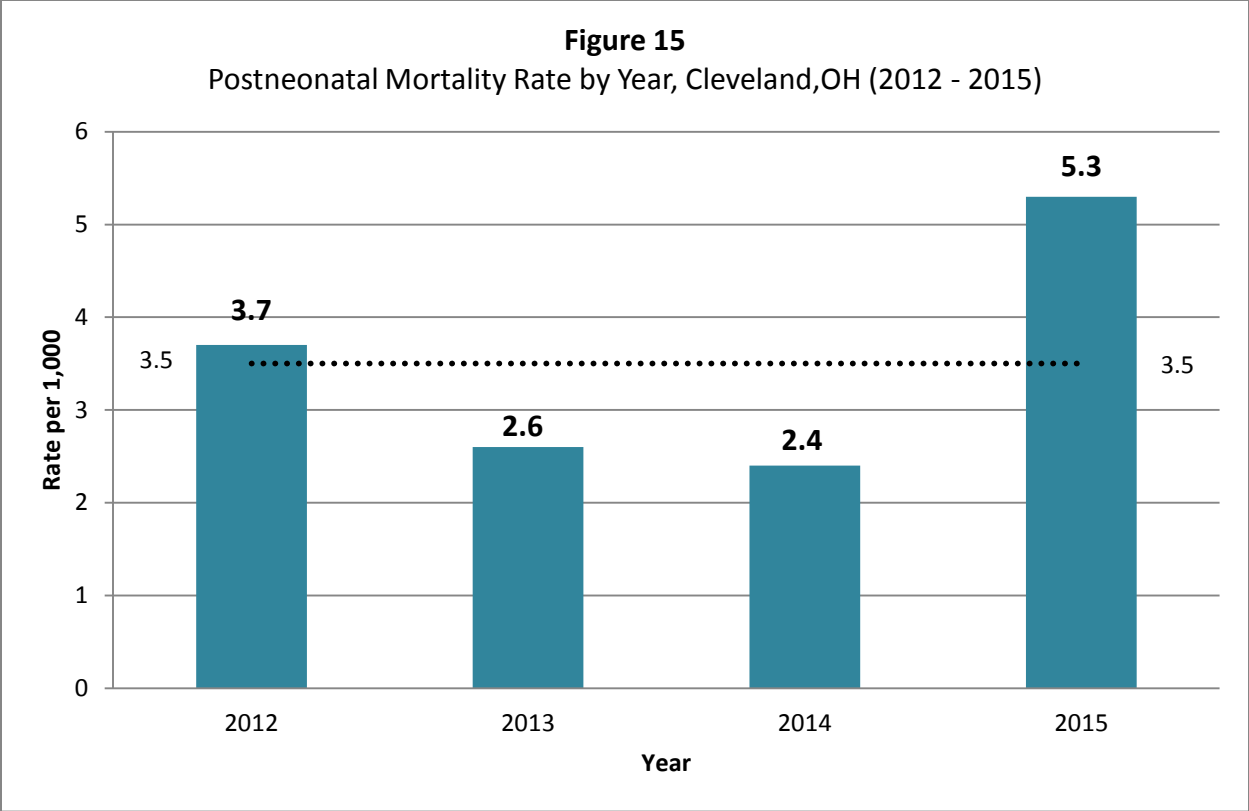
The city-wide neonatal mortality rate for 2012-2015 is 9.4 per 1,000 live births. Year specific rates are 9.1, 10.0, 8.0, and 10.5 per 1,000 live births for the years 2012, 2013, 2014, and 2015. Year specific rates and overall rate is presented in Figure 14. Overall, the City of Cleveland exceeds (i.e. does not meet) the Healthy People 2020 objective by 109%; i.e. rates of 4.5 vs. 9.4.



Postneonatal Mortality Rates

The postneonatal mortality rate measures the number of deaths occurring to infants aged 28 to 364 days per 1,000 live births. The Healthy People 2020 target was to have no more than 2.0 postneonatal deaths per 1,000 live births (HP, 2016). Yearly rates are illustrated in Figure 15.

The citywide postneonatal death rate for 2012-2015 is 3.5 per 1,000 live births. Year specific rates are 3.7 for 2012, 2.6 for 2013, 2.4 for 2014, and 5.3 for 2015. Year specific rates and overall rate are presented in Figure 6. Overall, the City of Cleveland exceeds (i.e. does not meet) the Healthy People 2020 objective by 75%; i.e. rates of 2.0 vs. 3.5.



Low Birth Weight Percentages by Neighborhoods

Birth weight is the measure of an infant’s weight at birth in grams. Infants weighing less than 2,500 grams (5lbs 8oz) are classified as being of low birth weight (LBW) (CDC, 2012).

Low Birth Weight (LBW) associated risk factors during pregnancy include smoking, drinking alcohol, lack of weight gain, aged younger than 15 or older than 35, and having a prior preterm birth (CDC, 2012). Infants who experience LBW are at greater risk of developing illnesses within the first few days of life, delayed motor and social skill development, and learning disabilities (CDC, 2012).

Healthy People 2020 objective MICH-8.1 states to reduce low birth weight to 7.8% (HP, 2016). In 2013, the US percentage of LBW infants was 8.0% (CDC, 2013). Ohio experienced a LBW percentage of 8.7% in 2013 (ODM, 2015). Cuyahoga county has a LBW percentage of 10.2% in 2013 (ODM, 2015). The City of Cleveland had an overall LBW percentage of 13.6% from 2012 to 2015. The mean weight of an infant born in Cleveland between 2012 and 2015 was 3,080 grams (6lbs 13oz). Means and percentages by neighborhood are presented in Table 9. Neighborhoods are significantly different ($F = 60.04$) ($p < 0.0001$) with respect to birth weight. St. Clair-Superior had the highest percentage of LBW infants (19.1%) with a mean infant weight of 2,955 grams (6lbs 8oz). Kamm’s Corners had the lowest percentage of LBW infants (8.1%) with a mean infant weight of 3,257 grams (7lbs 3oz). Distribution and comparisons are presented in Figures 16 & 17. Cleveland as a whole has a higher percentage of low birth weight infants than the US, Ohio, or

Cuyahoga County. Few neighborhoods achieve lower percentages of low birth infants than the county or state. The majority of neighborhoods on the east side of Cleveland have a higher percentage of low birth weight infants than on the west side, see Figure 16.

Low birth weight is significantly associated with death ($p < .0001$). When controlling for gestation length, low birth weight infants are 9.2 times more likely to experience death than normal weight infants.

Multiple linear regression was performed with birthweight (grams) as the outcome and the number of prenatal care visits and gestation length as the outcome. Both predictors are significantly associated with the outcome ($p < 0.0001$). Neither predictors experience multicollinearity as seen from the Variation Inflation Factor ($VIF = 1.0797$). On average, each prenatal care visit adds 14.25 grams to an infant's total birthweight. This is equivalent to approximately 0.5 ounces. This amount may seem insignificant; however, the average birth weight for infants in Cleveland was 3,080 grams (6lbs 13oz). One prenatal care visit, on average, adds 0.5% to total infant birthweight. A mother who has 10 prenatal care visits will give birth to an infant weighting 5 ounces (142.5 grams) more than a mother who does not have any prenatal care visits.

A t-test was conducted among infants with 40 weeks of gestation ($p = 0.0108$). Infants who were classified as low birth (<2,500 grams at birth) had, on average, 9 prenatal care visits. Infants who were of normal birth weight, (> 2,500 grams at birth) had, on average, 11 prenatal care visits.

Figure 16:

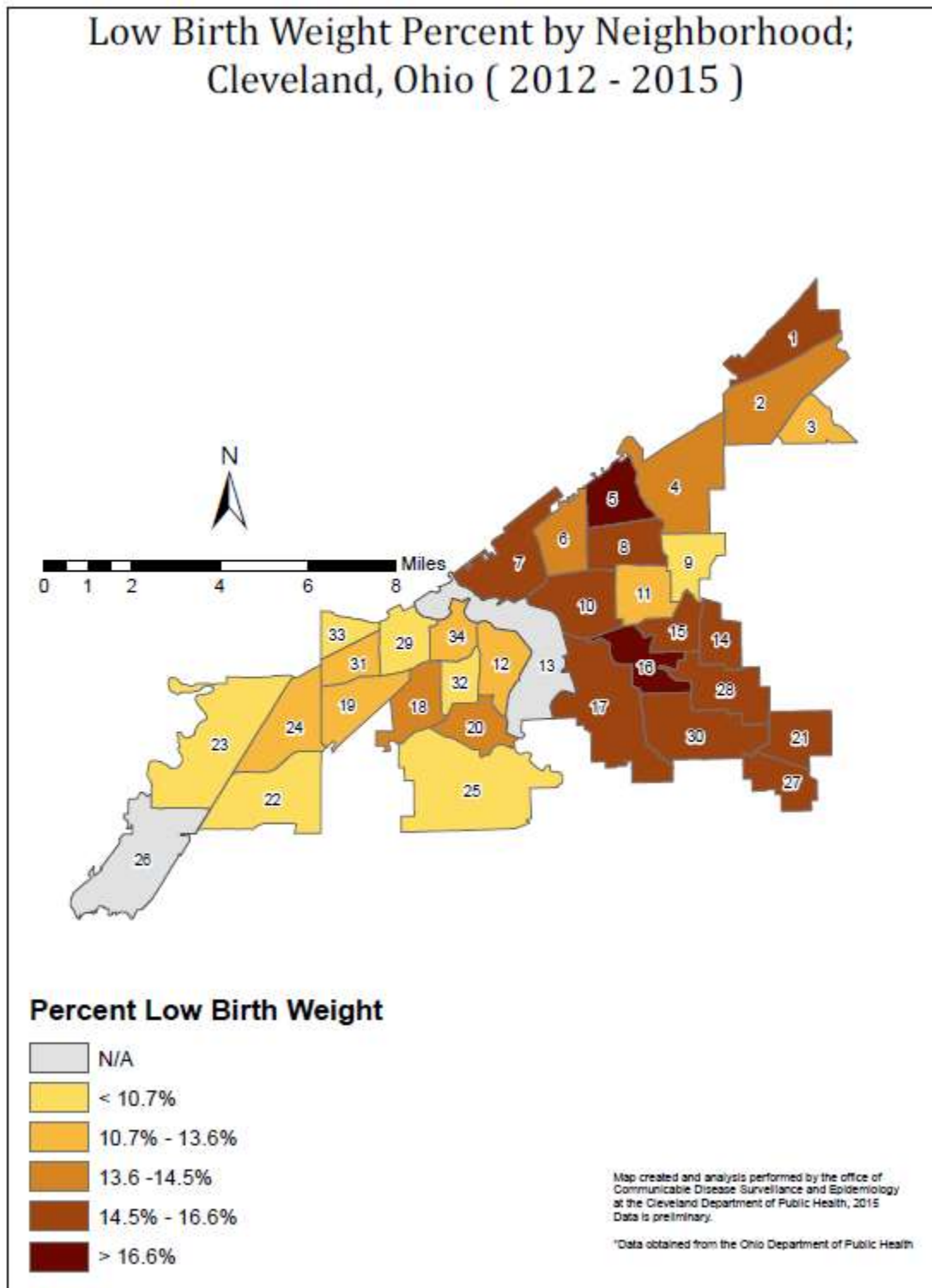


Figure 17:

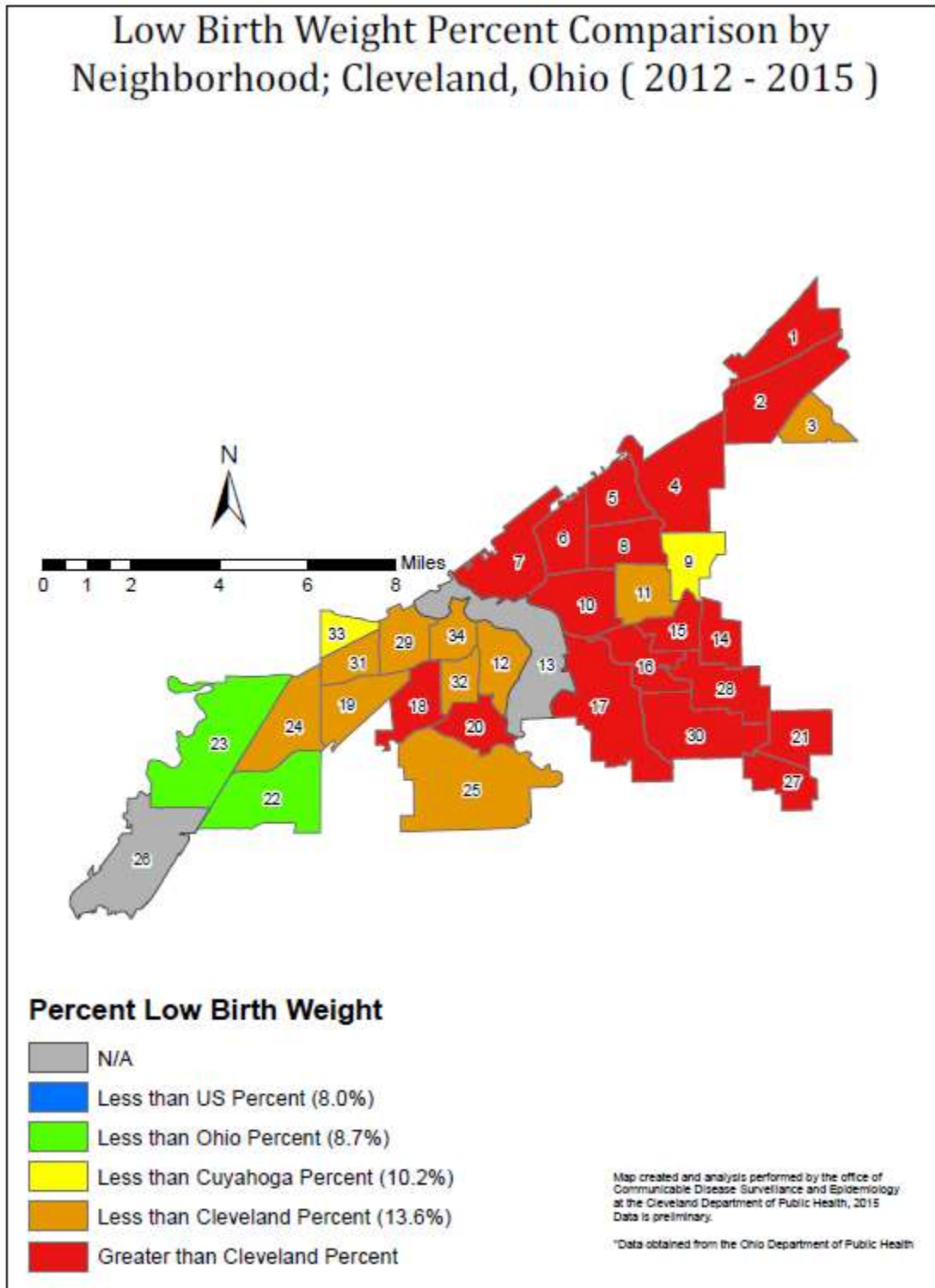


Table 9: Average Birth Weight and Percentage of LBW by Neighborhood			
Geographic Area	Average Birth Weight		Percent of LBW
	Grams	Pounds & Ounces	
United States*			8.0%
Ohio*			8.7%
Cuyahoga County*			10.2%
City of Cleveland	3079.83	6 lbs 13 oz	13.6%
Neighborhood (#)			
Bellaire-Puritas (22)	3184.48	7 lbs 0 oz	8.6%
Broadway-Slavic Village (17)	3010.74	6 lbs 10 oz	15.7%
Brooklyn Centre (20)	3071.53	6 lbs 12 oz	14.5%
Buckeye-Shaker Square (14)	3013.23	6 lbs 10 oz	15.6%
Buckeye-Woodhill (15)	3017.06	6 lbs 10 oz	15.8%
Central (10)	3020.55	6 lbs 11 oz	15.6%
Clark-Fulton (32)	3129.10	6 lbs 14 oz	10.7%
Collinwood-Nottingham (2)	3024.12	6 lbs 11 oz	13.8%
Cudell (31)	3112.62	6 lbs 14 oz	13.4%
Cuyahoga Valley (13)	3212.17	7 lbs 1 oz	**
Detroit Shoreway (29)	3142.10	6 lbs 15 oz	10.5%
Downtown (7)	3012.71	6 lbs 10 oz	15.4%
Edgewater (33)	3214.20	7 lbs 1 oz	9.9%
Euclid-Green (3)	3048.87	6 lbs 12 oz	13.2%
Fairfax (11)	3048.50	6 lbs 12 oz	13.6%
Glenville (4)	3017.96	6 lbs 10 oz	14.2%
Goodrich-Kirtland Park (6)	3091.70	6 lbs 13 oz	14.4%
Hopkins (26)	3039.00	6 lbs 11 oz	**
Hough (8)	3014.84	6 lbs 10 oz	16.6%
Jefferson (24)	3126.45	6 lbs 14 oz	12.9%
Kamm's Corners (23)	3257.09	7 lbs 3 oz	8.1%
Kinsman (16)	2973.26	6 lbs 9 oz	18.0%
Lee-Harvard (21)	2994.68	6 lbs 10 oz	15.6%
Lee-Seville (27)	3030.61	6 lbs 11 oz	15.6%
Mount Pleasant (28)	3018.78	6 lbs 10 oz	16.0%
North Shore Collinwood (1)	3076.85	6 lbs 13 oz	15.1%
Ohio City (34)	3106.54	6 lbs 14 oz	13.5%
Old Brooklyn (25)	3184.55	7 lbs 0 oz	10.7%
St. Clair-Superior (5)	2955.60	6 lbs 8 oz	19.1%
Stockyards (18)	3085.60	6 lbs 13 oz	13.8%
Tremont (12)	3138.44	6 lbs 15 oz	12.8%
Union-Miles (30)	2991.41	6 lbs 10 oz	15.4%
University (9)	3186.55	7 lbs 0 oz	9.8%
West Boulevard (19)	3120.12	6 lbs 14 oz	13.2%
* Percentages are from 2013 only			
** Statistics could not be calculated due to insufficient sample size			

Rate Ratios by Neighborhoods

A rate ratio was calculated for each neighborhood. This ratio compared the preterm birth rate to infant mortality rate. Neighborhoods with a higher rate ratio experienced more preterm births to deaths, indicating better health outcomes. The overall city rate ratio is 13.5 preterm births per death. Neighborhood level ratios are presented in Table 10. Ratios are illustrated in Figure 18. Neighborhoods with the best infant health outcomes are colored dark blue while neighborhoods with the worst infant health outcomes are colored red.

The neighborhoods of Lee-Harvard, St. Clair-superior, Lee-Seville, Union-Miles, and Jefferson had the lowest ratio of preterm births per deaths with 6.7, 8.3, 8.4, 9.8, and 9.9 respectively. These neighborhoods had the worst health outcomes for preterm births.

The neighborhoods of Buckeye-Woodhill, Clark-Fulton, Edgewater, University, and Detroit Shoreway had the highest ratio of preterm births to deaths with 51.5, 34.7, 33.0, 24.0, and 22.0 respectively. These neighborhoods had the best health outcomes for preterm births.

Preterm infants born in the Lee-Harvard neighborhood die at 7.7 times the rate of infants born in the Buckeye-Woodhill neighborhood. This is clear evidence that health disparities exist within the City of Cleveland.

Figure 18:

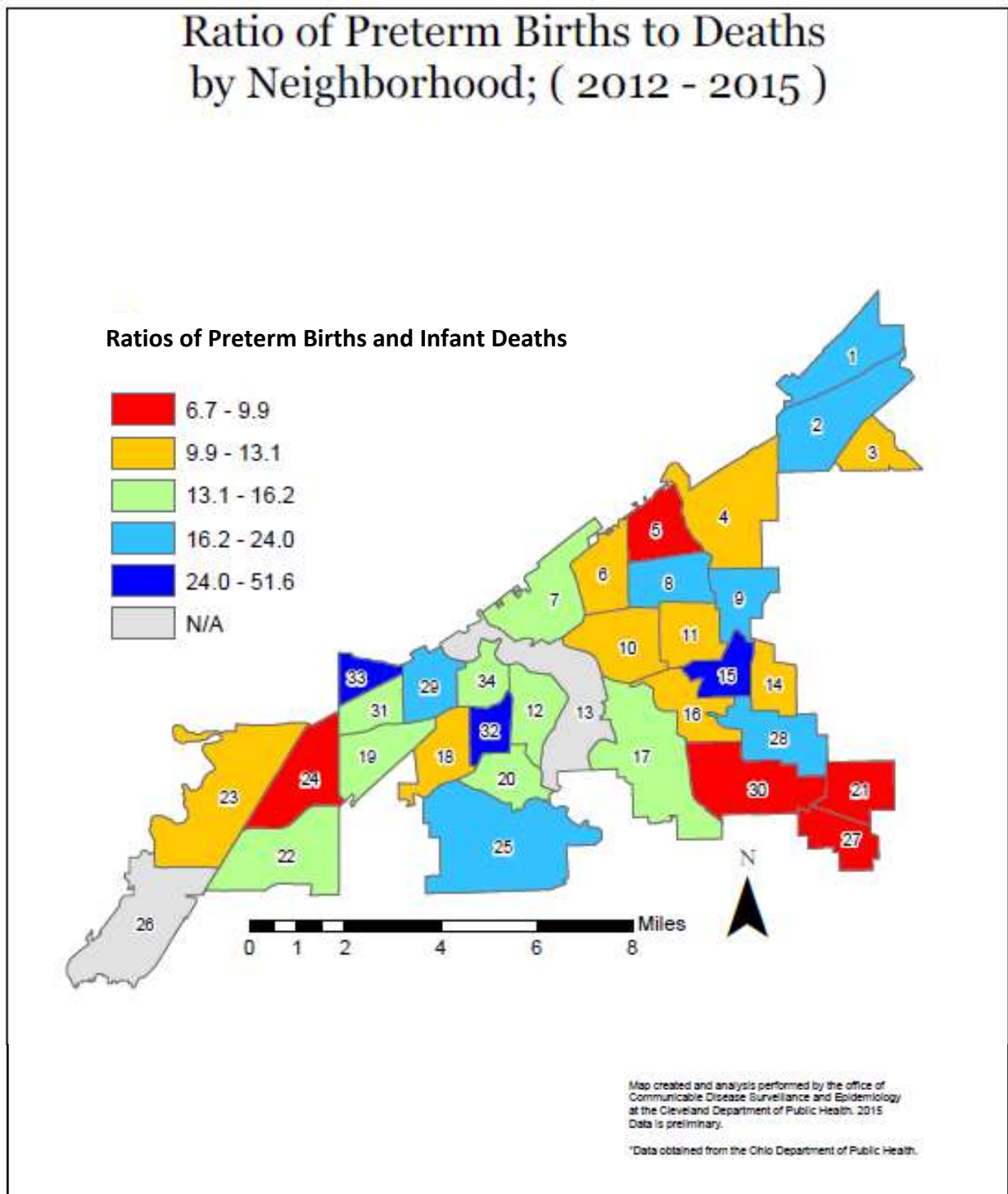


Table 10: Ratio of Preterm Births to Infant Fatalities by Neighborhood

Neighborhood (#)	# of Preterm Births	# of Infant Fatalities	Preterm Births per Death
Cleveland	3,900	290	13.4
Bellaire-Puritas (22)	81	5	16.2
Broadway-Slavic Village (17)	271	20	13.6
Brooklyn Centre (20)	115	8	14.4
Buckeye-Shaker Square (14)	111	9	12.3
Buckeye-Woodhill (15)	103	2	51.5
Central (10)	230	20	11.5
Clark-Fulton (32)	104	3	34.7
Collinwood-Nottingham (2)	125	7	17.9
Cudell (31)	111	8	13.9
Cuyahoga Valley (13)	2	1	**
Detroit Shoreway (29)	88	4	22.0
Downtown (7)	58	4	14.5
Edgewater (33)	33	1	33.0
Euclid-Green (3)	56	5	11.2
Fairfax (11)	73	6	12.2
Glenville (4)	268	23	11.7
Goodrich-Kirtland Park (6)	39	3	13.0
Hopkins (26)	3	0	**
Hough (8)	116	6	19.3
Jefferson (24)	139	14	9.9
Kamm's Corners (23)	145	12	12.1
Kinsman (16)	116	11	10.5
Lee-Harvard (21)	80	12	6.7
Lee-Seville (27)	42	5	8.4
Mount Pleasant (28)	210	12	17.5
North Shore Collinwood (1)	137	8	17.1
Ohio City (34)	94	6	15.7
Old Brooklyn (25)	230	13	17.7
St.Clair-Superior (5)	83	10	8.3
Stockyards (18)	126	10	12.6
Tremont (12)	70	5	14.0
Union-Miles (30)	195	20	9.8
University (9)	24	1	24.0
West Boulevard (19)	219	16	13.7

** Statistics could not be calculated due to insufficient sample size

Discussion and Conclusion

Infant mortality is a crucial indicator of a community's health. The City of Cleveland has been under recent scrutiny for its exceedingly high infant mortality rate. This report examined the distribution of infant mortality cases and general associated predictive factors. There is a statistically significant disparity of infant mortality in terms of race and location. Health disparities among neighborhoods are statistically significant. Initial analysis would suggest that areas with reduced access to quality health care also experience higher rates of infant mortality, independent of preterm birth.

Modifiable risk factors such as smoking status and medical history should be addressed in counseling. Lorenz (2016) suggests that increasing access to quality health care would have the most significant impact on reducing infant mortality among those with low socio-economic status.

Prenatal care plays an integral role in the health of the mother and infant during pregnancy. Findings show that prenatal care visits are significantly associated with the birth weight of an infant. Low birth weight is of significant concern due to health problems associated. Low birth weight infants are at additional risk of death. Additional health concerns include delayed motor skill development and learning disabilities (CDC, 2014). Significant birth weight differences exist between neighborhoods. Neighborhoods with the lowest low birth weight percentages experience percentages half that of neighborhoods with the highest low birth weight percentages. Additional attention to prenatal care in these neighborhoods will impact the health of the population by increasing infant birth weight, thus reducing the risk of death.

This report should be used to create effective evidence based public health programs in areas in need. Additional research is needed to understand the relationship between socio-economic status and infant health outcomes in the City of Cleveland.

Recommendations

Since preterm birth is so strongly associated with infant mortality, we would expect to see higher rates of infant death occurring in neighborhoods with higher preterm birth rates. The United States experiences 19 premature infants for every 1 death, 16.3 for Ohio, and 16.0 for Cuyahoga County. Cleveland experiences approximately 1 infant death for every 13.5 premature infants. A greater ratio of preterm births to infant deaths indicates better health outcomes for infants born in those areas. The neighborhood with the greatest ratio of preterm births to infant deaths is Buckeye-Woodhill, with 51.6 preterm births for every 1 infant death. Lee-Harvard has the lowest ratio of 6.7 preterm births to every 1 infant death. This ratio indicates that there is substantial difference among different areas of Cleveland. Infants born in certain areas of Cleveland have much better health outcomes than infants born in other areas. The scope of this problem is not yet fully understood. Nevertheless, infant mortality and associated risk factors within the City of Cleveland is worth exploring further. Since Cleveland neighborhoods experience such vastly different infant health outcomes, it is important to focus on these areas for future health programing. Infant health outcomes are modifiable through additional prenatal care visits and by addressing mother's medical history. The report provides the foundation for evidence based public health programs within the City of Cleveland.

Technical Notes

Geographic Description of the City of Cleveland

Cleveland is located within Cuyahoga County in the State of Ohio on the south shore of Lake Erie (See Appendix A). The City of Cleveland is comprised of 34 neighborhoods and 17 political wards. 2010 census figures report the city's population to be 396,815 (Census, 2016). Births and deaths were mapped by geographic location of the mother's address at year of incidence using ArcGIS v. 10.4. Neighborhood and ward level data were computed by conducting a spatial join using the City of Cleveland's corresponding shapefiles. Map created and analysis performed by the office of Communicable Disease Surveillance and Epidemiology at the Cleveland Department of Public Health. 2015 data is preliminary. Data was obtained from the Ohio Department of Public Health Office of Vital Statistics.

Calculating Rates

Yearly rates for each neighborhood and/or ward can result in a small number of cases, causing unstable statistics. Therefore, a 4 year rate was calculated for the years 2012 to 2015. Death data for 2015 is preliminary at the time of this report. Statistical analyses were performed using SAS v. 9.3.

Infant mortality is defined as the death of an infant prior to its first birthday (i.e. less than one year old). An infant mortality rate is calculated by dividing the total number of deaths in an area, (i.e. Cleveland), by the total number of live births occurring during that same time period. This rate is presented per 1,000 live births. In the State of Ohio, a birth is considered a "live birth" if the infant takes one breath. Infant mortality rates include only live births and do not account for abortions or stillbirths.

Making Predictions

Univariate and multivariate logistic regression analyses were performed. Overwhelmingly, preterm birth was associated with infant death. Odds of preterm birth were modeled as the outcome due to the large quantity of cases needed to conduct statistically significant analyses. Incidence of a prior preterm birth was modeled as the primary predictor of interest. Secondary sociodemographic predictors analyzed were mother's age, mother's race, insurance status, and mother's education. Secondary medical history predictors analyzed were body mass index (BMI), presence of gestational or prepregnancy diabetes, presence of gestational or prepregnancy hypertension, and smoking status of the mother. Univariate analyses were conducted using a 10% rule for determining potential confounders.

Data Sources

Birth and death data were obtained from the Ohio Department of Health Office of Vital Statistics for the years 2012 to 2015. Death data was trimmed to contain only records less than 1 year of age. Data files were matched based on matching birth certificate number with the corresponding record's death certificate number.

Limitations

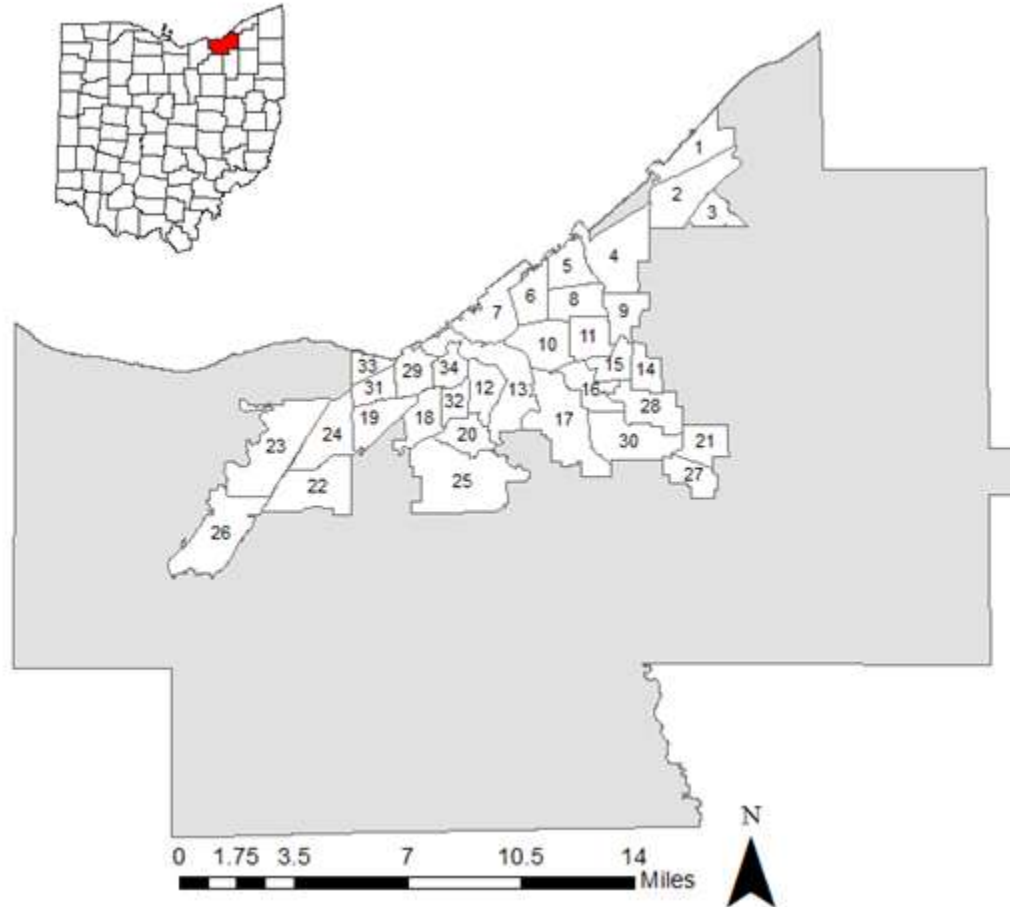
Neighborhoods with less than 100 births were excluded from neighborhood level analysis and were only analyzed at the city level. Small rates can cause instability in statistical analyses. The populations of some neighborhoods were so small that the rates could not be presented, due to concerns over possible breaches of confidentiality.

Data appears to be subjective to information bias, specifically nondifferential misclassification bias due to input error. No data was present on mother's income. Marital status was not analyzed due to varied amounts of missing data by year.

Data from both birth and death files were restricted to Cleveland cases only prior to matching. Possible data was lost due to the mother changing addresses from a municipality outside the City of Cleveland between birth and death of the infant. Infants born outside of Cleveland's borders that subsequently die within the municipality have incomplete records. Incomplete records were suppressed during analyses.

Appendix A:

Map of Cleveland Neighborhoods



Key:

- | | | |
|------------------------------|------------------------------|-----------------------|
| 1 - North Shore Collinwood | 13 - Cuyahoga Valley | 24 - Jefferson |
| 2 - Collinwood-Nottingham | 14 - Buckeye-Shaker Square | 25 - Old Brooklyn |
| 3 - Euclid - Green | 15 - Buckeye-Woodhill | 26 - Riverside |
| 4 - Glenville | 16 - Kinsman | 27 - Lee-Seville |
| 5 - St. Clair - Superior | 17 - Broadway-Slavic Village | 28 - Mount Pleasant |
| 6 - Goodrich - Kirtland Park | 18 - Stockyards | 29 - Detroit Shoreway |
| 7 - Downtown | 19 - West Boulevard | 30 - Union-Miles |
| 8 - Hough | 20 - Brooklyn Centre | 31 - Cudell |
| 9 - University | 21 - Lee-Harvard | 32 - Clark-Fulton |
| 10 - Central | 22 - Bellaire-Puritas | 33 - Edgewater |
| 11 - Fairfax | 23 - Kamm's Corners | 34 - Ohio City |
| 12 - Tremont | | |

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