Data Brief ■ No. 3 ■ June 2019

Infant Mortality

Delaware Profile 2010-2017

The data brief provides an overview of infant mortality rates (IMR) and its antecedent causes preterm births (PTB) and low birth weight (LBW) in Delaware using period linked birth and death certificate data from 2010-2017. During 2010-2017, there were a total of 671 infant deaths of which 658 deaths were matched to birth certificate data that contains information on mother and newborn characteristics.

Importance

Over 22,000 infants died in the United States and 72 infants died in Delaware in 2017. The 2017 Delaware IMR was 6.6 as compared with U.S. IMR of 5.8 per 1,000 live births.

Key findings

- Delaware's IMR (6.6 per 1,000 births) was slightly higher than the U.S. (5.8 per 1,000); there was approximately 27 percent decline in IMR from a high of 9 per 1,000 live births in 2015 to 6.6 in 2017.
- Delaware's fetal mortality rate in 2017 was 5.1 per 1,000 births was well below the U.S. fetal mortality rate of 5.9 per 1,000 births and Delaware met the HP 2020 goal for fetal mortality rate of 5.6 per 1,000 live births and fetal deaths.
- The overall neonatal mortality rates (4.3 per 1,000 live births in 2017) and postneonatal mortality rates (2.2 per 1,000 live births in 2017) for Delaware was higher as compared with the U.S. 3.9 and 1.9 in 2017). Despite higher neonatal and postneonatal mortality rates, Delaware saw a 15 percent and 18 percent decline, during 2010-2017 time-period.

Overview

Death of an infant or a newborn before his or her first birthday is infant mortality. The infant mortality rate (i.e., IMR) is expressed as the total number of infant deaths for every 1,000 live births. The IMR not only provides important information about a mother and an infant's health, but also provides insight into the overall health of a society [1]. According to the Centers for Disease Control and Prevention (CDC), the top five leading causes of infant mortality are are: 1) birth defects; 2) preterm and low birth weight; 3) maternal pregnancy complications; 4) sudden infant death syndrome; and 5) injuries (i.e., suffocation) [1]. Two terms often associated with infant mortality are: 1) neonatal mortality and 2) postneonatal mortality. Neonatal mortality refers to infant deaths less than or equal to 27 days of life, while postneonatal mortality refers to infant deaths 28 days to 364 days. Within neonatal mortality, there is an early neonatal period (i.e., 0-6 days) and late neonatal period (7-27 days) [2].

Infant deaths do not include fetal deaths, which are spontaneous intrauterine death of a fetus at any time during pregnancy. When fetal deaths occur later in the pregnancy (at 20 weeks of gestation or more, or 28 weeks or more, for example), they are also referred as stillbirths [3]. Most state laws require ascertainment of fetal deaths

and in Delaware fetal deaths are defined in Title 16 Chapter 31 § 3124.

Preterm birth, defined as delivery prior to 37 weeks of gestation (i.e., period of time between conception and birth measured in weeks) is the leading cause of neonatal mortality and morbidity [4, 5, 6, 7]. Any analyses of infant mortality entails analysis of preterm and its antecedent causes, as well as the different "periods of risk" [8, 9]. One approach to the "periods of risk" is the perinatal periods of risk (PPOR). This approach utilizes age at death and weight at birth (see figure 1) to outline strategies for specific interventions. Another approach "fetuses-at-risk" treats gestational age as survival time and enables estimation of incidence of birth, growth restriction, and perinatal death [8].

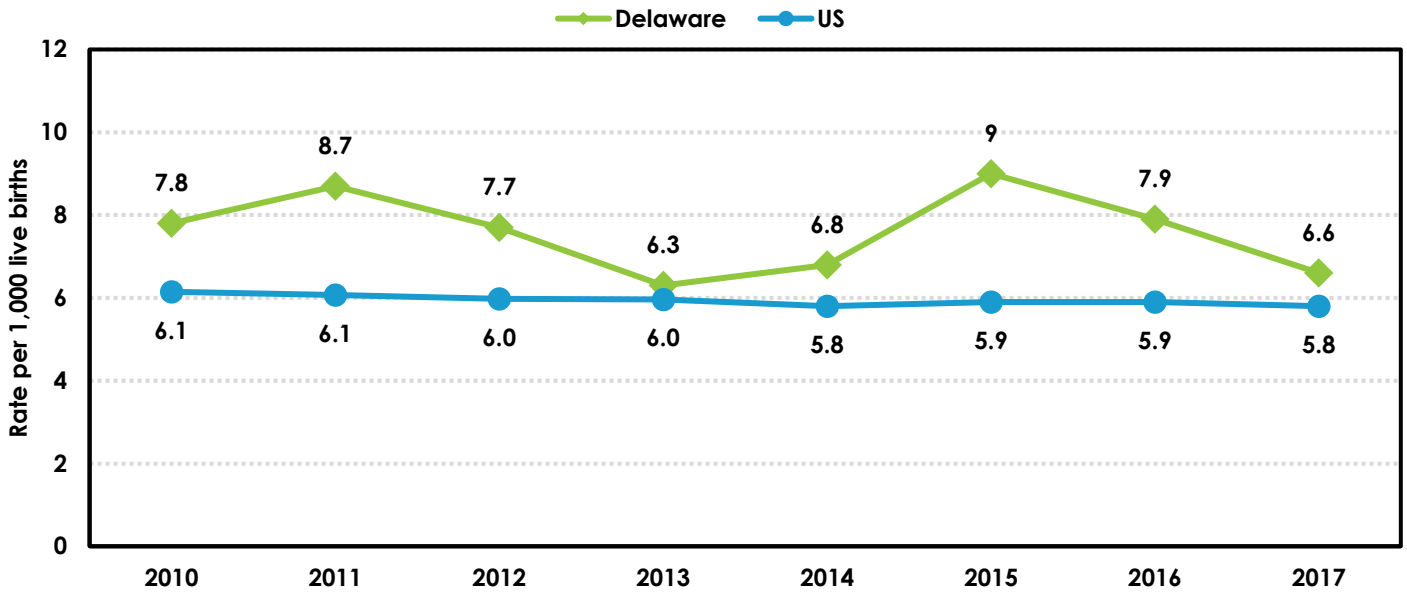
Figure 1. Perinatal periods of risk fetal-infant mortality map

<table>
<tr><td></td><td></td><td colspan="3">Age at Death</td></tr>
<tr><td></td><td></td><td>Fetal Death (20 weeks of gestation or 350 grams or more birth weight</td><td>Neonatal Death (birth to < 28 days)</td><td>Post-neonatal Death (28 to 364 days)</td></tr>
<tr><td rowspan="2">Birthweight</td><td>500-1,499 grams</td><td colspan="3">Maternal Health/Prematurity (Preconception Health, Health Behaviors, Perinatal Care)</td></tr>
<tr><td>1,500 grams or more</td><td>Maternal Care (Prenatal care, High Risk Referral, Obstetric Care)</td><td>Newborn Care (Perinatal Management, Neonatal Care, Pediatric Surgery)</td><td>Infant Health (Safe Sleep, Breastfeeding, Injury Prevention)</td></tr>
</table>

This data brief provides the extent of IMR burden in Delaware and the factors that contribute during 2010-2017 using three datasets. Annual vital statistics death certificate data; period-cohort linked birth and death certificate data (i.e., mortality dataset restricted to infants during 2010-2017 that contain underlying cause of death, and birth certificate data that contains maternal and newborn characteristics). The 2010-2017 infant deaths linked dataset for an infant who died in 2010 would contain maternal and newborn information from 2009 birth certificate data. Lastly, fetal death data that provides information on different "periods of risk." Where applicable, annual and moving average infant mortality and fetal death rates and their 95 percent confidence intervals are presented and some counts are derived from linked dataset may not match annual vital statistics data. In addition, the data are stratified by socio-demographic characteristics of the mother and the infant. Infant mortality and fetal death rates are estimated at the Census tract level to better understand the location-based context.

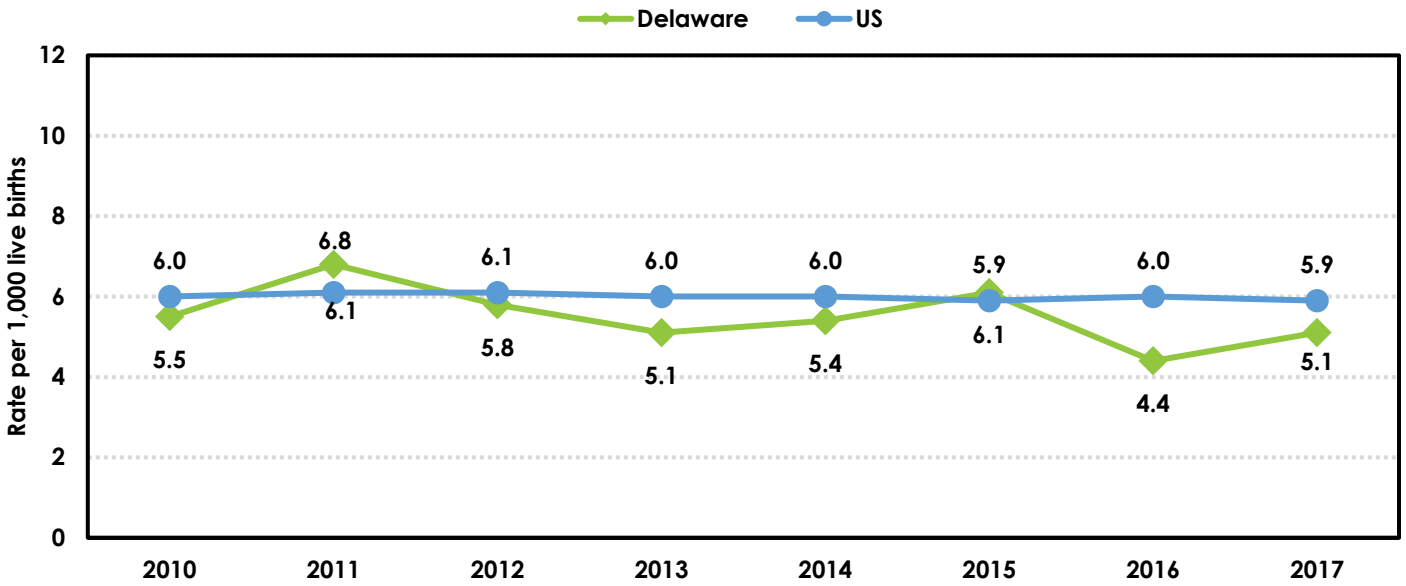
Over 22,000 infants in the U.S. and 72 infants in Delaware died in 2017. Similarly, over 22,000 fetal deaths in the U.S. and 56 fetal deaths in Delaware were reported in 2017. Figure 2 displays the annual U.S. and Delaware IMRs for 2010-2017. Figure 3 displays the fetal death rates per 1,000 live birth for the U.S. and Delaware for 2010-2017.

Figure 2. Infant mortality rates in the U.S. and in Delaware, 2010-2017



Source: Delaware Department of Health and Social Services, Division of Public Health, Delaware Health Statistics Center, Vital Records Data, 2010-2017.

Figure 3. Fetal death rates in the U.S. and in Delaware, 2010-2017

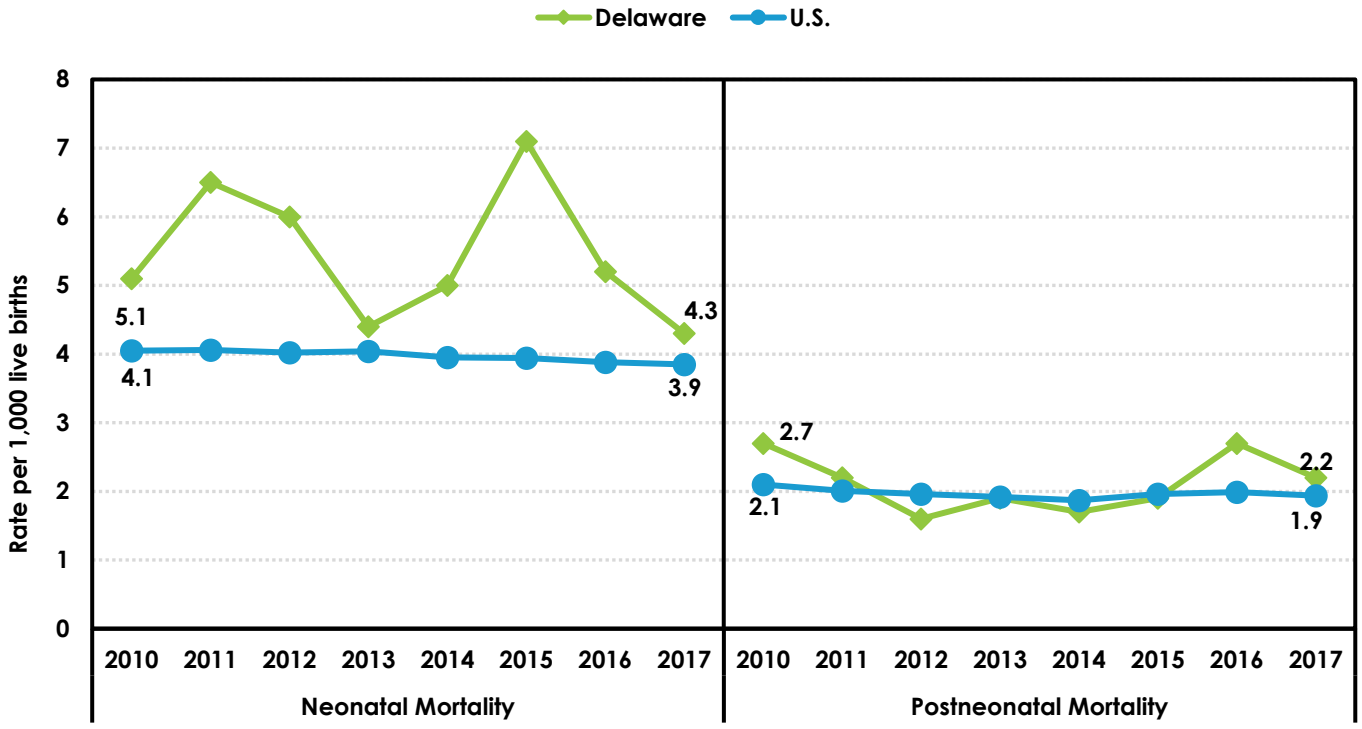


Source: CDC, National Center for Health Statistics (NCHS), Delaware Health and Social Services, Division of Public Health, Delaware Health Statistics Center, Vital Records Data, 2010-2017.
†Fetal death definition is consistent with NCHS definition and is reported at 20 weeks of gestation and/or 350 grams birthweight as per Delaware Code Title 19 §3124.

Despite the fact, that Delaware's IMR (6.6 per 1,000 births) was slightly higher than the U.S. (5.8 per 1,000); there was approximately 27 percent decline in the rates of infant mortality from a high of nine per 1,000 live births in 2015 to 6.6 in 2017. At the end of 2017, Delaware did not meet the Healthy People (HP) 2020 goal of six infant deaths per 1,000 live births. However, Delaware's fetal mortality rate in 2017 was 5.1 per 1,000 births and well below the U.S. fetal mortality rate of 5.9 per 1,000 births. Delaware met the HP 2020 goal for fetal mortality rate of 5.6 per 1,000 live births and fetal deaths with the exception of 2011 and 2015.

Figure 4 displays the U.S. and Delaware's annual neonatal and postneonatal mortality rates. The overall neonatal mortality rates (4.3 per 1,000 live births in 2017) and postneonatal mortality rates (2.2 per 1,000 live births in 2017) for Delaware were higher as compared with the U.S. (3.9 and 1.9 in 2017 respectively). Despite higher neonatal and postneonatal mortality rates, Delaware saw a 15 percent and 18 percent decline during 2010-2017 time-period.

Figure 4. Neonatal and postneonatal mortality rates in the U.S. and in Delaware, 2010-2017



Source: CDC, National Center for Health Statistics (NCHS), Delaware Health and Social Services, Division of Public Health, Delaware Health Statistics Center, Vital Records Data, 2010-2017.

Table 1 provides fetal death, early neonatal, late neonatal, and postneonatal mortality rates stratified by the time-period, maternal age, gestational age, maternal race and ethnicity and county of residence for 2010-2017.

Table 1. Fetal and infant mortality rates by maternal characteristics in Delaware, 2010-2017

Characteristics	Total Births	Fetal Deaths (350 grams or 20 weeks)		Early neonatal mortality (0-6 days)		Late neonatal mortality (7-27 days)		Post-neonatal mortality (28 days to 1 year)	
		n	Rate (95%CI)	n	Rate (95%CI)	n	Rate (95%CI)	n	Rate (95%CI)
Year									
2010	11,291	63	5.5 (4.3-7.1)	48	4.3 (3.1-5.6)	9	0.8 (0.4-1.5)	29	2.6 (1.7-3.7)
2011	11,227	77	6.8 (5.4-8.5)	65	5.8 (4.5-7.4)	8	0.7 (0.3-1.4)	25	2.2 (1.4-3.3)
2012	10,982	64	5.8 (4.5-7.4)	57	5.2 (3.9-6.7)	9	0.8 (0.4-1.6)	18	1.6 (1-2.6)
2013	10,802	55	5.1 (3.8-6.6)	41	3.8 (2.7-5.1)	5	0.5 (0.2-1.1)	21	1.9 (1.2-3)
2014	10,934	59	5.4 (4.1-6.9)	46	4.2 (3.1-5.6)	8	0.7 (0.3-1.4)	19	1.7 (1-2.7)
2015	11,147	68	6.1 (4.7-7.7)	68	6.1 (4.7-7.7)	12	1.1 (0.6-1.9)	19	1.7 (1-2.7)
2016	10,967	49	4.4 (3.3-5.9)	44	4 (2.9-5.4)	13	1.2 (0.6-2)	29	2.6 (1.8-3.8)
2017	10,835	56	5.1 (3.9-6.7)	35	3.2 (2.3-4.5)	8	0.7 (0.3-1.5)	22	2 (1.3-3.1)
Maternal age, years (2010-2017)									
<20	5,714	43	7.5 (5.4-10)	23	4.0 (2.6-6.0)	8	1.4 (0.6-2.8)	23	4.0 (2.6-6.0)
20-24	19,005	114	6.0 (4.9-7.2)	93	4.9 (4-6.0)	18	0.9 (0.6-1.5)	63	3.3 (2.5-4.2)
25-29	26,133	137	5.2 (4.4-6.2)	130	5.0 (4.2-5.9)	17	0.7 (0.4-1)	39	1.5 (1.1-2.0)
30-34	24,060	111	4.6 (3.8-5.5)	108	4.5 (3.7-5.4)	9	0.4 (0.2-0.7)	34	1.4 (1-2.0)
>=35	13,273	86	6.4 (5.2-7.9)	50	3.8 (2.8-5.0)	20	1.5 (0.9-2.3)	23	1.7 (1.1-2.6)
Gestational age, weeks (2010-2017)									
20-24	366	184	334.5 (295.2-375.7)	247	674.9 (624.2-722.6)	17	46.4 (27.3-73.3)	12	32.8 (17.1-56.6)
25-27	406	46	101.8 (75.5-133.4)	27	66.5 (44.3-95.3)	21	51.7 (32.3-78)	14	34.5 (19-57.2)
28-31	838	59	65.8 (50.4-84)	13	15.5 (8.3-26.4)	2	2.4 (0.3-8.6)	8	9.5 (4.1-18.7)
32-33	1,030	32	30.1 (20.7-42.3)	10	9.7 (4.7-17.8)	5	4.9 (1.6-11.3)	7	6.8 (2.7-14)
34-36	5,919	65	10.9 (8.4-13.8)	22	3.7 (2.3-5.6)	7	1.2 (0.5-2.4)	22	3.7 (2.3-5.6)
37-38	21,111	52	2.5 (1.8-3.2)	18	0.9 (0.5-1.3)	7	0.3 (0.1-0.7)	52	2.5 (1.8-3.2)
39+	58,329	37	0.6 (0.4-0.9)	18	0.3 (0.2-0.5)	13	0.2 (0.1-0.4)	66	1.1 (0.9-1.4)
Unknown†		16	-	49	-			1	-
Maternal race and ethnicity (2010-2017)									
White non-Hispanic	47,130	202	4.3 (3.7-4.9)	141	3 (2.5-3.5)	33	0.7 (0.5-1)	90	1.9 (1.5-2.3)
Black non-Hispanic	23,476	220	9.3 (8.1-10.6)	190	8.1 (7-9.3)	27	1.2 (0.8-1.7)	64	2.7 (2.1-3.5)
Hispanic	12,022	48	4 (2.9-5.3)	52	4.3 (3.2-5.7)	8	0.7 (0.3-1.3)	25	2.1 (1.3-3.1)
Other race and ethnicities	5,469	21	3.8 (2.4-5.8)	17	3.1 (1.8-5)	4	0.7 (0.2-1.9)	3	0.5 (0.1-1.6)
Maternal county of residence (2010-2017)									
Kent	17,723	87	4.9 (3.9-6)	73	4.1 (3.2-5.2)	8	0.5 (0.2-0.9)	32	1.8 (1.2-2.5)
New Castle	52,439	300	5.7 (5.1-6.4)	282	5.4 (4.8-6)	51	1 (0.7-1.3)	109	2.1 (1.7-2.5)
Sussex	18,023	104	5.7 (4.7-6.9)	49	2.7 (2-3.6)	13	0.7 (0.4-1.2)	41	2.3 (1.6-3.1)

Source: Delaware Department of Health and Social Services, Division of Public Health, Delaware Health Statistics Center, Period-linked Cohort data, 2010-2017

Note: Early neonatal, late neonatal and postneonatal mortality rates are derived from period-linked cohort data, **13 cases were unlinked and therefore, the effective sample size is 658 deaths in 2010-2017**. 95% Confidence Intervals (95%CI) are estimated using Clopper-Pearson Exact Method.

†16 cases of unknown gestational age for fetal mortality, however meets criteria for fetal death report of 350 grams or more. 48 cases of infant mortality (early, late, and postneonatal) have gestational ages <20 weeks and only 2 cases have no gestational ages.

Fetal death rates were highest in mothers who were younger (< 20 years) and older (>35 years of age); highest in earlier gestational intervals; and highest among non-Hispanic black mothers. For instance, fetal mortality rate of a non-Hispanic black mother (9.3 per 1,000 live births and fetal deaths) was twice that of a non-Hispanic white, Hispanics, and other race and ethnicities. This was true for early neonatal period (8.1 per 1,000 live births), late neonatal period (1.2 per 1,000 live births) and postneonatal period (2.7 per 1,000 live births). Both New Castle and Sussex counties had higher fetal and infant mortality rates. However, both neonatal (i.e., early and late) and postneonatal mortality rates were higher for New Castle and Kent counties.

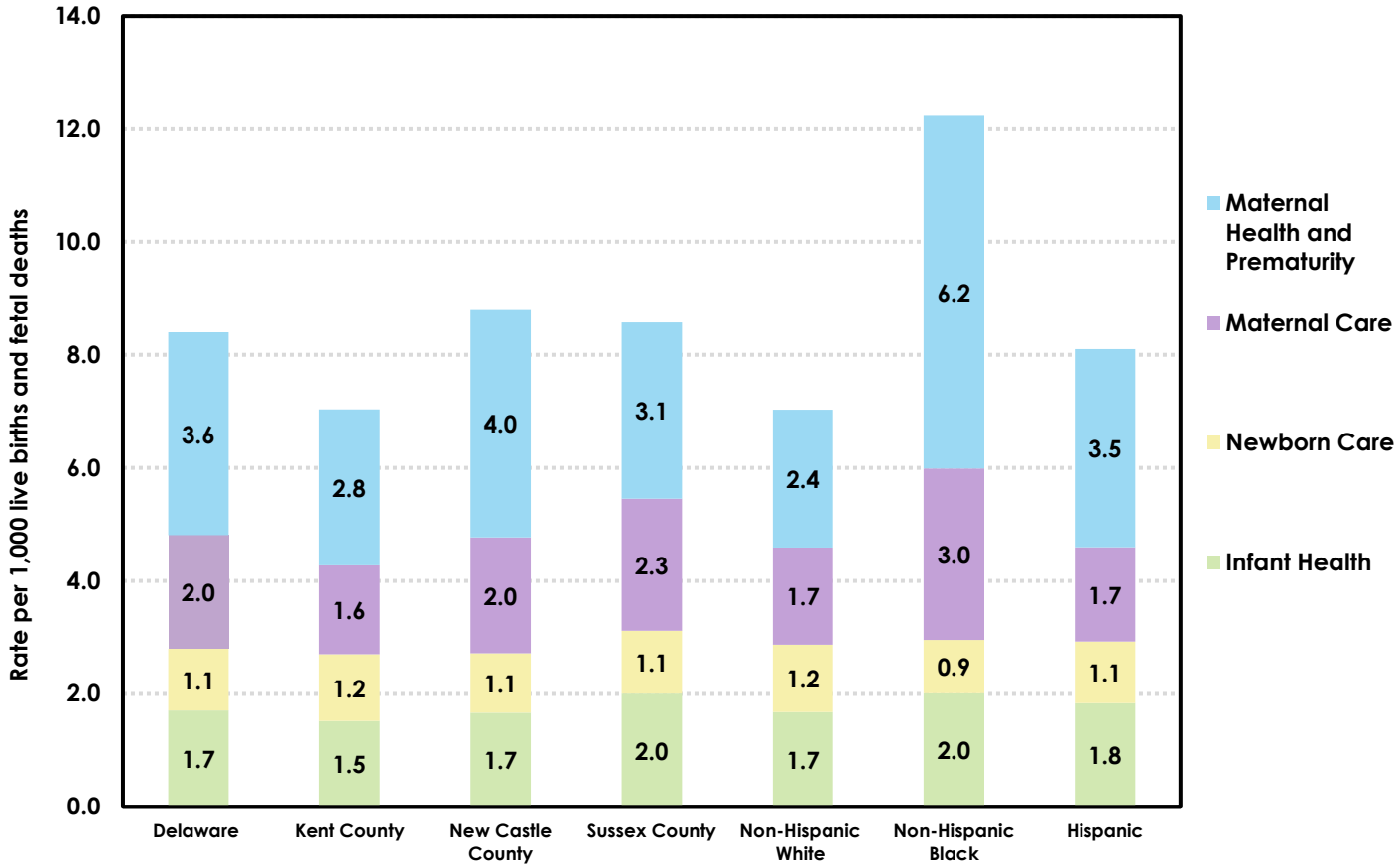
Figure 5 provides fetal infant mortality map for Delaware for 2010-2017 eight-year time-period based on perinatal periods of risk (see figure 1). A fetal infant mortality map is based on gestational age (>=24 weeks of gestation) and birth weight restrictions (>500 grams) criteria and as such is different than the rates estimated in Table 1. The overarching framework of a fetal mortality map is to identify potential prevention opportunities and understand the local context. Where feasible fetal infant mortality maps for different strata (i.e., maternal race and ethnicity, and county of residence) were developed. The overall fetal infant mortality for Delaware based on "periods of risk" approach was 8.4 per 1,000 live births and fetal deaths. The rate is the sum total of maternal health/prematurity period (3.6 per 1,000 live births and fetal deaths); maternal care (2.0 per 1,000 live births and fetal deaths); newborn care (1.1 per 1,000 live births and fetal deaths); and infant health (1.7 per 1,000 live births and fetal deaths). Based on Delaware 2010-2017 data "periods of risk" it is evident that maternal health and prematurity (43%) seems to be the largest contributor to mortality, followed by maternal care (24%), infant health (20%), and newborn care (13%).

As noted earlier, maternal health and prematurity involves preconception health, healthy behaviors, and perinatal care, while maternal care involves quality prenatal care, high-risk referral and obstetric care. Infant health involves safe sleep, breastfeeding, and injury prevention, while newborn care involves perinatal management, neonatal care, and pediatric surgery that are in essence clinical care components. While these provide broad domains for action it does not provide us with specific sub-group or populations where we could focus prevention efforts. Figure 6 displays fetal infant mortality maps for Delaware and its counties, as well as by race and ethnic groups.

Figure 5. Delaware fetal-infant mortality map, 2010-2017

<table>
<tr><td colspan="3">Maternal Health/Prematurity
n = 316 (121 fetal deaths + 195 live births)
<u>Rate = 3.6 per 1,000 live births and fetal deaths</u></td></tr>
<tr><td>Maternal Care
n = 177
<u>Rate = 2.0 per 1,000 live births and fetal deaths</u></td><td>Newborn Care
n = 96
<u>Rate = 1.1 per 1,000 live births and fetal deaths</u></td><td>Infant Health
n = 150
<u>Rate = 1.7 per 1,000 live births and fetal deaths</u></td></tr>
</table>

Figure 6. Delaware fetal-infant mortality maps by county, race and ethnicity, 2010-2017



Source: Delaware Department of Health and Social Services, Division of Public Health, Delaware Health Statistics Center, 2010-2017.

It is evident that there are substantial differences in fetal infant mortality rates by residence, race and ethnicity. In particular, non-Hispanic blacks have higher rates of fetal infant mortality across all "periods of risk" with the exception of newborn care. For instance, the non-Hispanic blacks the fetal infant mortality rate during the maternal health and prematurity period was 6.2 per 1,000 live births and fetal deaths as compared with non-Hispanic whites' rate of 2.4 per 1,000 per 1,000 live births and fetal deaths during the same period. Similarly, the fetal infant mortality rates for maternal care for non-Hispanic blacks was 3.0 as compared with 1.7 for non-Hispanic whites per 1,000 live births and fetal deaths. It is evident that the New Castle County fetal infant mortality rate for maternal health and prematurity was 4.0 per 1,000 live births and fetal deaths was higher as compared with Delaware 3.6 per 1,000 live births and fetal deaths and other counties (2.8 for Kent and 3.1 for Sussex County, respectively).

Table 2 provides excess mortality rates by race and maternal county of residence by using non-Hispanic whites as reference for race and ethnic sub-groups and Delaware as a reference for county sub-groups. The excess mortality rates and deaths help us to prioritize limited resources for

upstream prevention intervention efforts. The excess mortality rates was highest among non-Hispanic blacks with approximately 122 excess deaths. In particular, these excess deaths were in the maternal health and prematurity sub-domain (89 excess deaths) and maternal care (31 excess deaths). The overall excess mortality in the Hispanic sub-group was also higher in the maternal health and prematurity sub-domain with approximately 13 excess deaths. While large differences in rates point to opportunities for intervention, large numbers, point us to the overall "burden." From table 2 it is evident that the overall burden for fetal infant mortality is among non-Hispanic blacks. New Castle County has a higher proportion of births in Delaware as compared with other counties. It also had excess mortality rate 0.4 and excess deaths (i.e., 21 deaths).

Table 2. Excess fetal-infant mortality rates in Delaware, 2010-2017

Characteristic	Excess Mortality Rates				
	Maternal Health and Prematurity	Maternal Care	Newborn Care	Infant Health	Overall
Non-Hispanic White (Reference)					
Non-Hispanic Black	**3.8**	**1.3**	-0.2	0.3	**5.2**
Hispanic	1.1	0.0	-0.1	0.2	1.1
Delaware (Reference)					
Kent County	-0.8	-0.4	0.1	-0.2	-1.4
New Castle County	0.4	0.0	0.0	0.0	0.4
Sussex County	-0.5	0.3	0.0	0.3	0.2

Source: Delaware Department of Health Social Services, Division of Public Health, Delaware Health Statistics Center, 2010-2017.

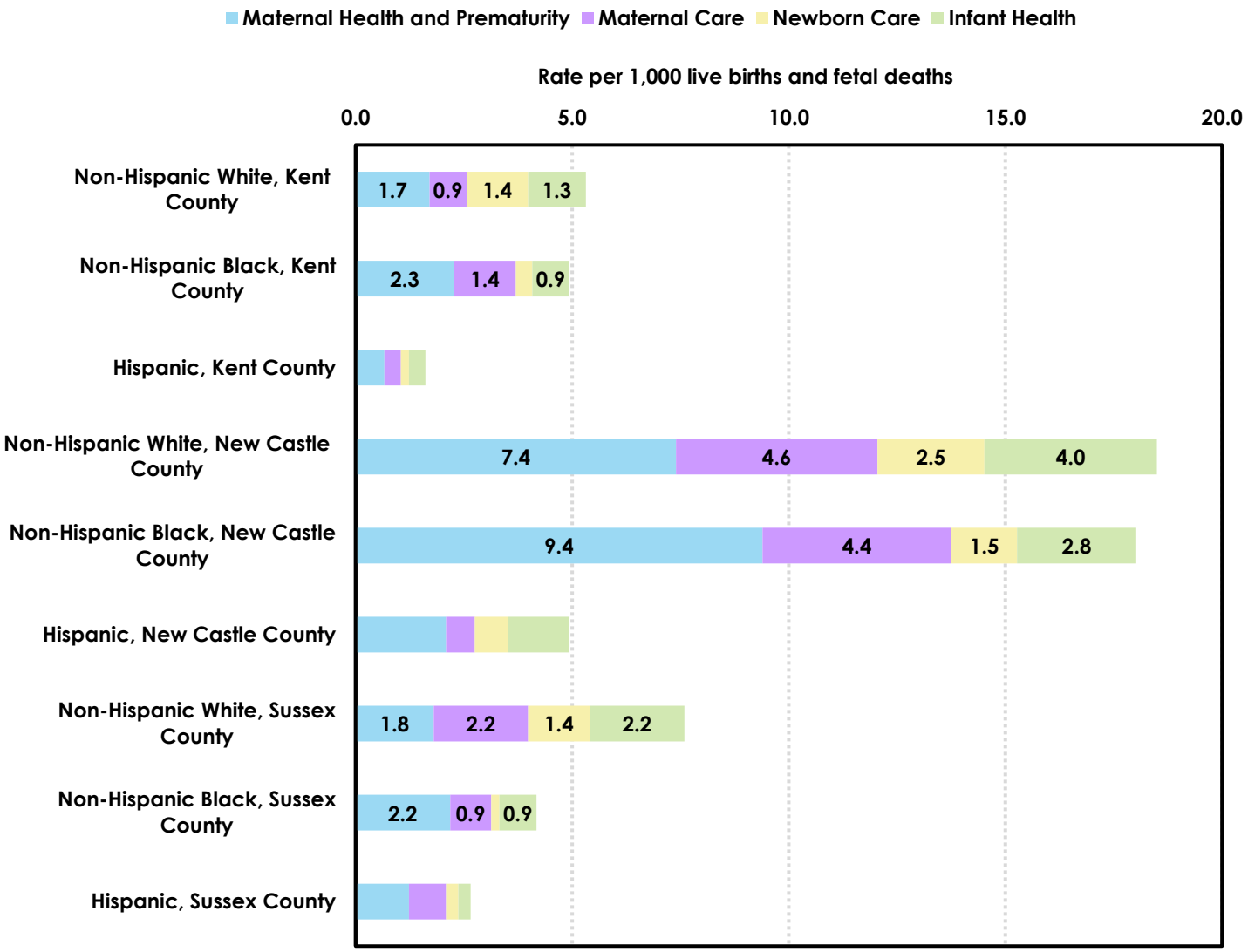
Note: Non-Hispanic white serve as the reference group for race and ethnicity for excess mortality, and Delaware serves as the reference group for maternal county of residence. A positive sign indicates there is excess mortality as compared with reference group.

Figure 7 combines the maternal county of residence and the maternal race and ethnicity sub-group to assess differences in fetal infant mortality rates. It is evident that the fetal infant mortality rates in New Castle County are highest among non-Hispanic blacks (9.4 per 1,000 live births and fetal deaths) specifically in the maternal health and prematurity period of risk. Unexpectedly, non-Hispanic whites in New Castle (4.6, 2.5, and 4.0 respectively) and Sussex County (2.2, 1.4, and 2.2 respectively) also have higher fetal infant mortality rates in different periods of risk (i.e., maternal care, newborn care, and infant health) as compared with non-Hispanic blacks in New Castle and Sussex County.

Fetal infant mortality rates in the maternal health and prematurity period was consistently higher among non-Hispanic blacks in all counties. Excess mortality rates were higher for non-Hispanic blacks in New Castle County 5.8 per 1,000 live births and fetal deaths (i.e., figure 7; 9.4 – Delaware's rate of 3.6; see figure 6) and non-Hispanic whites 3.8 per 1,000 live births and fetal deaths (i.e., figure 7; 7.4 – Delaware's rate of 3.6; see figure 6) in the maternal health and prematurity period. Excess mortality rates were also higher for non-Hispanic blacks in New Castle County 2.4 per 1,000 live births and fetal deaths (i.e., figure 7; 4.4 – Delaware's rate of 2.0; see figure 6). In addition, excess

mortality rates were also higher for non-Hispanic whites in New Castle County 2.6 per 1,000 live births and fetal deaths (i.e., figure 7; 4.6 – Delaware's rate of 2.0; see figure 6) for maternal care, newborn care (1.4 per 1,000 live births and fetal deaths), and infant health (2.4 per 1,000 live births and fetal deaths).

Figure 7. Delaware fetal-infant mortality map by county and race and ethnicity, 2010-2017

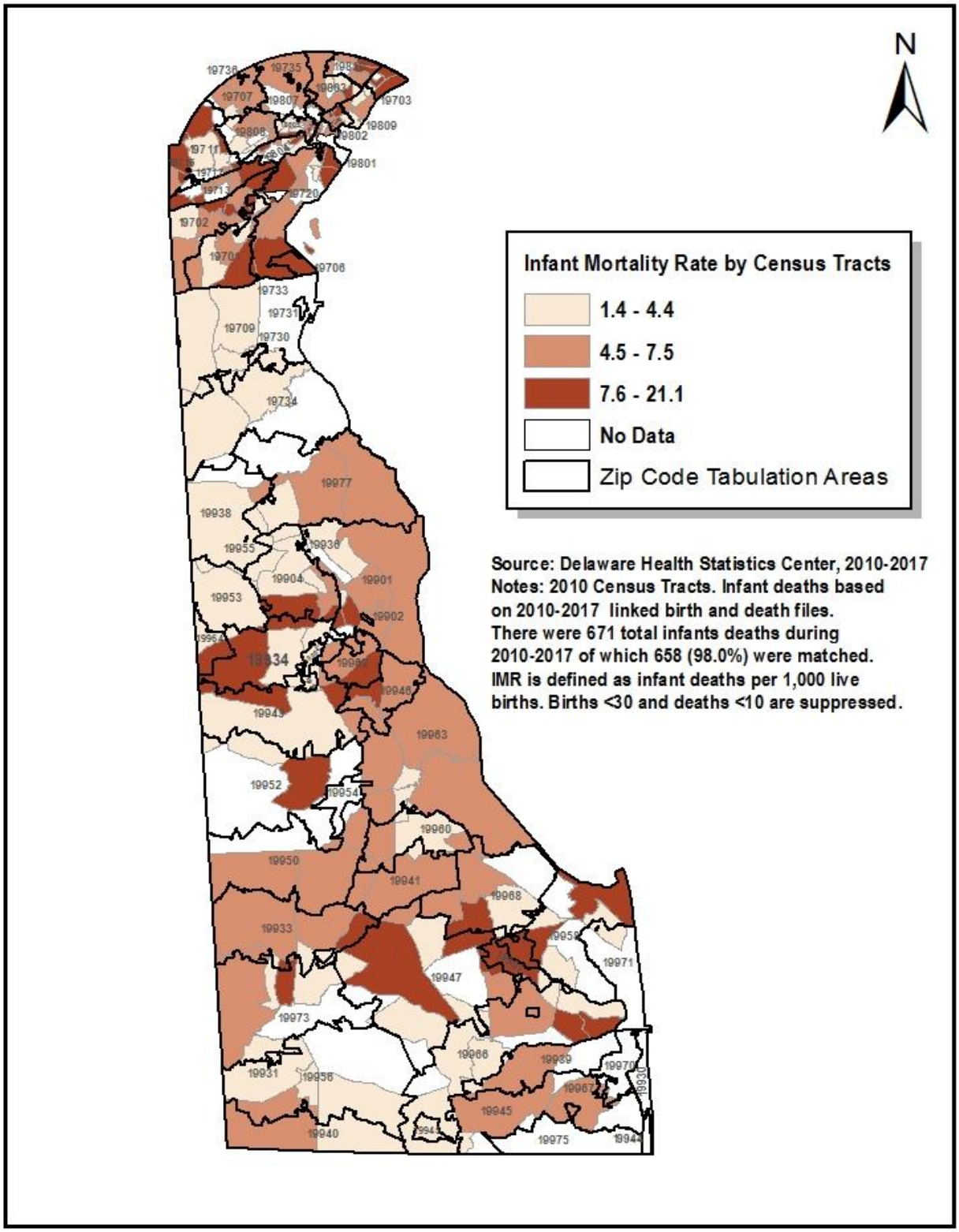


Source: Delaware Department of Health and Social Services, Division of Public Health, Delaware Health Statistics Center, 2010-2017.

To better understand and optimize upstream prevention efforts, it is also important to understand the distribution of infant mortality rates by smaller geographical boundaries (i.e. spatial units). Figure 8 displays the infant mortality map by census tracts for Delaware, from 2010 to 2017 time-period with births (i.e., denominator) less than 30 and numerators (i.e., infant deaths) less than 10 suppressed. Census tracts are well-defined spatial units; however, as compared with zip codes they are not necessarily intuitive. Hence, a zip code layer with overlapping census tracts are displayed for better

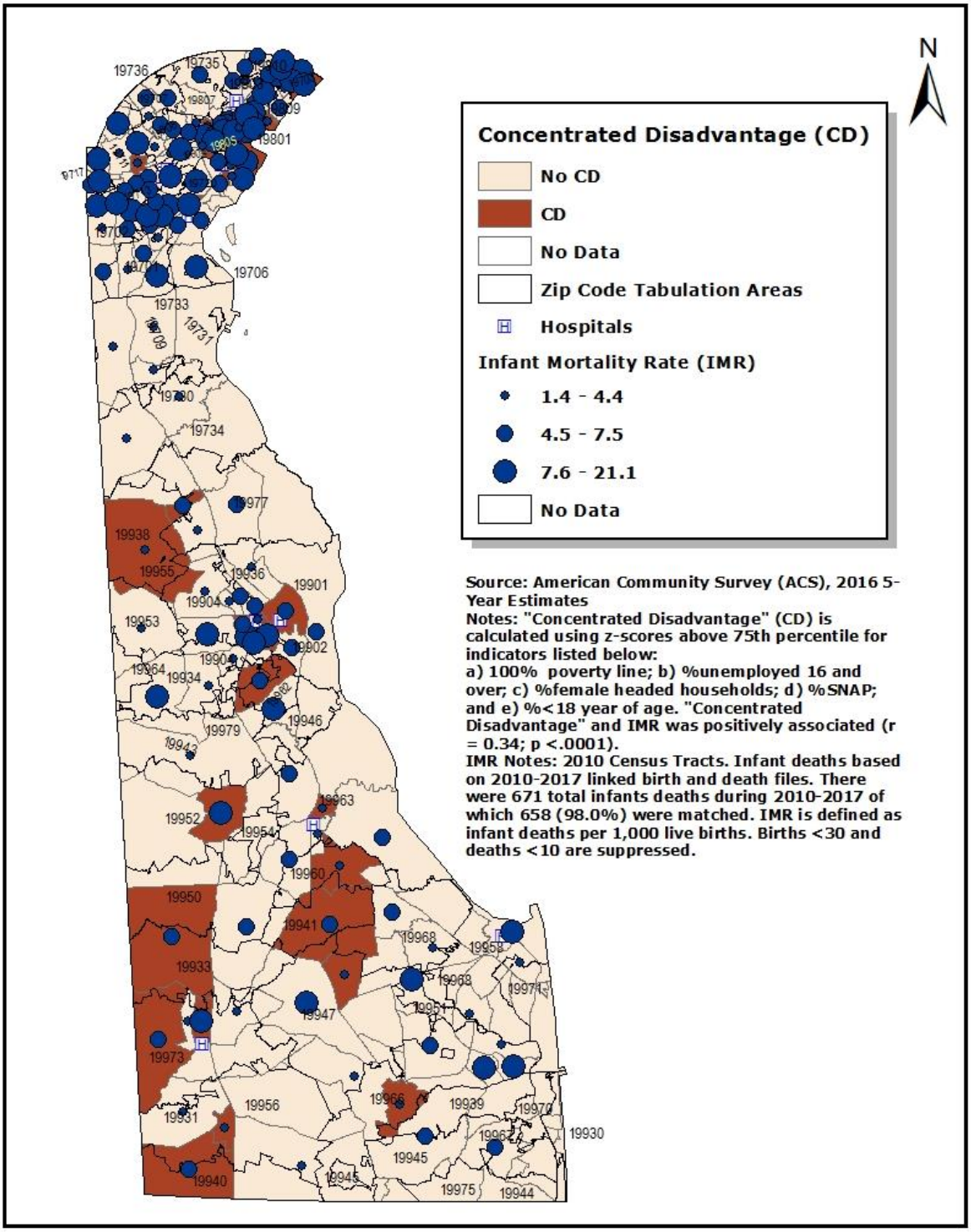
visualization of a location/neighborhood. It is evident that IMR is spread throughout Delaware and there are several census tracts that present opportunities for upstream intervention.

Figure 8. Delaware Infant Mortality Rates by Census Tracts, 2010-2017



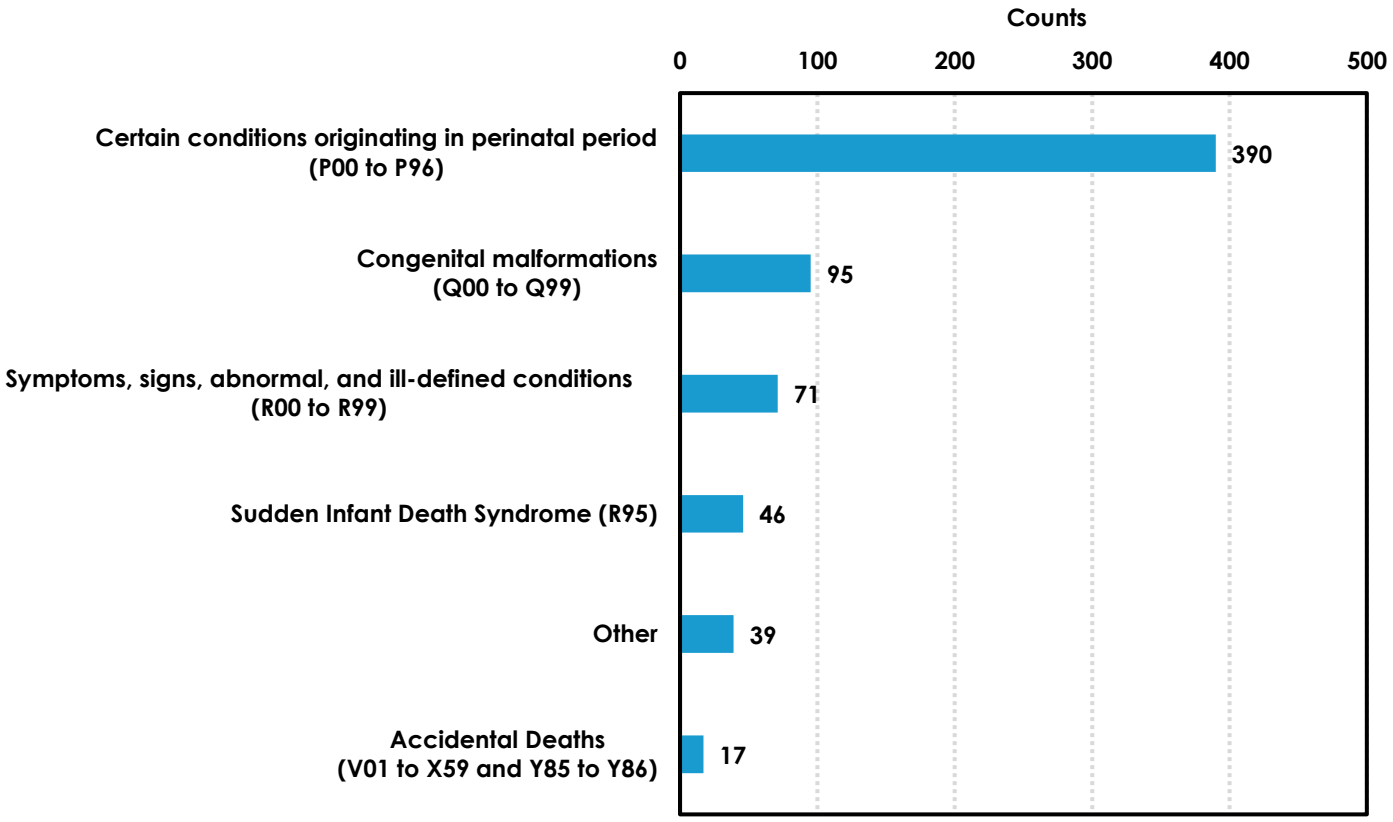
Concentrated disadvantage is known to contribute to increased rates of high school dropout, teen pregnancy, adolescent delinquency, and is known to be associated with poor mental health, as well as overall health including infant mortality, low birth weight, and child maltreatment [10]. Figure 9 overlays the concentrated disadvantage map and infant mortality map.

Figure 9. Concentrated Disadvantage and Infant Mortality in Delaware, 2010-2017



As anticipated concentrated disadvantage was positively associated with IMR ($r = 0.34$; $p < .0001$). However, it is also evident from figure 9 that IMR in Delaware varies considerably by location and not only in areas that have higher concentrated disadvantage. Figure 10 provides an overview of the underlying causes of IMR as recorded on the linked-birth and death certificate data for 658 infant deaths.

Figure 10. Underlying causes of infant death in Delaware, 2010-2017



Source: Delaware Department of Health and Social Services, Division of Public Health, Delaware Health Statistics Center, 2010-2017.

The underlying causes "certain conditions originating in perinatal period," "congenital malformations," and "symptoms, signs, abnormal, and ill-defined conditions" can be broadly classified under preterm-related, congenital malformation (i.e., birth defects), and sudden unexpected infant death (SUID). Using Collaborative Improvement and Innovation Network (COIIN) categorization of infant mortality, the leading causes of death were re-classified and about 50 percent of infant deaths or 1 in 2 infant deaths in Delaware in 2010-2017 related to prematurity; followed by 14 percent or 1 in 7 infant deaths due to congenital malformation; and 12 percent due to SUIDs. Table 3 details the maternal and infant characteristics of prematurity, congenital, and SUID deaths in Delaware for 2010-2017. Table 4 provides an overview of prenatal care, pre-pregnancy health and associated morbidity, and risk factors such as smoking, previous preterm birth of mothers who experienced an infant loss.

Table 3. Maternal and infant characteristics of infant deaths in Delaware, 2010-2017

Characteristics	Total Births	Total Deaths	Preterm-related mortality (n = 311)		Congenital malformations (n = 95)		Sudden Unexplained Infant Deaths (n = 77)	
		n	n (%)	Rate (95%CI)	n (%)	Rate (95%CI)	n (%)	Rate (95%CI)
Year								
2010	11,291	86	32 (37.2%)	2.8 (1.9-4.0)	17 (19.8%)	1.5 (0.9-2.4)	12 (14.0%)	1.1 (0.5-1.9)
2011	11,227	98	48 (49.0%)	4.3 (3.2-5.7)	14 (14.3%)	1.2 (0.7-2.1)	8 (8.2%)	0.7 (0.3-1.4)
2012	10,982	84	43 (51.2%)	3.9 (2.8-5.3)	16 (19.0%)	1.5 (0.8-2.4)	7 (8.3%)	0.6 (0.3-1.3)
2013	10,802	67	31 (46.3%)	2.9 (2.0-4.1)	6.0 (9.0%)	0.6 (0.2-1.2)	13 (19.4%)	1.2 (0.6-2.1)
2014	10,934	73	35 (47.9%)	3.2 (2.2-4.4)	10 (13.7%)	0.9 (0.4-1.7)	8 (11.0%)	0.7 (0.3-1.4)
2015	11,147	99	54 (54.5%)	4.8 (3.6-6.3)	10 (10.1%)	0.9 (0.4-1.6)	7 (7.1%)	0.6 (0.3-1.3)
2016	10,967	86	43 (50.0%)	3.9 (2.8-5.3)	9 (10.5%)	0.8 (0.4-1.6)	11 (12.8%)	1.0 (0.5-1.8)
2017	10,835	65	25 (38.5%)	2.3 (1.5-3.4)	13 (20.0%)	1.2 (0.6-2.1)	11 (16.9%)	1.0 (0.5-1.8)
Infant sex (2010-2017)								
Male	44,908	352	183 (52.0%)	4.1 (3.5-4.7)	43 (12.2%)	1.0 (0.7-1.3)	41 (11.6%)	0.9 (0.7-1.2)
Female	43,277	306	128 (41.8%)	3.0 (2.5-3.5)	52 (17.0%)	1.2 (0.9-1.6)	36 (11.8%)	0.8 (0.6-1.2)
Plurality (2010-2017)								
Singleton	85,337	545	237 (43.5%)	2.8 (2.4-3.2)	87 (16.0%)	1.0 (0.8-1.3)	67 (12.3%)	0.8 (0.6-1.0)
Multiple	2,848	113	74 (65.5%)	26 (20.5-32.5)	8.0 (7.1%)	2.8 (1.2-5.5)	10 (8.8%)	3.5 (1.7-6.4)
Maternal age, years (2010-2017)								
<20	5,714	54	22 (40.7%)	3.9 (2.4-5.8)	6 (11.1%)	1.1 (0.4-2.3)	10 (18.5%)	1.8 (0.8-3.2)
20-24	19,005	174	69 (39.7%)	3.6 (2.8-4.6)	25 (14.4%)	1.3 (0.9-1.9)	34 (19.5%)	1.8 (1.2-2.5)
25-29	26,133	186	95 (51.1%)	3.6 (2.9-4.4)	20 (10.8%)	0.8 (0.5-1.2)	20 (10.8%)	0.8 (0.5-1.2)
30-34	24,060	151	84 (55.6%)	3.5 (2.8-4.3)	22 (14.6%)	0.9 (0.6-1.4)	8 (5.3%)	0.3 (0.1-0.7)
>=35	13,273	93	41 (44.1%)	3.1 (2.2-4.2)	22 (23.7%)	1.7 (1-2.5)	5 (5.4%)	0.4 (0.1-0.9)
Maternal education (2010-2017)								
< 9 years of schooling	4,860	35	14 (40%)	2.9 (1.6-4.8)	8 (22.9%)	1.6 (0.7-3.2)	2 (5.7%)	0.4 (0-1.5)
9-11 years of schooling	10,735	82	36 (43.9%)	3.4 (2.3-4.6)	8 (9.8%)	0.7 (0.3-1.5)	14 (17.1%)	1.3 (0.7-2.2)
High school graduate	22,352	250	115 (46%)	5.1 (4.2-6.2)	36 (14.4%)	1.6 (1.1-2.2)	36 (14.4%)	1.6 (1.1-2.2)
1-3 years of college	23,317	159	79 (49.7%)	3.4 (2.7-4.2)	20 (12.6%)	0.9 (0.5-1.3)	20 (12.6%)	0.9 (0.5-1.3)
> 3 college graduate	26,365	112	57 (50.9%)	2.2 (1.6-2.8)	19 (17.0%)	0.7 (0.4-1.1)	5 (4.5%)	0.2 (0.1-0.4)
Unknown	556	20	10	-	4	-	0	-
Maternal race and ethnicity (2010-2017)								
White non-Hispanic	47,130	264	91 (34.5%)	1.9 (1.6-2.4)	42 (15.9%)	0.9 (0.6-1.2)	39 (14.8%)	0.8 (0.6-1.1)
Black non-Hispanic	23,476	281	167 (59.4%)	7.1 (6.1-8.3)	24 (8.5%)	1 (0.7-1.5)	32 (11.4%)	1.4 (0.9-1.9)
Hispanic	12,022	85	37 (43.5%)	3.1 (2.2-4.2)	23 (27.1%)	1.9 (1.2-2.9)	6 (7.1%)	0.5 (0.2-1.1)
Other race and ethnicities	5,469	24	13 (54.2%)	2.4 (1.3-4.1)	5 (20.8%)	0.9 (0.3-2.1)	0	-
Unknown	88	4	3	-	1	-	-	-
Maternal county of residence (2010-2017)								
Kent	17,723	113	54 (47.8%)	3.0 (2.3-4.0)	20 (17.7%)	1.1 (0.7-1.7)	16 (14.2%)	0.9 (0.5-1.5)
New Castle	52,439	442	229 (51.8%)	4.4 (3.8-5.0)	53 (12.0%)	1.0 (0.8-1.3)	48 (10.9%)	0.9 (0.7-1.2)
Sussex	18,023	103	28 (27.2%)	1.6 (1.0-2.2)	22 (21.4%)	1.2 (0.8-1.8)	13 (12.6%)	0.7 (0.4-1.2)
Maternal insurance at delivery (2010-2017)								
Medicaid	41,203	350	147 (42%)	3.6 (3.0-4.2)	47 (13.4%)	1.1 (0.8-1.5)	60 (17.1%)	1.5 (1.1-1.9)
Private Insurance	42,344	264	145 (54.9%)	3.4 (2.9-4.0)	40 (15.2%)	0.9 (0.7-1.3)	13 (4.9%)	0.3 (0.2-0.5)
Self Pay	1,602	20	8 (40%)	5.0 (2.2-9.8)	1 (5.0%)	0.6 (0-3.5)	1 (5%)	0.6 (0-3.5)
Other	2,547	14	8 (57.1%)	3.1 (1.4-6.2)	3 (21.4%)	1.2 (0.2-3.4)	1 (7.1%)	0.4 (0-2.2)
Other government	427	10	3 (30.0%)	7.0 (1.5-20.4)	4.(40.0%)	9.4 (2.6-23.8)	2 (20%)	4.7 (0.6-16.8)
Unknown	60	-	-	-	-	-	-	-

Source: Delaware Department of Health and Social Services, Division of Public Health, Delaware Health Statistics Center, Period-linked Cohort data, 2010-2017

Note: Percents are percentage of total deaths in the category, and rates are derived from period-linked cohort data with live births as denominators for each category. **13 cases were unlinked and therefore, the effective sample size is 658 deaths in 2010-2017**. 95% Confidence Intervals (95%CI) are estimated using Clopper-Pearson Exact Method.

Table 4. Prenatal, pre-pregnancy health and risk characteristics of mothers' who experienced infant loss in Delaware, 2010-2017

Characteristics	Total Births	Total Deaths	Preterm-related mortality (n = 311)		Congenital malformations (n = 95)		Sudden Unexplained Infant Deaths (n = 77)	
		n	n (%)	Rate (95%CI)	n (%)	Rate (95%CI)	n (%)	Rate (95%CI)
Trimester of entry into prenatal care								
No Prenatal Care	2,200	79	47 (59.5%)	21.4 (15.7-28.3)	6 (7.6%)	2.7 (1.0-5.9)	5 (6.3%)	2.3 (0.7-5.3)
First Trimester	64,951	446	209 (46.9%)	3.2 (2.8-3.7)	64 (14.3%)	1.0 (0.8-1.3)	52 (11.7%)	0.8 (0.6-1.0)
Second Trimester	14,510	74	36 (48.6%)	2.5 (1.7-3.4)	10 (13.5%)	0.7 (0.3-1.3)	12 (16.2%)	0.8 (0.4-1.4)
Third Trimester	3,933	19	1 (5.3%)	0.3 (0-1.4)	3 (15.8%)	0.8 (0.2-2.2)	7 (36.8%)	1.8 (0.7-3.7)
Unknown	2,591	40	18	-	12	-	1	-
Pre-pregnancy body mass index (BMI)								
Underweight	4,951	37	16 (43.2%)	3.2 (1.8-5.2)	6 (16.2%)	1.2 (0.4-2.6)	4 (10.8%)	0.8 (0.2-2.1)
Normal weight	36,691	222	99 (44.6%)	2.7 (2.2-3.3)	29 (13.1%)	0.8 (0.5-1.1)	32 (14.4%)	0.9 (0.6-1.2)
Overweight (BMI 25.0 to 29.9)	22,219	160	73 (45.6%)	3.3 (2.6-4.1)	30 (18.8%)	1.4 (0.9-1.9)	15 (9.4%)	0.7 (0.4-1.1)
Obese (BMI >=30.0)	22,851	233	119 (51.1%)	5.2 (4.3-6.2)	28 (12.0%)	1.2 (0.8-1.8)	26 (11.2%)	1.1 (0.7-1.7)
Unknown	1,473	6	4	-	2	-		
Pre-pregnancy								
Diabetes	849	14	7 (50.0%)	8.2 (3.3-16.9)	2 (14.3%)	2.4 (0.3-8.5)	1 (7.1%)	1.2 (0-6.5)
Hypertension	3,082	34	16 (47.1%)	5.2 (3.0-8.4)	3 (8.8%)	1.0 (0.2-2.8)	5 (14.7%)	1.6 (0.5-3.8)
Gestational								
Diabetes	5,968	23	5 (21.7%)	0.8 (0.3-2)	4 (17.4%)	0.7 (0.2-1.7)	4 (17.4%)	0.7 (0.2-1.7)
Hypertension	6,199	30	10 (33.3%)	1.6 (0.8-3)	4 (13.3%)	0.6 (0.2-1.7)	5 (16.7%)	0.8 (0.3-1.9)
Risk factor								
Smoking during pregnancy	9,539	106	39 (36.8%)	4.1 (2.9-5.6)	9 (8.5%)	0.9 (0.4-1.8)	31 (29.2%)	3.2 (2.2-4.6)
Previous preterm birth	4,827	99	61 (61.6%)	12.6 (9.7-16.2)	6 (6.1%)	1.2 (0.5-2.7)	6 (6.1%)	1.2 (0.5-2.7)

Source: Delaware Department of Health and Social Services, Division of Public Health, Delaware Health Statistics Center, Period-linked Cohort data, 2010-2017

Note: Percents are percentage of total deaths in the category, and rates are derived from period-linked cohort data with live births as denominators for each category. **13 cases were unlinked and therefore, the effective sample size is 658 deaths in 2010-2017**. 95% Confidence Intervals (95%CI) are estimated using Clopper-Pearson Exact Method.

It is evident from table 3 that prematurity-related deaths over the 2010-2017 time-period accounted for over 45 percent of all infant deaths. On the contrary, the percentage of deaths due to congenital malformations varied from a high of 20 percent to a low of nine percent and SUID related deaths varied from a high of 19 percent to a low of seven percent during 2010-2017. Preterm-related mortality rates were higher in male infants, while congenital related mortality was higher in females. In general, multiple births had higher rates of premature-related mortality, congenital malformations, and SUIDs. Percentage of prematurity-related, congenital malformations, and SUID deaths fluctuated between 12 to 13 percent on average. Premature-related mortality, congenital malformation related mortality, and SUID rates were higher among mothers with a high-school diploma. While premature-related mortality and SUID rate was higher in non-Hispanic blacks, congenital malformation related mortality rate was highest in Hispanics. Percentage of premature-related mortality and congenital malformation related mortality was higher in mothers who resided in New Castle County and was higher among mothers with private insurance.

From table 4, it is evident that of the total deaths in the no prenatal category, about 60 percent was due to premature-related mortality and the rate of premature-related mortality was 21.4 per 1,000 live births (95%CI: 15.7-28.3). Premature-related mortality was also higher among mothers whose BMI range fell in the obese spectrum. For instance, the premature-related mortality rate was 5.2 per 1,000 live births (95%CI: 4.3-6.2). Similarly, of the total deaths in smoking during pregnancy category, over 1 in 3 deaths related to prematurity, and of the total deaths in previous preterm birth category, slightly over 1 in 2 infant deaths related to preterm.

Similar to the U.S., prematurity is a key driver in Delaware for infant mortality as shown from both "periods of risk" as well as IMR cause of death analyses. We also found a strong association of concentrated disadvantage and IMR. Since prematurity and low birthweight are in the causal pathways to IMR, it is important to assess if individual-level and ecological-level factors such as concentrated disadvantage is associated with prematurity and low birthweight. At the census tract level, concentrated disadvantage was also positively associated with both prematurity ($r = 0.34$; $p < .0001$) and low birth weight ($r = 0.49$; $p < .0001$).

The following analyses examines if concentrated disadvantage (CD) influences prematurity in Delaware after accounting for individual maternal characteristics. Concentrated disadvantage was categorized into percentiles (i) low CD (below 25 percentile); (ii) medium CD (25 to <75th percentile; (iii) high CD (at or above 75th percentile). The premise of this was to assess, if there were differences between different levels of concentrated disadvantage at the census tract level after accounting for individual maternal characteristics (i.e., maternal age, maternal race and ethnicity, prenatal care, pre-pregnancy body mass index, previous history of a preterm birth, pre-pregnancy and gestational hypertension, and smoking during pregnancy) that are known to be associated with prematurity. As expected census tracts with high-levels of concentrated disadvantage had higher rates of preterm births aOR = 1.2 (95%CI: 1.1-1.3). In other words, census tracts vis-à-vis neighborhoods with higher concentrated disadvantage were 20 percent more likely to have higher rates of preterm birth.

To better understand the contextual levels (i.e., whether location measured using census tracts) and how it may influence preterm birth, multilevel models were developed. Perhaps the most significant aspect of a multilevel model is to understand the proportion of overall individual variation in a health outcome such as preterm birth that could be attributed to the contextual-level (i.e., the intra-cluster correlation at the census tracts level) [11-18]. With regards to preterm birth, the larger variance due to location (i.e., census tracts or in statistical jargon "between-cluster variation") the more relevant is the cluster-level of analysis [11-18].

To avoid statistical jargon and technical details only results of the multilevel models are presented in this brief for ease of interpretation. Two models were estimated: the first model examined the effects of census tracts on preterm births (i.e., 'intercept only/unconditional model' or those that do not account for maternal characteristics); the second model includes individual maternal characteristics in addition to the census tract-specific effects. Results from the first model indicated that there was some variation in preterm births by census tracts and that on average, the estimated probability of a preterm birth in a census tract was 0.27 or 27 percent. Alternatively, for 95% of the

census tracts in Delaware, the census-tract specific probability of a preterm birth would be between 24 to 30 percent (95%CI: 0.24-0.30). However, the intra class correlation (ICC) or the total amount of variation in preterm accounted by census tracts, suggests that 1.7% of the individual variation in the underlying propensity to deliver a preterm birth was due to systematic differences between census tracts (without considering the possibility of a different census tract composition), while the remaining 98.3% is due to systematic differences between maternal characteristics.

As noted earlier, the second model accounted for both census tracts as well as individual maternal characteristics. Results from this model suggest that the estimated probability of a preterm birth in a census tract was 0.17 or 17 percent for a mother who was 30 to 34 year old; non-Hispanic white; normal pre-pregnancy BMI; had prenatal care and who did not have a previous history of preterm birth; did not have pre-pregnancy hypertension; did not have gestational hypertension; and did not smoke. In comparing preterm births for black, non-Hispanic as compared to white non-Hispanic who share identical characteristics and who also lived in the same census tract, the odds of preterm birth was 1.5 times higher (aOR = 1.49; 95%CI: 1.41, 1.57). In other words, non-Hispanic blacks who shared the same attribute as non-Hispanic whites, on average were 50 percent more likely to deliver a preterm birth. Similarly, Hispanics as compared non-Hispanic whites were 40 percent more likely to deliver a preterm birth (aOR = 1.39; 95%CI: 1.30, 1.49) and other race and ethnicities on average were 16 percent more likely to deliver a preterm birth (aOR = 1.16; 95%CI: 1.06, 1.28).

In summary, neighborhood or location (i.e., census tracts) seems to affect prematurity in Delaware, although the relative effect was small. Other structural and social factors seem to impact preterm births vis-à-vis infant mortality those that relate to prematurity.

Suggested citation: Hussaini, SK. Infant Mortality, Delaware Profile 2010-2017. Data Brief No.3. Delaware Health and Social Services, Division of Public Health. Published August 2019.

Endnotes

1. Centers for Disease Control and Prevention. Infant Mortality. https://www.cdc.gov/reproductivehealth/maternalinfanthealth/infantmortality.htm. Accessed: 2019-06-19.

2. Heron M. Deaths: Leading causes for 2016. National Vital Statistics Reports; vol 67 no 6. Hyattsville, MD: National Center for Health Statistics. 2018. Available at https://www.cdc.gov/nchs/data/nvsr/nvsr67/nvsr67_06.pdf. Accessed, 2019-06-19.

3. Centers for Disease Control and Prevention. Fetal Death Data. https://www.cdc.gov/nchs/nvss/fetal_death.htm Accessed 2019-06-19.

4. Mathews TJ, MacDorman MF, Thoma ME. Infant mortality statistics from the 2013 period linked birth/infant death data set. National vital statistics reports; vol 64 no 9. Hyattsville, MD: National Center for Health Statistics. 2015. Available at https://www.cdc.gov/nchs/data/nvsr/nvsr64/nvsr64_09.pdf. Accessed, 2019-06-19.

5. Lisonkova S, Hutcheon JA, Joseph KS. Temporal trends in neonatal outcomes following iatrogenic preterm delivery. BMC Pregnancy Childbirth. 2011;11:39. Published 2011 May 25. doi:10.1186/1471-2393-11-39

6. Brown HK, Speechley KN, Macnab J, Natale R, Campbell MK. Neonatal morbidity associated with late preterm and early term birth: the roles of gestational age and biological determinants of preterm birth. Int J Epidemiol. 2014;43(3):802–814. doi:10.1093/ije/dyt251.

7. Parks SE, Erck Lambert AB, Shapiro-Mendoza CK. Racial and Ethnic Trends in Sudden Unexpected Infant Deaths: United States, 1995-2013. Pediatrics. 2017;139(6):e20163844. doi:10.1542/peds.2016-3844

8. Joseph KS, Kramer MS. The fetuses-at-risk approach: survival analysis from a fetal perspective. *Acta Obstet Gynecol Scand. 2018; 97:454–465*

9. Peck MG, Sappenfield W, Skala J. Perinatal Periods of Risk: A Community Approach for Using Data to Improve Women and Infants' Health. *Matern Child Health J*. 2010;14:864–874

10. Association for Maternal and Child Health Program (AMCHP). Life Course Indicator. Concentrated Disadvantage. 2013. Available at: http://www.amchp.org/programsandtopics/data-assessment/LifeCourseIndicatorDocuments/LC-06_ConcentratedDisad_Final-4-24-2014.pdf accessed on August 13, 2019.

11. Snijders T, Bosker R. Multilevel Analysis: *An Introduction to Basic and Advanced Multilevel Modeling*. Sage Publications: London, 2012.

12. Goldstein H. *Multilevel Statistical Models*. John Wiley & Sons Ltd.: West Sussex, 2011.

13. Raudenbush SW, Bryk AS. *Hierarchical Linear Models: Applications and Data Analysis Methods.* Sage Publications: Thousand Oaks, 2002.

14. Schmidt-Catran AW, Fairbrother M. The random effects in multilevel models: getting them wrong and getting them right. *European Soc. Rev.* 2016;32(1):23-28.

15. Schempf AH, Kaufman JS. Accounting for context in studies of health inequalities: a review and comparison of analytic approaches. *Ann Epidemiol*. 2012 Oct;22(10):683-90.

16. Schempf AH, Kaufman JS, Messer LC, Mendola P. The neighborhood contribution to black-white perinatal disparities: an example from two north Carolina counties, 1999-2001. *Am J Epidemiol*. 2011 Sep 15;174(6):744-52.

17. Austin PC, Merlo J. Intermediate and advanced topics in multilevel logistic regression analysis. *Stat Med*. 2017 Sep 10;36(20):3257-3277.

18. West BT, Welch KB, Galecki AT. *Linear Mixed Models. A Practical Guide Using Statistical Software*. Chapman and Hall/CRC: Second edition, 2014.

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