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Infant Mortality and Maternal Health in Hartford, CT

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A Review of the 2013 CT Department of Health and Human Services
Maternal and Child Health Division's Strategic Plan Objectives

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Abstract

Infant mortality is the death of an infant within the first year of life. These deaths are measured annually as a rate per every 1,000 live births and is a key indicator about maternal and infant health in a society (CDC, 2018). The United States infant mortality rate is very high when compared to other equally wealthy nations. Black infants die at a much higher rate than other racial groups, including in Connecticut. The city of Hartford's Department of Health and Human Services has plans to reduce infant mortality by providing quality prenatal and postpartum care programs and services. In 2013, the Maternal and Child Health Division (MCHD) developed a Strategic Plan with specific objectives to monitor these deaths in hopes of reducing them. The present study analyzed the vital records of live births (N = 11,553) and infant mortalities (N = 105) from 2010 to 2015 to chart progress on several specific goals of the MCHD by comparing Pre-Plan (2010-2012) and Post-Plan (2013-2015) groups. The comparisons show that MCHD has met goals in several but not all areas for data available up to 2015. It is recommended that extending the Strategic Plan and where possible analyzing data more quickly, may lead to better tailored objectives that can be reached in a timely manner.

Child and infant deaths carry a dual message in society; they are perceived in one respect as a tragedy and yet, can be interpreted as a “symbolic benchmark” of the overall health of a population (Matoba & Collins, 2017). Although these deaths differ by definition, as data they reflect the successes and failures of policies that contribute to public health (Pecholdová, 2015). Age at the time and cause of death are what differentiates various types of mortality. Distinguishing differences between types of infant and child deaths affects the accuracy of national and state vital registration systems, stillbirth registries, and hospital records. Proper death identification can also impact clinical research studies that use these data as forms of measurement and comparison (Tavares Da Silva et. al., 2016). Child and infant mortality differ. Child mortality is a death that occurs before the age of five years while, infant mortality is defined as the death of an infant before his or her first birthday (Centers for Disease Control and Prevention, 2017). Infant death can be further specified into the perinatal or neonatal period. Perinatal death occurs during the first week of life (less than or equal to 7 days); death during the neonatal period occurs within the first four weeks (less than or equal to 28 days) of life. Stillborn infants can occur in utero but are most present after delivery. Stillborn infants are defined as appearing to have no signs of life and may or may not have an identifiable cause of death (World Health Organization, 2018; Tavares Da Silva et al., 2016). These developmental periods are where the child establishes foundational skills like eating habits and creating a bond with their parent(s) however, it is also a time at which the infant is at the greatest risk of dying. This is due to factors such as changes in the environment leading to an elevated risk of infection, complications during labor and delivery, nutrient deficiency, or prematurity (World Health Organization, 2006). Rapid development continues throughout these periods including physiological and physical changes, which can reveal conditions like congenital abnormalities or poor adaptation to extrauterine environment (World Health Organization, 2016 & 2018; Medline Plus, 2018).

Risk for maternal mortality also increases risk post birth, often lasting up to one year. Maternal mortality is assessed in conjunction with infant mortality and is expressed as a rate per 100,000 live births. These deaths can occur while the woman is still pregnant or within 42 days of terminating a pregnancy excluding, accidental or unintentional causes (World Health Organization, 2018). Both of these types of death data are used as a unit of measurement, not only within the United States but internationally. Major organizations such as the World Health Organization (WHO), collect, measure, and analyze these data to evaluate and make recommendations to improve global health at both community and individual levels.

Infant mortality is a multivariate and multilevel issue that involves many disciplines such as public health, government, and medicine. Data pertaining to the causes of death, mother's medical histories, individual and even familial demographic characteristics, help researchers, clinicians, public health and government officials to formulate plans that aim to reduce health disparities and improve maternal and child health.

Infant Mortality Rate

Despite increased success in medical and technological advances within obstetrics, perinatal, and neonatal medicine, the United States ranks exceptionally high in infant mortality rates both internationally and comparatively to other industrialized countries of similar wealth. According to the Peterson-Kaiser Health System Tracker (2017) the U.S. ranks first with the highest infant mortality rate amongst other developed nations. Among the top 35 wealthiest nations the United States ranks at a frightening 32nd (Organisation for Economic Co-operation and Development, 2018). Internationally, the U.S. ranks at 170th out of 225 (United States

Central Intelligence Agency, 2018). Infant mortality rate (IMR) is a unit of measurement that is used as an indicator of the health of a country and is expressed as number of infant deaths per 1,000 live births (Center for Disease Control and Prevention, 2018). This indicator is used by countries across the world, in addition by large global health organizations, such as the World Health Organization (WHO), World Bank, United Nations, and the Center for Disease Control and Prevention (CDC). This widely used method of measurement quantifies deaths and their causes. These data show longitudinal trends in causes of death and the populations most affected by them that are important to helping craft policies to reduce infant mortality.

Causes of Infant Death

The top five causes of infant mortalities remain highly consistent rotating marginally from year to year. In the United States, the causes reported by the Center for Disease Prevention and Control, looking as far back as 2004 to the present day include: 1) congenital malformations (e.g., birth defects, deformations, and chromosomal abnormalities), 2) preterm birth and low birthweight (previously identified as 'short gestation'), 3) Sudden Infant Death Syndrome (SIDS), 4) maternal pregnancy complications, and 5) accidental or unintentional injuries such as, suffocation or poisoning. Although congenital abnormalities rank as the number one cause of infant death, close contributors are preterm birth and low birth weight. When a baby is born fewer than 37 weeks gestation, it puts them at an increased risk for dying. According to the March of Dimes (2016), the annual number of preterm births is the underlying cause for the United States' poor ranking in infant mortality. This is most likely due to the serious health complications that prematurity produces including death. The U.S.'s highest recorded infant mortality rate was 6.8 in 2005, which does not differ dramatically from the current rate, at 5.9 in 2016; this indicates only a small decline. In 2015, the rate was 5.8 and rests nearly at the same rate today (CDC, 2018). This less than notable decline in the U.S.'s infant mortality rate conveys that there is a need for a reevaluation of the quality of prenatal and postpartum services offered to expectant mothers. Although to some degree, some of the causes of infant mortality are beyond the scope of preventative medicine, there are practical solutions and protective factors that can help to reduce the maternal complications, infant mortality, and improve birth outcomes.

When looking at Connecticut's infant mortality rate, comparatively, it has hovered close to the nationwide rate. The most recent published data from 2013 indicates a rate of 5.5 per 1,000 live births. Prior to that, the rate has shown minimal fluctuation; in 2012 at 5.0, 2011 at 5.6, and in 2010 at 5.2 (Connecticut Department of Public Health, 2016). The state's capital, Hartford, has surpassed the state and nation's infant mortality rate, seeing dramatic annual fluctuations in recent years. Unlike the consistency of the nation and state's rate, Hartford's rates reflect that of an electrocardiogram, with staggering highs and lows. Within a five-year period, the city had a low of 5.5 in 2010, a rise to a high of 12.7 the year after, and then a slight drop in 2015 down to 11.5 (Connecticut Department of Public Health, 2017). Factors such as the number of live births and plurality of birth (multiples) do influence the infant mortality rate, and both the city and state have seen a consistent decline in the number of live births between 2010 to 2015, averaging 36,577 in the state and 10,026 in the city. While the number of births is important for statistical calculation, it is important to investigate what is causing these deaths and why infants are dying at a higher rate within the city than within the state.

Risk Factors for Infant Death

Factors that increase the risk or likelihood of a problematic developmental outcome(s) such as a disease or injury are known as risk factors. These can emerge from biological, environment, social, or economic factors (Pechholdová, 2015). Well-documented determinants of infant mortality range in proximity, from environmental and community-level factors to heritable genetic traits and chromosomal abnormalities. Environmental factors at a community level such as accessibility to healthcare and education, climatic conditions, and local town or state economies have been found to impact women and infants' health during pregnancy (Brown Speights et al., 2017). Much of the research has focused on the impact of maternal and paternal characteristics including age, race and ethnicity, socioeconomic status, marital status, level of education, and income on preterm birth and low birth weight outcomes. There is substantial evidence that supports a strong association of poor birth outcomes and infant death within parental characteristics but, it is often a combination of these factors and not any single factor that increase risk (Matoba & Collins, 2017). The following sections will address how systematic inequalities at both the environmental and individual level impact maternal health and increase the risk of poor birth outcomes that often lead to infant death.

Socioeconomic Status and Racial Ethnic Disparities

For centuries, long-standing structural barriers have perpetuated an inequitable system that has placed Whites at a socioeconomic advantage with greater opportunities to higher quality of living, education, employment, and positions of political power (Wallace, Crear-Perry, Richardson, Tarver, & Theall, 2017). This unequal system is based on a history of structural racism; a system which has restricted access of non-Whites to opportunities of wealth, employment, safe housing, quality health related resources, and other factors which favor a higher quality of life (Wallace et al., 2017; Kothari et al., 2016). One of the major effects of structural racism is the creation of resource-poor and highly concentrated poverty neighborhoods, mostly inhabited by minority groups, particularly Black and African-Americans. The effects of systematic barriers can be seen in the commonality of intergenerational poverty among Black and African-Americans. Blacks are more than twice as likely to experience intergenerational poverty and live in racially segregated highly impoverished communities (Korthari et al., 2016) Those who live in these neighborhoods are more likely to be classified as lower socioeconomic status, living at or below federal or state poverty levels. According to the U.S. Department of Health and Human Services's poverty guidelines (2018), an income of $25,100 or less for a family of four is classified as living in poverty. These disadvantaged neighborhoods often have higher crime rate, poor housing conditions, lack of accessibility to nutritious foods, lower access to quality education, and higher levels of pollution and toxins (Matoba & Collins, 2017; Margerison-Zilko et al., 2015). Pregnant women living in these areas often experience high levels of stress detrimental to the length of gestation. Perception of how safe living conditions are, feelings of isolation, and exposure to stressful events like discrimination have been linked to preterm births (Kramer, Cooper, Drews-Botsch, Waller & Hogue, 2010). Moreover, biobehavioral responses to stress such as, smoking or alcohol consumption, can impact maternal neuroendocrinology that can cause epigenetic changes in the fetus producing both short and long-term consequences (Brown Speights, et al., 2017). Women of childbearing age residing in these underserved spaces are negatively impacted in a multitude of ways prior to conception and throughout pregnancy. The interplay between social inequality, environment, and socioeconomic status have been linked to the increased rates of adverse birth outcomes and infant death for Black and African-American individuals.

Prior research on racial disparities and maternal and child health, predominantly between Blacks and Whites in the United States are long-standing and noteworthy but, not surprising given the country's history of racial discrimination and segregation. Black infants die at a much higher rate, more than twice, than that of White infants. Moreover, Black women are more likely to experience preterm birth and recurrent preterm birth than White women (Kothari et al., 2016; Purisch & Gyamfi-Bannerman, 2017). As recently as 2016, the Center for Disease Control and Prevention declared that the rate of preterm birth for African-American women was about 50% higher than White women, 14% and 9% respectively. The relationship between characteristics of impoverished communities, specifically residential neighborhood environment and preterm birth, even after adjusting for individual characteristics, is well-established (Margerison-Zilko, et al., 2015). Shortened gestation also known as preterm birth is defined as the delivery of a live baby born before 37 weeks gestation (Purisch & Gyamfi-Bannerman, 2017; World Health Organization, 2018). Subcategories of preterm birth are based on gestational age; extremely preterm infants are born at or less than 28 weeks, very preterm infants are born between 28 to 32 weeks, and moderate to late preterm infants are born between 32 to 37 weeks gestation (World Health Organization, 2018). Preterm birth can be attributed to maternal health complications such as hypertension and has shown to correlate with the excessive release of the hormone corticotropin, triggered by events involving interpersonal racism and racial discrimination (Chae et al., 2018). Marerison-Zilko et al., (2015) found that pregnant women residing in neighborhoods that have experienced both high rates and prolonged poverty were at a greater risk of preterm birth than those living in a "long-term low poverty area" (p. 1178). They propose that the long-term socioeconomic history of an expectant mother's residential neighborhood can contribute to poorer birth outcomes. Areas with systemic, long-term poverty contain more adverse conditions such as hazardous physical elements, higher rates of unemployment, and fewer social networks. Collectively these factors contribute over time to negative birth outcomes and poor perinatal health.

According to the Connecticut Department of Economic and Community Development (2015), Hartford's median income of $30,630 is significantly less than the state median income ($71,346) with about 33% of its population living in poverty (DataUSA, 2015). West Hartford, a neighboring town, has a median income of $86,569 and a poverty rate of only 8% (DataUSA, 2015). The stark contrast between these two cities can be partially explained by the inequitable system of opportunity for Whites. This is partly a result of decades of federal, state, and local discriminatory housing policies and exclusionary ordinances, which has contributed to racial residential segregation and concentrated areas of poverty (Osypuk, Galea, McArdle, & Acevedo-Garcia, 2009). The majority of West Hartford's residents of whom are White, have college degrees and higher income from well-paying jobs and are able to afford the town's high cost of living. Educational attainment influences both individual and household income, which is a determinant of neighborhood residence (Elder, Goddeeris, Haider, 2016). Housing affordability and the cost of living are two factors which inhibit middle and lower-income families from moving in to towns like West Hartford (DataUSA, 2015). Poorer Hartford neighborhoods are inhabited predominately by minorities and have a smaller percent of college-degree holders, fewer higher paying jobs, and elevated crime rates (Matoba & Collins, 2017). This type of residential clustering and socioeconomic isolation has further shown to increase risk for poor birth outcomes among Black and African-American women. A study conducted by Bell, Zimmerman, Almgren, Mayer, and Huebner (2006) examined residential isolation (the probability of two Black individuals encountering one another at random in an area) and clustering (close proximity concentrated areas inhabited by Blacks) amongst African-Americans across Metropolitan Statistical Areas (MSAs). They found that after controlling for individual and area socioeconomic factors, higher isolation was associated with higher preterm birth rates, and lower birthweight. Bell et al., (2006) speculate that isolation may have greater adverse effects on birth outcomes due to discrimination, harmful intra-group social norms, poor neighborhood quality, and economic disenfranchisement. In contrast, higher clustering was associated with lower preterm birth rates and higher birthweight. This suggests that racial homogeneity in neighborhoods can provide social cohesion and support and protection from discrimination, acting as protective factors for Black women.

Kramer, Cooper, Drews-Botsch, Waller and Hogue (2010) sought to understand the relationship between racially segregated areas and the health of the populations within those areas. They were particularly interested in whether there was an association between residentially segregated neighborhoods and the elevated risk of preterm birth for Black women, found in previous studies. The “Black isolation index” approximates the probability of any two randomly selected individuals from the same census-tract are both Black. Kramer et al. (2010), examined regions of the United States (Northeast, Midwest, South, and West) using census-tract data, birth record data, and a spatial surface-density-derived measure, ArcGIS. The census data converted populations by race and ethnicity into a high-resolution surface density grid. Their results confirmed that for black women living in more segregated areas, or areas with high Black isolation, they had an increased risk for very preterm or preterm birth. They concluded this may due to Black women predominately inhabiting high-poverty neighborhoods with environments that are toxic (e.g., crumbling infrastructure, high crime). In contrast to poor White women who reside in more segregated neighborhoods, the risk for toxic-to-health neighborhood deterioration declines, reducing risk for preterm birth. The authors suggest this may be due to White women being more apt to live in mixed income neighborhoods, which are less likely to experience high-poverty environment type conditions (Kramer et al., 2010). These findings, which use macrolevel units of analysis and larger sample populations, are not generalizable to smaller communities or mixed urban-rural areas with fewer minorities.

While previous research focused on the individual-level social determinants of health, more recent studies have begun to re-explore the relationship of macro-level conditions (e.g., social inequality, socioeconomic status) and maternal psychosocial characteristics (e.g., stress, social support) between racial/ethnic groups birth outcomes. Past studies have found that infant mortality decreases as income and higher levels of education are attained for both Black and White women, however, this effect is stronger for White woman (Smith, Bentley-Edwards, El-Amin, & Darity, 2018; Kothari et al., 2016). College-educated Black women, including those with doctorates and professional degrees, and who receive adequate prenatal care are more likely to give birth to low birth weight infants than White women with less than a High School degree (Smith et al., 2018; Matoba & Collins, 2017). While there is no definite explanation for this phenomenon, a theory known as “the Weathering Hypothesis” developed by Geronimus (1994) suggests a connection between changes in Black women’s reproductive physiology and their experiences of discrimination and interpersonal racism.

For minority groups living in a racial conscious society like the United States, their life-long experiences greatly differ from those of their Whites counterparts. Experiencing either blatant or implicit discrimination can cause prolonged physical and mental distress. Black and African-American women face both gender and racial discrimination. Maternal age and optimum child-bearing years had been thought to be a determinant of birth outcomes as a response to Black-White disparities in infant mortality rates (Geronimus, 1996). The effects of this can be further exacerbated by living in poverty and residing in impoverished segregated neighborhoods. In the past, researchers’ logic was that high rates of teenage birth rates were a social response by Black teenage girls, who experienced higher infant mortality rates than Whites, due to their disadvantaged surroundings, poor education, and perceived "carelessness" (Villarosa, 2018). According to the developmental paradigm, optimum child bearing age for women would be in their mid-20s. The highest risk for preterm delivery and low birth weight infants follow a U-shaped age curve; women who are younger than 18 or over 35 are at highest risk with the lowest risk group in their mid-20s (Kramer & Hogue, 2009). Older women are more likely to have preexisting health conditions such as high blood pressure leading to gestational diabetes and preeclampsia which have been found to negatively impact gestation length (American College of Obstetricians and Gynecologists, 2017). While this is the case for White women, this is not the case for Black and African-American women, whose highest risk are mid-to-late 20s, early thirties, and above (Collins, Rankin, & Hibbs, 2015; Geronimus, 1994). Geronimus (1994) hypothesized that life-long exposure to the effects of social inequalities have detrimental effects on the female reproductive system and furthermore onto birth outcomes. The prolonged and repeated release of stress hormones by the hypothalamic-pituitary adrenal axis such as corticotropin, causes premature deterioration, or "weathering" on the mother's body (Geronimus, 1994; Kramer & Hogue, 2009; Collins, Rankin, & Hibbs, 2015; Villarosa, 2018). Disruptions of the endocrine system have subsequent negative effects on other systems such as the immune system, lowering the chances to fight infection and illness, which also can impact perinatal health.

To test her hypothesis, Geronimus (1996) examined the birth outcomes of over 55,000 Black and White women aged 15-34. Her results indicated that Black women had a negative slope; birth weights were lowest as mother's age increased. Higher rates of low birth weight were found in Black women in their 20s and 30s and lowest at 15-19 years of age. These results were different for White women, who experience elevated rates of low birth weight in their teens with decreases in their 20s. These findings support her theory that Black women, especially those in lower socioeconomic groups, experience more advanced physical and physiological deterioration at a more rapid rate in older age. This may in part be due to experiences of inequality and the hardships of living in poverty. These findings held even when controlling for maternal health characteristics (e.g., prenatal care, hypertension, and smoking).

Researchers have also looked at the types of stress, time periods of stress, and perinatal outcomes. Kramer and Hogue (2009) conducted a systematic review of the literature on racial disparities, the social determinants and biology of preterm and very preterm birth. Part of their review contained studies that examined the role of stress and its impact on the mother's body prior to conception, during pregnancy, and after delivery. They defined types of psychosocial stress and time periods as: "acute stress during pregnancy" and "life-course exposure to stressors prior to conception." Acute stressors were identified as pregnancy-related anxiety, life events such as divorce, death of a loved one, or illness. Preconceptional stressors were identified as adverse childhood events, longtime exposure to poverty, discrimination, or abuse. Their review supports the hypothesis that life-long "patterned maternal stress," is a cause for very preterm birth (Kramer & Hogue, 2009, p. 93). The stress response can cause inflammation and dysfunction in the neuroendocrine system that compromises gestation length that causes premature delivery. Pregnant women's responses to acute stress were found to increase immune responses (Kramer & Hogue, 2009). Adverse events up to one year prior to pregnancy were found to be significantly associated with preterm birth. Frequent exposure to discrimination and interpersonal racism, prior to or during pregnancy for Black women, were found to elevate risk (double or triple) for preterm birth.

Lack of Accessibility and Poor Quality of Care

Accessibility to healthcare is a critical factor in predicting infant mortality and is related to many of the other risk factors previously discussed. Persistent racial inequalities in the American healthcare system are evident and significantly influence both the types of services individuals are offered and the quality of care they receive. Many low-income women and their families, who live at or below state and federal poverty level rely on Medicaid, a federally regulated insurance program that provides free or low-cost insurance plans for low income families. The program is funded by both state and the federal governments. Medicaid and the Children's Health Insurance Program (CHIP) offer "minimum essential coverage" for routine visits including immunizations, testing and screenings; recently added were prenatal and postpartum care services. While optimal care should be provided, regardless of race, ethnicity, age or gender, discriminatory practices by medical professionals can influence the types of services they offer and administer and the adequacy of information they may or may not disclose to a patient (U.S. Centers for Medicare & Medicaid Service, 2018). For pregnant women this can mean missing out on nutritional and health counseling, recommendations for those who are at-risk and may need specialized follow-up care, screenings or tests not covered by insurance, or even prescription prenatal vitamins, for those who can't afford them out of pocket.

Public Policy and Interventions

Federal and state governments view infant mortality data for ideas on how to develop and maintain public health policies, which protect the right to accessible quality pregnancy-related and postpartum care. Childbearing aged women in the United States are often unaware of their legal rights about health-related choices for themselves and their children. They are often given less information about procedures, screenings and tests, or alternatives options. Policies related to care also protect a women's right to detection and treatment of pregnancy-related complications, information on the benefits and risks of procedures, tests, and treatments, as well as, access to records that pertain to pregnancy, labor, and postpartum care (Childbirth Connection, 2018). The World Health Organization (WHO), the major contributor in producing global health-related statistics including measuring infant mortality, has published guidelines on effective care from the prenatal through the postpartum period.

These evidence-based prenatal-care and postnatal care guidelines focus on the importance of healthcare professionals delivering quality care for all pregnant women and adolescent girls, which include: risk identification, prevention and management of pregnancy-related or concurrent diseases, health education, and health promotion (WHO, 2016). These guidelines are patient-centered and have a human-rights based approach to aid public health officials and policy-makers in developing quality maternal and child health services that are accessible and affordable.

The Affordable Healthcare Act makes health insurance more affordable for those in lower socioeconomic categories and/or those living at the federal poverty level in the United States (Healthcare.gov, 2018). Unlike previous state funded health insurance policies and healthcare reforms, this act covers pre-existing conditions like pregnancy. The act also covers prenatal care, child birth, and postpartum related care charges, including, breastfeeding equipment and maternal postpartum support. Although accessibility is a crucial component for infant and maternal well-being, equally important is the quality of care. To simply increase accessibility to prenatal care and postnatal related healthcare without attention to quality is a simple solution to a complex issue. Improving the quality of care that women and children receive should help facilitate long-lasting health care. Furthermore, the benefits of receiving quality care extends past healthy pregnancies to include educating and encouraging women to seek reproductive-health services such as contraception and information about sexually transmitted diseases or infections (Kearns, Caglia, Hoope-Bender, Langer, 2015).

Prenatal Care Services

Protective factors help to reduce risk of maternal complications, improve the chance for a full-term pregnancy thus, improving birth outcomes for both mother and child. As discussed in the aforementioned sections, many factors including poor neighborhood conditions, low income, lack of quality health and pregnancy related care can negatively impact pregnancy and gestation length (Garg, Butz, Dworkin, Lewis, & Serwint, 2009). Low income and minority groups are most impacted by these inadequacies, which is connected to higher mortality rates and preterm births. Almost all states, including Connecticut, offer health assistance programs for expectant mothers that are free or covered by state insurance plans, such as Medicaid. Some programs offer specialized services such as Women, Infants, and Children (WIC), a nationwide nutrition program. WIC provides supplemental foods, nutrition education and counseling to low-income pregnant, breastfeeding (or non-breastfeeding) postpartum women, and their children up to the age of 5 who are at nutritional risk (United States Department of Agriculture, 2015). This federal funded program distributes specific food vouchers that are intended to supplement specific nutrients into their clients' diet. Vouchers can include infant foods, cereals, fruits, vegetables, dairy or soy-based products, iron-fortified products, and whole-grain options. Vouchers for these items can be redeemed at over 46,000 merchants (United States Department of Agriculture, 2015). The program also offers breastfeeding counseling, health referrals, and immunization screenings. Other programs are able to offer a more individualized-based range of services, one such program in Hartford is the Maternal and Infant Outreach Program (MIOP), which was created to help reduce infant mortality and low birth weight rate by offering case-based services that are free of charge. The program offers health and nutrition education for each stage of pregnancy and infant development through the first year of life. Home visitation is also provided to ensure social and emotional support for the mother. Emotional and social support are important elements of pre and postnatal care; these services can aid those suffering with postpartum depression and anxiety. Since low birth weight and preterm babies are at a greater risk for neurodevelopmental and health complications, this can increase the risk for psychoemotional problems in caregivers (Casey et al., 2017). Similar to WIC, MIOP offers referrals, assistance with applications for third party services, and transitioning eligible participants to their sister-program, the Nurturing Families Network (NFN). NFN is a weekly home-visitation program, also offering health and nutritional educational services, to women with children up to the age of 5 years. They help women register for prenatal care and offer prenatal and parenting groups that ensure social and emotional support.

Both larger scale programs, like WIC and home visitation programs, such as MIOP and NFN, have been shown to be effective in reducing low birth weight, preterm birth, and infant mortality (Gai & Feng, 2012; Colman, Nicholas-Barrer, Redline, Devaney, Ansel, 2012). Moreover, Khanani, Elam, Hern, Jones and Maseru (2010) found women who enrolled in WIC during their pregnancy were less likely to experience an infant death than non-WIC participants. Specifically, African-American WIC enrolled participants had a statistically significant reduction in their infant mortality rate and preterm births compared to Non-WIC participants. Hoynes, Page, and Stevens (2011) found that babies born to women enrolled in WIC had in increase in birth weight. This was evident for women with less than a high school education and living in high poverty areas. Moreover, home-visitation studies have found that preterm infants enrolled in these programs have a lower risk of mortality, are more likely to be immunized and taken to recommended routine visits, and experience more positive parent-infant interactions. Mothers also benefited from enrollment and were less likely to have low birth weight babies and more likely to receive referrals for social and medical services. (Casey et al., 2017; Lee et al., 2009; Goyal, Teeters, & Ammerman, 2013).

A more personalized service that studies have shown to have a positive impact on birth outcomes is the use of doulas. Doulas or midwives are medically trained professionals that provide physical, emotional, and informational support throughout a woman's pregnancy, labor, and post birth (Gruber, Cupito, & Dobson, 2013; Kang, 2014). They act as a liaison between the mother, doctor, and medical staff, expressing the mother's desires and choices at times when she is most vulnerable, during and after labor. Skilled doulas, can help empower women to communicate their needs (Villarosa, 2018; Hartocollis, 2015). Doulas also consult on breastfeeding, nutrition, safe sleeping, and postpartum maternal mental health (Gruber, et al., 2013). Researchers have found that the presence of a doula throughout pregnancy and labor has shown to reduce: maternal stress, the use of medical interventions, pain medications (e.g., epidurals), cesarean births, and birth complications. These positive findings have been greatest in low-income, socially disadvantaged, and less English-proficient women. Infants born to a doula-assisted mother were less likely to have low birth weight, have higher APGAR scores, and be breastfed for a longer time after birth (Kang, 2014; Gruber et al., 2013). Unfortunately, the medical field has been slow to embrace the idea of doulas being a part of their profession, in part because many insurance companies have not been willing to pay for doula services (Hartocollis, 2015). This makes it difficult for women who would most benefit from these services to hire a doula. Doulas are advocates who are culturally-sensitive and practice patient-centered care. They not only help women navigate through the complex process of medical and health-related decisions, they also provide continuous support from the prenatal through the neonatal period.

Adverse birth outcomes and infant mortalities are exceptionally high in the United States and even higher in Hartford, Connecticut. Research suggests that the causes for these infant deaths derive from systemic inequality that has produced a lower quality of life with fewer quality resources for minority groups. Black women of childbearing age are the most negatively affected, experiencing racial and gender discrimination causing chronic stress detrimental to physical and biological functioning. This "weathering" or deterioration of the body is strongly associated with adverse birth outcomes and infant death. An examination of the risk factors attributed to infant death, poor birth outcomes, and the populations most at risk offer pivotal information to public health policy makers, and state and federal-funded programs such as WIC and MIOP.

Hartford's Health and Human Services Maternal and Child Health Division's Strategic Plan

The Connecticut Department of Health and Human Services Maternal and Child Health Division developed a set of twelve objectives in 2013 to help reduce the number of infant deaths and adverse birth outcomes. Objectives also looked to increase the number of women receiving quality pregnancy-related care, enrollment into health-related programs, and improve child health. The plan's deadline is set for June 2018.

Current Study

The purpose of this study was three-fold. First, it aimed to bring awareness to the issue of infant mortality by identifying the leading causes of infant death and the Hartford populations most affected from 2010 to 2015. Second, it sought to determine if key objectives of the Connecticut Department of Health and Human Services Maternal and Child Health Division (MCHD) Strategic Plan have been met and lastly, to provide recommendations for public health policies and state programs that would reduce infant mortality. Analyses of the vital record data collected from 2010 to 2015 by the Connecticut Department of Public Health Vital Statistics Office were used to answer the following research questions:

1) What were the underlying causes of infant mortality in Hartford from 2010 to 2015?

2) How well have the objectives of the MCHD's Strategic Plan been met?

3) What recommendations can be made for public health policies to help reduce infant mortality?

Method

Vital Record Data

The archived data set used in this study contained linked birth and death data collected by the Connecticut Department of Public Health Vital Statistics Office. The specific data were the vital records of 11,553 live births that occurred in Hartford from 2010 to 2015. Within this population, was a subset consisting of 105 infant mortality cases. All deaths occurred within 364 days after birth between 2010 to 2015. All personally-identifiable information was previously removed from the dataset. A new dataset was created to identify infant deaths along with demographic information and specific risk factors. These cases were divided by birth year into two groups based on the Connecticut Department Health and Human Services's (HHS) Strategic Plan. Infants born between the years 2010 to 2012 were identified as the Pre-Plan group and those born from 2013 to 2015 were identified as the Post-Plan group. Relevant variables from the vital records were exported into an SPSS data file in order to perform statistical analyses. The analysis procedures used included chi-square tests of association, t-tests, and quantitative comparisons that were used to determine if specific objectives of the HHS's Strategic Plan had been met. Analyses were also conducted to determine if infant deaths were connected to specific identified risk factors.

The Connecticut Department of Health and Human Services distributed and authorized the data to be analyzed at Trinity College upon approval from Trinity College's Institutional Review Board and the State of Connecticut Department of Public Health Human Investigations Committee (HIC). Researcher(s) were Collaborative Institutional Training Initiative (CITI) certified and complied with ethical guidelines to preserve confidentiality of all cases in the data including: the Health Insurance Portability and Accountability Act (HIPPA), the Connecticut Department of Health and Human Services, and Trinity College's Institutional Review Board guidelines.

Descriptions of Adequacy of Prenatal Care and APGAR Variables Categories

Coded categories for adequacy of prenatal care. The Adequacy of Prenatal Care Utilization Index (APNCU), developed by Kotelchuck (1994), is an assessment tool comprised of two dimensions. The first dimension refers to the month when prenatal care began and the second, the "adequacy of received services," is a ratio of the number of reported visits up until delivery to the expected number of visits (March of Dimes, 2018, p.1; Kotelchuck, 1994). A mother's initial prenatal visit was categorized as: early prenatal care, second trimester care, late or no prenatal care (March of Dimes, 2018). According to the March of Dimes (2018), early prenatal care occurs within the first to three months of confirmed pregnancy, second trimester care is care received within the fourth to sixth month of pregnancy and late, or no care starts in the third trimester. For quality of care, the index was divided into 4 categories: adequate plus, adequate, intermediate, and inadequate. For the purpose of this study, the former APNCU categories of prenatal care were collapsed into one category labeled "not intensive care" and an additional category of "intensive care" was developed.

APGAR Score. Immediately following birth, newborns are assessed using a standardized scoring system known as the Apgar Score. Infants receive a score of 0, 1, or 2, based on five components: their color, heart rate, reflexes, muscle tone, and respiration. The scores are reported at 1 minute of age, 5 minutes, and continues at 5-minute intervals until 20 minutes, if an infant has received a score of less than 7 (American Academy of Pediatrics, 2015). Lower Apgar scores are often found in premature infants and low (and very low) birth weight infants who are at a higher risk for neonatal and perinatal mortality. Although low scores are not a definitive predictor of infant death they help to predict mortality.

Causes of Infant Death Classification. In the result of death, the assessment tool used to classify the cause(s) of death in the current study, as well as, by the CT Department of Vital Statistics was the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10), published in 2016.

Birth and Infant Death Populations

Of the 11,553 live births that were reported in Hartford from 2010 to 2015, the infants born were identified as Hispanic (50.3%), Black Non-Hispanic (35.2%), White Non-Hispanic (8.4%) or Other Race Non-Hispanic (5.2%). There were few missing cases (see Table 1 for number of births per year).

For the one hundred and five infant deaths there were 87 single births and 18 infants identified as twins. The race and ethnicity of the infant mortality population reflect that of the birth population. A majority were reported as Hispanic (46.2%), Black Non-Hispanic (40.4%), White Non-Hispanic (9.6%), Other Race Non-Hispanic (1%), and Unknown or Missing (3%). Nearly all births occurred at Hartford Hospital (48.6%) or St. Francis Hospital and Medical Center (40%). While residential street addresses were omitted, neighborhood zip codes were identified. The most frequently reported neighborhoods of residence were: Behind the Rocks (28.6%), Blue Hills (23.8%), South Meadows (23.8%) and North Meadows (12.4%). While all infants were identified as Hartford residents, some of their deaths were reported as occurring outside of Hartford hospitals. Deaths were reported at: Connecticut Children's Medical Center (31.6%), St. Francis Hospital and Medical Center (31.5%), Hartford Hospital (26.7%) and other hospitals (10.7%) (see Table 1 for number of deaths per year).

Mothers' characteristics. Mothers within the birth population ranged in age from 13 to 51 years old, with a mean age of 26.36. Mothers within the infant mortality population ranged in age from 17 to 45 years, with a mean age of 27.25.

Levels of educational attainment were categorized as: less than a High School degree, High School degree, some college, Bachelor's Degree, and more than a Bachelor's degree. The proportions of women's highest-level education attained for both the birth and infant mortality population were similar. Most mothers of the birth population had received a high school degree (36%), followed by those with less than a High School degree (28%), and those who completed some college (25%). Mothers who had obtained a Bachelor's degree or more was 11% of the population. Within the infant mortality population, most mothers had a High School degree (45%), less than a High School degree (21%), and some college (24%). Mothers who had obtained a Bachelor's or more was 9.5% of the population.

The following results across all variables and comparative analyses in this study include, participant data from the birth population of 11,552 and 104 of the 105 infant mortality cases. Results that include a different sample size are specified where appropriate. All statistical tests were performed with an alpha level of 0.05.

Results

Five objectives (numbers 3, 4, 5, 7 and 8), were directly relevant to questions of infant mortality. All analyses were run using the live birth population (N = 11,553) which was divided into Pre-Plan (2010-2012) and Post-Plan (2013-2015) groups. Tests used to determine the success or failure of an objective were chi-square tests of association for comparisons and t-tests for ordinal level measures.

Hartford Health and Human Services' Strategic Plan Objectives (HHS)

Objective 3: *Reduce infant deaths in the City of Hartford by 10% by June 2018 (baseline 9.8 per 1,000 live births).*

The baseline calculated from the dataset was consistent with the baseline stated within the objective. A 10% reduction would mean reaching a rate of 8.82. In the Post-Plan group, there were 46 infant mortality cases out of 5,612 live births, equivalent to a rate of 8.2 (a 17.1% reduction). However, the infant mortality rate shows an increase between 2013 and 2015 (see Table 1 and Figure 1). This objective has been met through 2015.

Objective 4. *Reduce preterm births (<37 weeks gestation) in the City of Hartford by 10% by June 2018 (baseline is 13.6% of live births).*

The baseline calculated in the dataset differed from the one stated in the Strategic Plan. The dataset's baseline was 13.1% versus the 13.6% stated in the Plan. The proportion of infants born preterm in the Post-Plan group was significantly lower than the proportion of infants in the Pre-Plan group, χ^2 (1; N = 11,553) = 4.50, p = 0.034 (see Table 2 and Figure 2). From the calculated baseline there was an exact 10% reduction from the Pre-Plan to Post-Plan groups; 13.1% to 11.8% respectively. A 10% reduction from the Plan's baseline would have been equivalent to 12.24%. This objective has been met through 2015.

Objective 5. *Reduce the low birth weight rate (<2,500 grams) in the City of Hartford by 10% by June 2018 (baseline is 12.1%).*

The Strategic Plan's baseline and the calculated baseline from the dataset differed; the dataset showed a baseline of 11.4%. A 10% reduction from the (dataset's) calculated baseline would be 10.26%. A 10% reduction from the Plan's baseline at 12.1% would be 10.89%. There was no association found between groups (Pre-Plan and Post-Plan) and infants weighing less than 2,500 grams, χ^2 (1; N = 11,549) = 0.13, p = .72) (see Table 3 and Figure 3). When groups were looked at by birth year, there was also no association found between birth year and low birth weight, χ^2 (5; N= 11,549) = 1.70, p = .89 (see Table 3 and Figure 3). This objective has not been satisfied through 2015.

Objective 7. *Increase the proportion of pregnant women in the City of Hartford who receive adequate prenatal care throughout their pregnancy by 10% by June 2018 (baseline 39%).*

The dataset's calculated baseline was 41.6% and a 10% increase would have been equivalent to 45.8%. When APNCU ratings were recoded to, *Intensive* or *Not Intensive* there was a significant difference. There were significantly fewer women in the Post-Plan group who received *Intensive* prenatal care (36.8%) versus Pre-Plan group women at 41.6%, χ^2 (1, N = 11, 290) = 28.26, p < .001. An increase from the Plan's baseline of 39% would have been 42.9%. When looking across birth years there was a significant decline χ^2 (5; N = 11,290) = 50.81, p < .001. This objective has not been satisfied through 2015 (see Table 4 and Figure 4).

Objective 8. *Reduce the teen pregnancy rate (females 15-19 years of age) in the City of Hartford by 10% by June 2018 (baseline is 63.2% of live births).*

The size of Hartford's female teenage population was not within the dataset; therefore, we could not calculate a baseline and evaluate this objective directly. However, the proportion of births to teens was significantly reduced from the Pre-Plan group at 13.4% (797 cases out of 5,940) to 9.3% in the Post-Plan group (524 cases out of 5,612) (see Table 5). This is more than a 10% reduction. The objective has been partially satisfied through 2015.

Pre and Post Risk Factors of HHS's Strategic Plan

The following results were based on analyses of data from the 105 infant mortalities reported in Hartford, CT from 2010 through 2015.

Mothers' characteristics. There were more mothers in the Pre-Plan group (58) who were also older, with a mean age of 28 years. The Post-Plan group mothers (47) had a mean age of 26. There was no significant difference between groups (Pre and Post) and mother's age $t(103) = 1.26$, $p = .21$. Teenage mothers were identified as being between the ages of 15 to 19. In the Pre-Plan group there were 797 teenage mothers and 524 in the Post-Plan groups. There was no association between groups and birth year χ^2 (20, N = 1321) = 2.04, p = 0.73 (see Table 5).

Pregnancy order and previous births. For most women this was their first pregnancy (43 out of 104); second pregnancy (26 out of 104), and third or more pregnancy (34 out of 104). There was no effect found between Pre and Post groups and the order of pregnancy $F(5,99) = 0.76$, $p = 0.58$. There was also no association between pregnancy order and birth year χ^2 (15, N = 104) = 4.76, p = 0.99. The mothers' previously born children were analyzed and were grouped into three categories: number of previous children born alive and still living, number of previous children born alive, now dead, and number of previous children born dead. All categories of previous born children were found to be unrelated to birth year. There was no effect between birth year and previous children born alive and still living $F(5,104) = 0.33$, $p = 0.89$. There was no effect between birth year and children born, now dead $F(5,104) = 0.76$, $p = 0.58$. Lastly, there was no effect between birth year and previous children born dead $F(5,104) = 0.74$, $p = 0.59$ (see Table 6).

Tobacco use during pregnancy. All mothers self-reported the use or nonuse of tobacco. From both groups about 11% self-reported the use of tobacco while pregnant. Among these mothers who used tobacco, the average number of cigarettes smoked per day ranged from 2 to 20.

The most frequently reported average was 5. The remaining 89% reported no use of tobacco during pregnancy. In the Pre-Plan group, 12% of women reported use of tobacco (7 of 57 women), while 8% Post-Plan group of women (4 of 47) reported use. There was no association between the mother's use of tobacco during pregnancy and when the Strategic Plan was implemented, χ^2 (1, N = 104) = 0.39, p = 0.53.

Alcohol use during pregnancy. Only one woman of the mothers of the infant mortality population reported use of alcohol while pregnant. No further statistical testing was performed due to the rarity of this self-reported behavior.

Prenatal care. There was no difference in the month during which prenatal care began between the Pre-Plan group (M = 2.50, SD = 1.41) versus the Post-Plan group (M = 2.58, SD = 1.66), t(95) = -0.26, p = .80. There was also no difference in the number of prenatal care visits attended by the Pre-Plan group (M = 6.54, SD = 4.52) versus Post-Plan group (M = 6.82, SD = 3.90), t(84) = -0.30, p = .77.

Adequacy of Prenatal Care Utilization Index (APNCU). Adequacy of Prenatal Care scores were indicated as *Inadequate*, *Intermediate*, *Adequate*, and *Intensive*. Group (Pre-Plan versus Post-Plan) was not significantly associated with APNCU rating, (3, N = 92) = 2.78, p = .43. Overall, 21% of the infant mortality population was rated as "inadequate" APNCU. The percentages of "Intermediate," "Adequate," and "Intensive" in the population were 12%, 20%, and 48%, respectively.

Complications of labor and/or delivery. The most frequently reported labor and delivery complications in both groups were fetal malpresentation of a breech position (21 of 104 cases reported) and premature rupture of the membrane (20 of 104). Overall, 72 mothers were at risk for complications during labor and delivery, and 32 were reported to not have any medical risks during labor or delivery. There was no significant association between groups (Pre-Plan versus Post-Plan) and risk for complications during labor, χ^2 (1, N = 104) = 0.13, p = .72. Breech or Malpresentation were not associated with groups (Pre-Plan versus Post-Plan groups), χ^2 (1, N = 104) = 0.02, p =.89. Complications involving premature rupture of membrane was not associated with groups, χ^2 (1, N = 104) = 2.03, p = .15.

Obstetric procedures. A majority of infants who died, 80% from Pre-Plan and Post-Plan groups overall, reported to have some risk at birth and needed one or more obstetric procedures due to that risk. Only 20% had no risk. There were no significant association between group (Pre-Plan versus Post-Plan) and likelihood at risk at birth, χ^2 (1, N = 104) = 0.12, p = .73.

The most frequently used obstetric procedures were: electronic fetal monitoring (63 yes, 41 no); ultrasound (28 yes, 76 no); induction of labor (23 yes, 81 no). The need for electronic fetal monitoring was reported in 62% of the Pre-Plan group (36 of 58 cases). There were fewer reported cases in the Post-Plan group with 59% (27 of 46 cases), there was not a significant difference between groups; χ^2 (1, N = 104) = 0.12, p = .73. Induction of labor was similar for both groups; within the Pre-Plan group there were 11 reported cases and 12 cases in the Post-Plan group. There was no significant association between Pre-Plan and Post-Plan groups and whether an induction of labor procedure was performed, χ^2 (1, N = 104) = 0.76, p = .38. There was a strong association between the use of an ultrasound during labor and delivery and Pre-Plan and Post-Plan groups, χ^2 (1, N =104) = 13.93, p < .001. In the Pre-Plan group 41% (24 of 58 cases) had an ultrasound performed. In the Post-Plan group only 9% (4 of 46 cases) had an ultrasound. Women who gave birth prior to the Strategic Plan were more likely to receive an ultrasound than those who gave birth after the Strategic Plan was established.

Infant deaths to births by racial/ethnic group. Odds ratios were calculated by dividing the percentage of infant deaths by the percentage of live births within racial/ethnic groups. An odds ratio of 1.0 means that the percentage of infant deaths is exactly what would be expected, given the percentage of live births for that group. An odds ratio above 1.0 means that the percentage of infant deaths is above what would be expected, given the percentage of live births for that group. An odds ratio below 1.0 means that the percentage of infant deaths is below what would be expected, given the percentage of live births for that group. The odds ratios for 2010 through 2015 in Hartford were: Black (non-Hispanic), 1.15 (40.4%/35.2%); Hispanic, 0.92 (46.2%/50.3%); and White (non-Hispanic), 1.14 (9.6%/8.4%). Non-Hispanic Blacks and Whites were more likely than expected to have infant deaths. Hispanics were less likely than expected to have infant deaths (see Table 7).

Plurality of birth. Plurality refers to the birth of multiple babies from a single pregnancy. Within the infant mortality population, there were 87 single births and 18 twins; overall, groups had 17% of plurality births die. Of the sets of twins, 7 first born infants died and 11 infants born second died. There is a slightly higher risk of death for the second-born infant in a set of multiples. The Pre-Plan group had 10 deaths 8 involving plural births, altogether there were 5 second-born, 1 first-born, and 2 sets of twins. For the Post-Plan group 8 infants died including 4 sets of twins. There was no association between groups (Pre-Plan versus Post-Plan) and plurality, χ^2 (1, N = 105) = 0.00, p = .98. Furthermore, there was no association between birth year and plurality, χ^2 (5, N = 105) = 3.45, p = .63.

APGAR scores. The APGAR scoring system ranges from 0 to 10 and is based on five criteria (color, heart rate, reflexes, muscle tone, and respiration), each coded as 0, 1, or 2. The following scores are an average at 1 minute and 5 minutes of age, post birth.

Within the infant mortality population, APGAR scores at 1 minute ranged from 0 to 9, with 66% of all cases falling at or below 3. APGAR scores at 5 minutes ranged from 0 to 9, with 59% of all cases falling at or below 3. Most infants (59 of 102) had the same APGAR scores at 1and 5 minutes. Some (34 of 102) showed an increase in APGAR scores from 1-minute and 5-minutes; a few (9 of 102) showed a decrease in APGAR scores from 1-minute and 5-minutes. There was no relationship between group (Pre-Plan versus Post-Plan) APGAR scores at 1-minute post birth; χ^2 (9, N = 102) = 6.43, p = .70. There was also no significant association between group and the APGAR scores at 5-minutes, χ^2 (9, N = 103) = 9.70, p = .38. APGAR score at 1-minute was not found to be related to birth year, χ^2 (45, N = 102), = 39.42, p = .71. APGAR scores at 5-minutess were also found to be unrelated to birth year, χ^2 (45, N = 103) = 48.71, p = .33

Infant mortality population causes of death. The most frequent categories amongst the infant death population were “conditions originating in the perinatal period”, then “congenital malformations, deformations and chromosomal abnormalities,” and lastly, “symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified” (ICD-10, 2016). There were up to six causes of death reported within a case, however nearly all had a single cause of death; 50 suffered from 2 causes, 30 with 3 causes, 12 with 4 causes, 4 with 5 causes, and 1 with reported 6 causes for death. The leading causes of death were extreme prematurity (70 cases), premature rupture of the membranes (20 cases), and Sudden Infant Death Syndrome (8 cases).

Discussion

Data on infant mortalities is an important unit of measurement and an indicator of the overall health of a specific population or nation. These data expressed as rates are often used by researchers and public health government officials to assess health risks, risk factors attributed to death, and causes of death of a population. While these deaths provide statistical evidence that are used to help officials and researchers in both clinical and public health fields, it is essential to note that these deaths are a tragedy for women and their families who experience them. They represent lives lost too soon and too quickly. Unfortunately, the United States has an exceptionally high infant mortality rate when compared to countries of similar wealth. Over the last decade the U.S.'s rate has only been slightly reduced. There is a serious problem for a country that has one of the highest per capita health care spending, averaging to over $9,800 per person (OECD, 2017). Moreover, the United States allots a significant amount of money towards medical research, technological advancements, and other health-related resources annually. The National Institutes of Health invests nearly 37 billion alone on medical research (National Institutes of Health, 2018). This suggests not enough is being done to reduce infant mortality in the United States, despite the wealth of research on this issue. Extensive research focused on infant death suggests identifiable risk factors can lead to poor birth and perinatal outcomes or infant death. Moreover, these findings show a complexity of interconnected variables, some of which require the restructuring of governmental support systems.

The city of Hartford in Connecticut struggles with the number of infant deaths and adverse birth outcomes. Although the city has not been able to sustain a continuous reduction of infant deaths each year, they are assiduously working to find solution(s). Hartford's Department of Health and Human Services acknowledged that there was a series of problems in terms of infant deaths. The MCHD's response was to develop a set of objectives to more closely monitor the health of women and their children and determine its root causes, hoping to decrease the escalating rate. The 5-year Strategic Plan timeline allowed time for vital record data to be collected, analyzed, and to identify previously undetected trends in health quality.

Objective 3 sought to reduce the infant mortality rate by 10% from a baseline (9.9) calculated from Pre-Plan (2010-2012) group birth and death data. While the objective was met, succeeding the baseline objective by 7%, the previous high to low trend seems to continue on with the rate increasing after the implementation of the Plan. This may suggest that Hartford women of childbearing age may be experiencing the effect of weathering and suffering from chronic stress. The mean age for both Pre and Post groups were 26 and 27, respectfully, and falling within the age range Geronimus (1996) found lower-income women giving birth prematurely and to more low birth weight babies. Furthermore, non-Hispanic Black infants had the most deaths and had the highest birth to death ratio. This is also consistent with Geronimus's findings, that the most affected population are Black women. Women residing in the poorest and most underserved Hartford neighborhoods may be the ones who are experiencing most of these fatalities. It was however, not possible to definitively identify this possibility, since individual data were not available for analyses.

Objective 4 was to reduce the number of preterm births by 10% from a baseline of 13.6%. The number of preterm births within the Post-Plan group (2013-2015) did decline and the objective was successfully met. Although this goal was met, there appears to be an increase similar to the trend reflected in the infant mortality rate. While immediately following the Plan's implementation, fewer low birth weight babies were born, but there was an increase in 2014 and 2015. What this might imply, again, that the women of Hartford may be experiencing the weathering effect. The second leading cause of death within the mortality population was premature rupture of the membranes (PROM). This is defined as the rupture of the fetal membrane or amniotic sac which surrounds the fetus; rupture can occur before 37 weeks gestation thus inducing labor (Burd, Zieve, & Ogilvie, 2016). Babies born due to PROM before

37 weeks gestations are often low birth weight and have higher risks for perinatal death, and risk increases in multifetal pregnancies (Mercer, 2003). Although plurality was not found to be statistically significant between groups, in the Post-Plan group all 4 sets of twins died. Moreover, Pre-Plan group women were significantly more like to have an ultrasound performed than Post-Plan group women. This may suggest that babies of the Pre-Plan group were screened for fetal abnormalities or pregnancy-related complications were found earlier than in the Post-Plan group.

Objective 5 aimed to reduce the number of low birth weight rate by 10%, from a baseline of 12.1%. Unfortunately, this objective was not met. While there was a decline, it was not 10% nor did it reach statistical significance when looking at Pre vs Post-Plan groups. The leading cause of death within the mortality population was extreme prematurity. Infants often born extremely premature are very-low or low birth weight babies, based on the week of gestation they are born (Koller-Smith et al., 2017; MedlinePlus, 2018). Moreover, premature rupture of the membranes, the second leading cause of death, could have also influenced the number of infants born with low birth weight in the Post-Plan group.

Objective 7 aimed to increase the proportion of women receiving adequate prenatal care; this objective was not met. Unfortunately, for this objective the findings were inversed. Fewer women in the Post-Plan group received intensive prenatal care than the Pre-Plan group. Although there was no significant difference between groups, there were overall fewer women reported in the Post-Plan group. This could have impacted individually calculated and the scores reported.

Objective 8 was to reduce teen pregnancy by 10%. Analyses for this objective were limited due to missing data within the dataset pertaining to the Hartford female teenage population. A baseline could not be calculated therefore analyses for the Post-Plan group could not be performed. Teen pregnancy was reduced by more than 10% after the implementation of the

Strategic Plan. Although the national rate has also since decreased, this may suggest that more Hartford teens in the Post-Plan group used contraceptives more often than those in the Pre-Plan group. Abstinence may have also been practiced by more Post-Plan group teens. Additionally, programs aimed at reducing teen pregnancies in Hartford may be achieving success.

Risk Factors

A significant body of research pertaining to infant death looks at risk factors attributed to poor birth outcomes such as prematurity, low and very low birth weight outcomes. These studies have dominated research and focus primarily on individual-level maternal characteristics including her race and ethnicity, level of education, socioeconomic status, and marital status. While findings from these studies did indicate that there was a relationship to poor birth outcomes and infant death, they also highlight racialized patterning (Wallace et al., 2017). The Black and African-American and White racial disparities of infant mortalities continue to the present day. Black infants die at a much higher rate than Whites, as far back as 35 years (Smith, et al., 2018). This corresponds to data from the current study, which shows (non-Hispanic) Black infants were more likely to experience death but only when compared to Hispanics. Whites had a similar death to birth ratio to Blacks while, Hispanics were less likely than expected to experience an infant death. While these findings may be in part due to the small sample size, there are several interacting factors at play. Mother's income was not included in the dataset, however, a majority (76%) of mothers in the infant mortality population named Medicaid as their primary method of payment, covering both prenatal and after delivery care. This suggests that mothers using Medicaid were living at or below state-level poverty. Also, the highest level of education for most women was a high school degree, and fewer with some college education or college degrees, which is consistent with findings in the research literature (Elder, Goddeeris, & Haider, 2016).

Policy Implications and Recommendations

While it is important for cities such as Hartford, to have objectives (or goals) set in place to monitor the changes in maternal and child health it is imperative that there is enough time for the goals to be assessed. The deadline of the Strategic Plan is June 2018 and infant mortality data for 2016 and 2017 was not available for assessment in the current study. Due to the average time of 2-2.5 years for final infant mortality data to be published, the first recommendation is where possible, to collect and analyze vital record and infant death data in a timely manner. If data can be analyzed more quickly, objectives can be more closely monitored to help the city better understand if objectives are on target. Moreover, this would help address problem areas where needed policies can be implemented more readily. A second recommendation is to extend the Strategic Plan's beyond the current deadline. This extension will allow for more data to be analyzed, allowing for a clearer picture of whether the city's goals are being maintained. Extending the plan by an additional 5 years, making it a 10-year plan is a key recommendation based on the findings from the current study.

Findings from this study showed that fewer women after the Strategic Plan's implementation received intensive prenatal care. The MIOP program reported that up until 2015, no mothers enrolled in the program had an infant die. The study's author proposes that elements of the MIOP program be used as a guideline for other Hartford programs that offer prenatal to postpartum, pregnancy-related, and/or maternal and health care services. By doing so this may help to improve birth outcomes and maternal health for all Hartford women. Lastly, it is recommended that all Hartford women have the opportunity to receive intensive prenatal care.

This will ensure that objectives 5 and 7 are being met, which aim at reducing infant mortality. For this to occur however, changes would need to be made in provider practices, clinical infrastructure, changes to social service department budgets, along with amending current policies related to pregnancy-related care and maternal health care.

Limitations

The dataset used in this study contained provisional data which may differ from official reports, therefore findings from this study should be considered as provisional. For some objectives, the baselines reported by HHS differed from baselines calculated from the dataset. This included objective 4; the provisional dataset baseline that was calculated was 13.1% and 13.6% reported by HHS. For objective 5, the provisional dataset baseline was calculated as 11.4% and 12.1% reported by HHS. Lastly, objective 7's provisional dataset calculated baseline was reported as 41.6% while HHS reported 39%. These differences may have occurred due to additional births or deaths being added to reports after publication of the Strategic Plan.

The population of infant deaths was small, which had an effect on analyses run for several of the risk factors. Nearly all risk factors showed no statistical significance in the mortality population, which differs from findings in the research literature. Additionally, findings are not generalizable to other Connecticut cities, which may have different ethnic and racial populations.

The findings from this study add to the body of literature on the risk factors of infant mortality. These findings reaffirm that the health of women and infants of Hartford are not at an optimal state and needs to continue to be addressed in connect with the Hartford Strategic Plan. Although the findings from this study have not identified specific trends in what is impacting Hartford women prior to conception through labor and delivery, these findings can be used as evidence to improve existing pregnancy- related services, especially in light of Geronimus (1996) weathering hypothesis. Many neighborhoods of Hartford are impoverished and are home to many Black and African-American women, who had the highest proportion of infant mortalities in the study. Public health and state officials when considering changes to city objectives, health care policies, and allocating funding to maternal and child health services should be cognizant of the populations that utilize them. Moreover, minimizing racial inequalities by making higher quality of care accessible to minority women should take priority in decision-making.

Table 1

Infant Mortalities and Mortality Rate by Birthyear in Hartford, CT (2010-2015).

Year	Number of Births	Number of Infant Deaths	Infant Mortality Rate (per 1,000 births)
2010	2,004	13	6.5
2011	1,968	25	12.7
2012	1,968	21	10.7
2013	1,903	11	5.8
2014	1,878	15	7.5
2015	1,831	21	11.5
Total	11,552	105	

Note. Infant death is defined as a live birth who does not survive past 364 days.

Table 2

Clinical Estimation of Gestation in Weeks of Hartford Births by Birth Year, 2010-2015.

	Birth Year		
Clinical Estimation of Gestation (in weeks)	2010-2012 (Pre-Plan)	2013-2015 (Post-Plan)	Total
Preterm (< 37 weeks)	777 (13.1%)	661 (11.8%)	1,438
Not Preterm (37 or more weeks)	5,153 (86.9%)	4,942 (88.2%)	10,095
Total	5,930	5,603	11,553

Note. Preterm infants included "e^{x}tremely preterm" (less than 28 weeks), "very preterm" (28-32 weeks), and "moderately-late" preterm (32-37 weeks) (World Health Organization, 2018).

Table 3

Hartford's Live Birth Population's Birthweight in Grams by Birth Year, 2010-2015.

	Birth Year		
Birthweight	2010-2012 (Pre-Plan)	2013-2015 (Post-Plan)	Total
Less than < 2,500 grams	674 (11.4%)	625 (11.1%)	1,299
2,500 grams or more	5,264 (88.6%)	4,986 (88.9%)	10,250
Total	5,938	5,611	11,549

Note. Less than < 2,500 grams included infants identified and defined as "very low birth weight" (< 1,500 grams), "low birth weight" (< 2, 500 grams), and "moderately low birth weight" (1,500 – 2,499 grams) (Centers for Disease Control and Prevention, 2018).

Table 4

Adequacy of Prenatal Care Received by Hartford, CT's Birth Population 2010-2015.

	Birth Year		
Adequacy of Prenatal Care	2010-2012 (Pre-Plan)	2013-2015 (Post-Plan)	Total
Not Intensive	3,386 (58.4%)	3,471 (63.2%)	6,857
Intensive	2,416 (41.6%)	2,017 (36.8%)	4,433
Total	5,802	5,488	11,290

Note. "*Not Intensive*" includes prenatal care that was reported as *Inadequate*, *Intermediate,* and *Adequate*. Unreported or missing data was excluded.

Table 5

Proportion of Live Births to Female Teenagers by Birthyear in Hartford, CT (2010-2015).

Birth Year	Number of Births	Number of Births for Teenage Mothers	Percent of Births to Teenage Mothers
2010	2,004	302	15.1%
2011	1,968	252	12.8%
2012	1,968	243	12.3%
2013	1,903	191	10.0%
2014	1,878	180	9.6%
2015	1,831	153	8.4%
Total	11,552	1,321	

Note. Mothers' identified as teenagers were 15 to 19 years of age.

Table 6

Number of Previous Born Children to Mothers with an Infant Mortality in Hartford by Birth Year, 2010-2015

Measure	Birth Year					
	2010	2011	2012	2013	2014	2015
Number of Previous children born alive, still living	1.00	1.30	1.10	0.91	1.00	1.45
Number of Previous children born alive, now dead	0.24	0.05	0.19	0.09	0.00	0.30
Number of previous children born dead	1.06	0.50	1.10	0.91	0.73	0.65

Table 7

Share of Hartford's Infant Deaths to Birth by Race and Ethnicity

Race and Ethnicity	Ratio (Percent of Infant Deaths/Percent of Live Births)
Black (Non-Hispanic)	1.15
Hispanic	0.92
White (Non-Hispanic)	1.14

Figure 1. City of Hartford’s Annual Infant Mortality Rate from Birthyears 2010 to 2015.

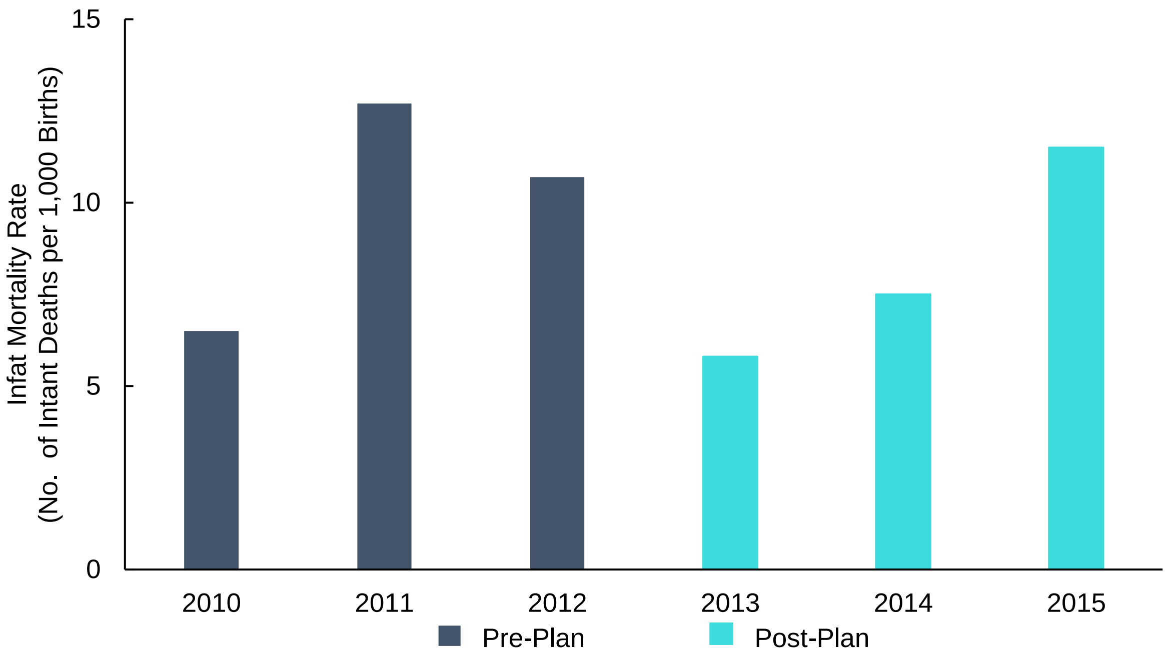


Figure 2. Percent of Annual Preterm Births in Hartford, CT from 2010-2015

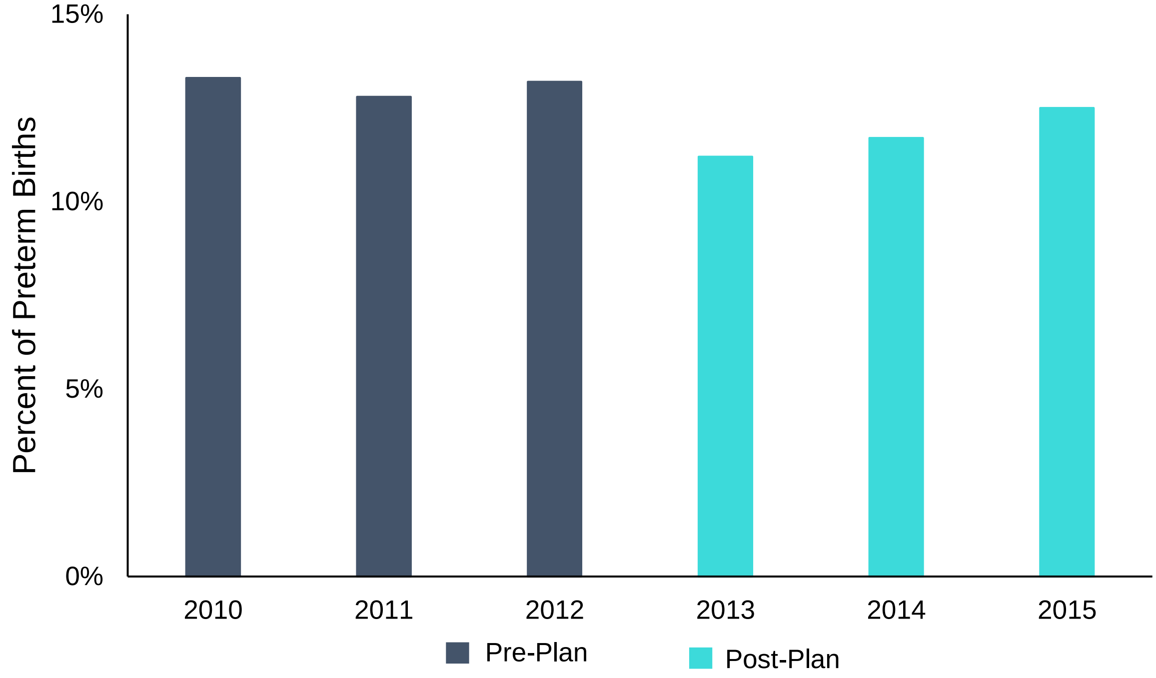


Figure 3. Proportion of Low Birthweight Babies by Birth Year in Hartford, CT

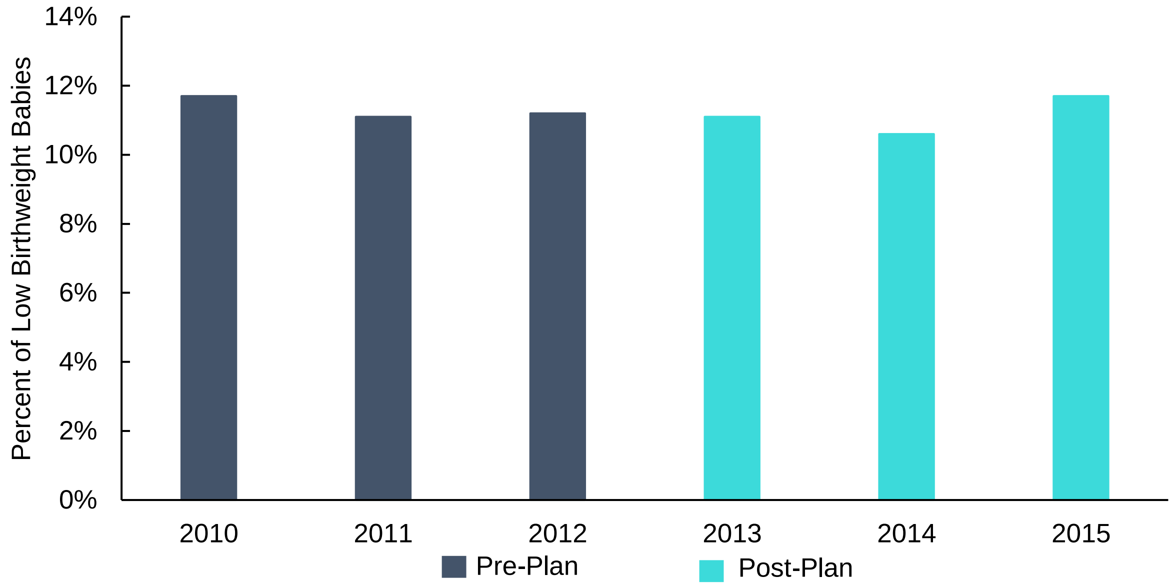
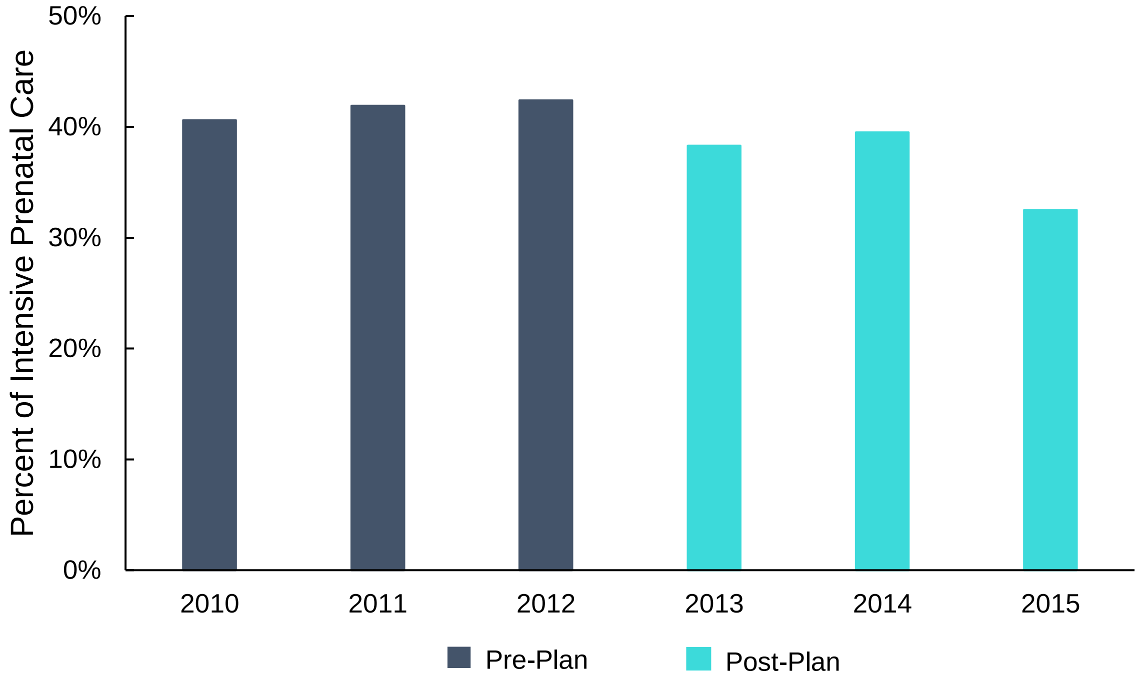


Figure 4. Hartford's Proportion of Mothers Receiving Intensive Prenatal Care Birth Years 2010-2015



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