Perinatal Periods of Risk: A Community Tool for Addressing Fetal and Infant Mortality

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Division of Epidemiology
Deputy Director's Office

Division of Child and Adolescent Health
Bureau of Prevention and Wellness

Metropolitan Public Health Department of Nashville and
Davidson County, Tennessee

March 2003

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Message from the Director of Health

Stephanie B.C. Bailey, MD, MSHSA
Director of Health

Both individuals and the community at large share responsibility for working toward the best possible health status for Davidson County. Information is crucial to that process. The goal of this report is to provide information which can help guide actions toward health improvement in our community.

The Metropolitan Public Health Department (MPHD) of Nashville is spearheading the implementation of a Fetal-infant Mortality Review Committee (FIMR) for Davidson County. In 1994, the Child-Death Review Committee was established by Executive Order. The overall outcome objective is the establishment of systems at the community, institutional, family, and individual level to improve birth outcomes.

This report presents the findings and conclusions from Nashville's two-year involvement with the Perinatal Periods of Risk process. This process has enabled us to look at our local infant mortality data in a new, and more informative manner. Through the guidance of the CityMatCH organization out of the University of Nebraska Medical Center, and support from committed stakeholders like *Tennessee Department of Health, the March of Dimes, Metro General Hospital, Xantus Health Plan*, and other partners, it has been possible to rekindle community energies around the many issues that contribute to fetal and infant mortality and other health disparities.

Fetal mortality is defined as the death of a fetus in utero at 20 weeks or more gestation. It is viewed as an important indicator of overall perinatal wellness. Infant mortality is defined as the death of a child before one year of age. The infant mortality rate is an indicator of social, economic, and community factors as well as medical and health conditions.

The United States infant mortality rate decreased to 7.2 in 1997, approaching the Year 2000 goal of 7 deaths per 1,000 live births. This decrease is attributed to the discovery of new medical treatments, improvements in case management, and protective maternal and family health behaviors. However, this decrease is not uniform across many of the nation's communities. In Nashville, as in other communities across the country, infants born into poor families are twice as likely to die as those born to families above the poverty level. Also, the infant mortality rates for Blacks and Native Americans, as well as some subgroups of Latinos, are higher than the overall rate. The Black rate is at least double the rate for white infants. By working together as a community, these disparities can be eliminated.

Stephanie B.C. Bailey, M.D., M.S.H.S.A.
Director of Health

Executive Summary

Perinatal Periods of Risk (PPOR) is a methodology that allows communities to examine fetal and infant mortality in a new way. Instead of viewing feto-infant mortality as a whole, mortality can be partitioned into four groups, in order to see which groups are most in need of improvement, which intervention types are likely to be most effective, and at what age these interventions should be applied.

This report presents the findings of an intensive examination of feto-infant mortality rates in Nashville using the PPOR methodology. The results can be used to direct intervention efforts where they will do the most good.

The results of this analysis reveal several key issues regarding fetal and infant mortality in Nashville. First, a major contributor to the overall feto-infant mortality rate in Nashville is a high frequency of very low birth weight (VLBW) infants, or infants weighting less than 1,500 grams. Compared to the U.S., Nashville has a high number of infants born each year with birth weights below 1,500 grams. The risk factor information typically collected on Tennessee birth certificates does not provide any clues as to the cause for this high frequency of VLBW in Nashville. Further study will need to be conducted.

Second, in Nashville, younger and less educated women tend to have poorer outcomes than their older and more educated counterparts. Similarly, blacks fare worse in perinatal outcomes than other racial groups in the community. However, developing effective intervention strategies that target women's health issues and prematurity may help reduce feto-infant mortality by 34% overall, and 53% among blacks.

Another key area of infant mortality in Nashville occurs among infants aged 28 to 364 days with birth weights of 1,500 grams or more. Irrespective of race, most of these deaths are caused by Sudden Infant Death Syndrome (SIDS) or injury. Further research into the risk factors associated with either of these causes of death will help guide the formation of interventions.

Acknowledgements

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Introduction

Infant mortality in the early 20th century in the United States was extremely high. It is estimated that 100 infants died for every 1,000 live births, and in some U.S. cities 30% of infants died before reaching the first birthday.[1] As the 20th century progressed, improvements in nutrition, medical care availability and practice, and education helped to reduce infant mortality. Further declines in infant mortality resulted from improved sanitation and living conditions, the development and use of antibiotics, technologic advances in neonatal medicine, and immunization practices for many childhood diseases.[1] By 1999, the infant mortality rate in the U.S. had decreased from 100 to 7.1 deaths per 1,000 live births.[2]

However, examining the overall infant mortality rates only paints half the picture. Although infant mortality rates are generally decreasing nationwide, this reduction is not seen uniformly across all population groups. On the contrary, the past century has seen black infants die at a rate twice as high as the rate for white infants.[1,3] In 1999, for example, the black infant mortality rate in the U.S. was 14.6 deaths per 1,000 live births, compared to the white rate of 5.8.[2] Furthermore, this disparity between infant outcomes for blacks versus whites is increasing with time.[4]

Traditional methods for investigating the causes of infant mortality are failing to address the disparity gap. The purpose of this report is to present the Perinatal Periods of Risk (PPOR) approach as a new tool to evaluate infant mortality. For the duration of this report, usage of the term "Nashville" refers to the entirety of Davidson County.

Chapter 1 will present an assessment of fetal and infant mortality in Nashville in an attempt to define the problem. Information will also be provided on two large contributors to feto-infant mortality, specifically, low birth weight and preterm birth. Frequent comparisons are made between Nashville's rates and the national Healthy People 2010 objectives. The Healthy People 2010 objectives have been established by the Centers for Disease Control and Prevention (CDC) for a wide variety of outcomes and represent health goals for the U.S. to achieve by the year 2010.[5] The information within Chapter 1, along with information on a broad range of other topics, may also be found in the *Healthy Nashville 2002* report, published by the Division of Epidemiology in the Metropolitan Public Health Department of Nashville and Davidson County (MPHD). Chapter 2 will outline and explain the PPOR approach as presented by CityMatCH and the CDC. Chapter 3 will present the results of the PPOR analysis. Chapter 4 will present the recommendations of the PPOR team.

CHAPTER 1
Fetal and Infant Mortality in Nashville

Definitions

Fetal death, also referred to as stillbirth, has been officially defined by the World Health Organization (WHO) as "death prior to the complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of pregnancy; the death is indicated by the fact that after such separation, the fetus does not breathe or show any other evidence of life such as beating of the heart, pulsation of the umbilical cord, or definite movement of voluntary muscles."[6] States, however, differ on the recording requirements for fetal death. Tennessee requires all fetal deaths 500 grams and greater to be recorded. If the birth weight is unknown, then the fetal death must be at least 22 weeks of gestation.[7] The fetal death rate is calculated by dividing the number of fetal deaths in a year by the number of live births plus fetal deaths in that same year and multiplying the quotient by 1,000.[8]

Infant mortality has a much clearer definition. It is defined as the death of a child before his or her first birthday. This indicator is further divided into two categories: neonatal mortality and postneonatal mortality. Neonatal mortality refers to the death of a child aged 0-27 days. Postneonatal mortality refers to the death of a child aged 28-364 days. The infant mortality rate is calculated by dividing the number of infant deaths in a time period by the number of live births in that same time period and multiplying the quotient by 1,000.[8]

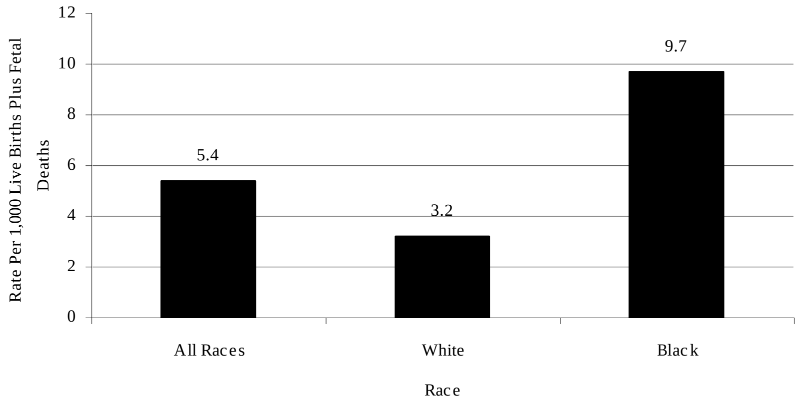
Table 1. Measures of Infant and Fetal Mortality

Measure	Numerator	Denominator	Unit
Infant Mortality Rate	Number of deaths under 1 year of age during a given time interval	Number of live births reported during the same time interval	1,000 live births
Neonatal Mortality Rate	Number of deaths aged 0-28 days during a given time interval	Number of live births reported during the same time interval	1,000 live births
Postneonatal Mortality Rate	Number of deaths aged 28-364 days during a given time interval	Number of live births reported during the same time interval	1,000 live births
Fetal Mortality Rate	Number of fetal deaths during a given time interval	Number of live births plus fetal deaths reported in the same time interval	1,000 live births plus fetal deaths

Fetal Mortality in Nashville

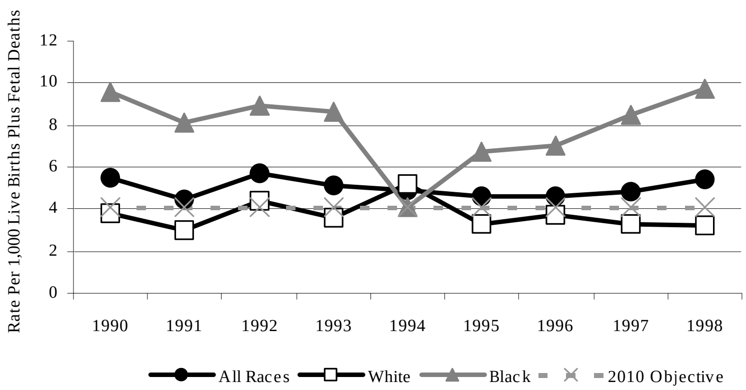
The most recent fetal death data is from 1998. In that year, the mortality rate for all races in Nashville was 5.4 per 1,000 live births plus fetal deaths. There is a very large disparity between blacks and whites. Black fetuses are 3 times more likely to die than white fetuses. In 1998, blacks had a fetal mortality rate of 9.7 deaths per 1,000 live births plus fetal deaths, compared to whites with a fetal mortality rate of 3.2 deaths per 1,000 live births plus fetal deaths (Figure 1).

Figure 1. Fetal Mortality Rates by Race of Mother, Nashville, TN, 1998



The Healthy People 2010 objective (16-1a) is to reduce fetal mortality to 4.1 deaths per 1,000 live births plus fetal deaths (Figure 2). If we examine the trend for fetal mortality rates from 1990 to 1998 in Nashville, it appears that fetal mortality is worsening instead of improving. Since 1994, the disparity between blacks and whites appears to be getting larger, and the rate of fetal deaths for blacks is increasing. White rates have been consistently lower than the 2010 objective since 1995 and demonstrate no signs of increasing above the objective.

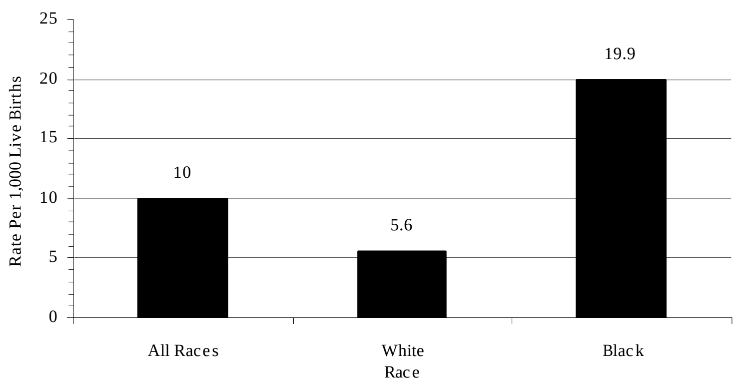
Figure 2. Fetal Mortality Rates by Race Compared to the Healthy People 2010 Objective, Nashville, TN , 1990-1998



Infant Mortality in Nashville

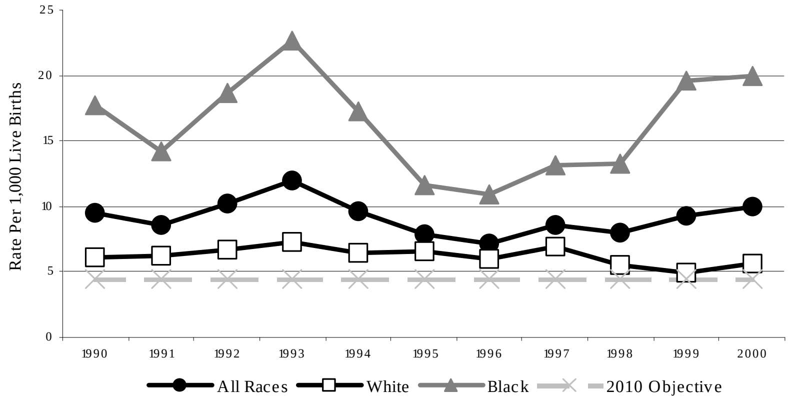
In the year 2000, the infant mortality rate for Nashville was 10 per 1,000 live births. When examined by race, a rather large disparity between the rates for blacks and whites appears. Black babies died at the rate of 19.9 per 1,000 live births, while white babies died at the rate of 5.6 per 1,000 live births (Figure 3). This means that black babies born in Nashville were 3.6 times more likely to die than white babies.

Figure 3. Infant Mortality Rates by Race of Mother, Nashville, TN, 2000



The Healthy People 2010 objective (16-1c) is to reduce infant mortality to 4.5 deaths per 1,000. Examining infant mortality rates through the past decade, as depicted in Figure 4, indicates that rates in Nashville are not improving. Infant mortality rates for all races are greater than the 2010 goal. Blacks have had the highest rate of infant mortality during the past decade, while whites have consistently had the lowest infant mortality rates. White infant mortality rates appear to be stable at approximately 6 deaths per 1,000 live births, but the rates for blacks appear to have great variability.

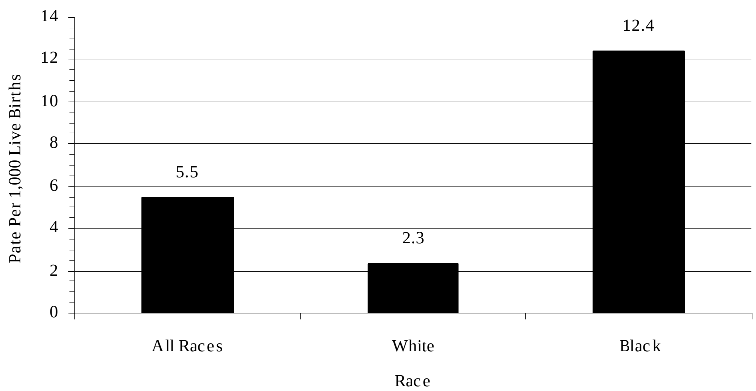
Figure 4. Infant Mortality Rates by Race of Mother Compared to the Healthy People 2010 Objective, Nashville, TN, 1990-2000



Neonatal Mortality in Nashville

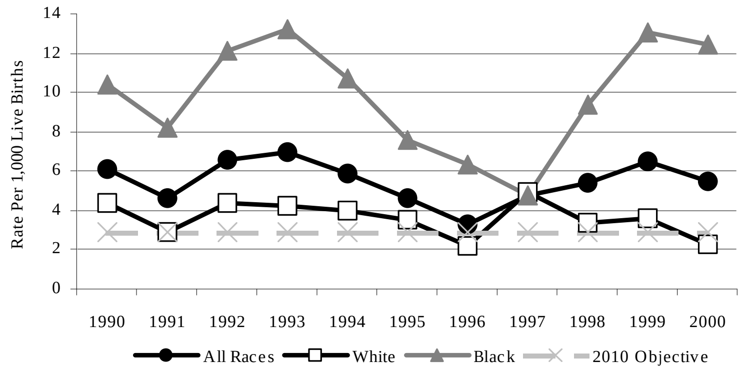
As mentioned previously, infant mortality is composed of two parts – neonatal mortality and postneonatal mortality. Neonatal mortality refers to the death of children aged 27 days and less. In 2000, Nashville had a neonatal mortality rate of 5.5 per 1,000 live births. White neonates died at the rate of 2.3 per 1,000 live births while neonatal black babies died at the rate of 12.4 per 1,000 (Figure 5). Black neonates were 5.4 times more likely to die than white neonates.

Figure 5. Neonatal Mortality Rates by Race of Mother, Nashville, TN, 2000



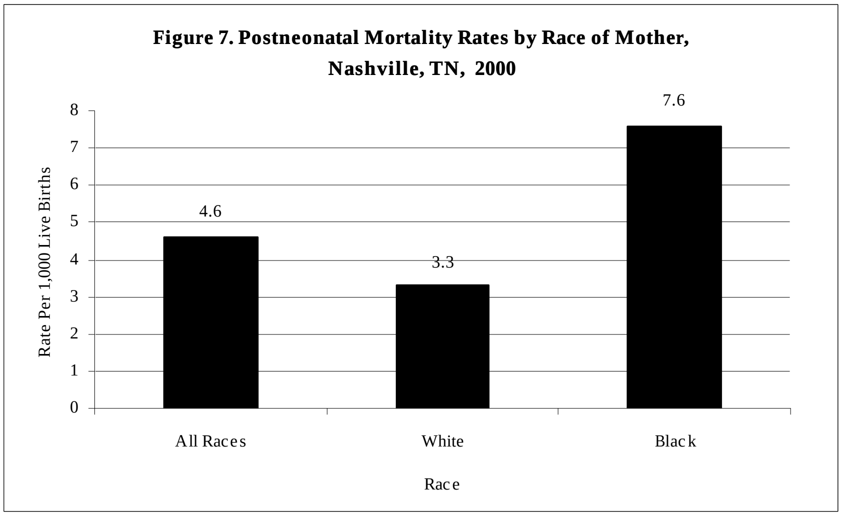
Healthy People 2010 Objective (16-1d) is to reduce the neonatal mortality rate to 2.9 deaths per 1,000 live births. Examining neonatal mortality rates through the past decade, in comparison to the Healthy People 2010 Objective, reveals that white neonates achieved the goal in the year 2000. It is unknown if the white neonatal mortality rates will remain below the goal. Blacks have the highest rates of neonatal mortality, while whites have the lowest. In general, the neonatal mortality rates for Nashville are twice as high as the 2010 objective; black neonatal mortality rates are nearly 4 times higher than the objective (Figure 6).

Figure 6. Neonatal Mortality Rates by Race of Mother Compared to the Healthy People 2010 Objective, Nashville, TN, 1990-2000



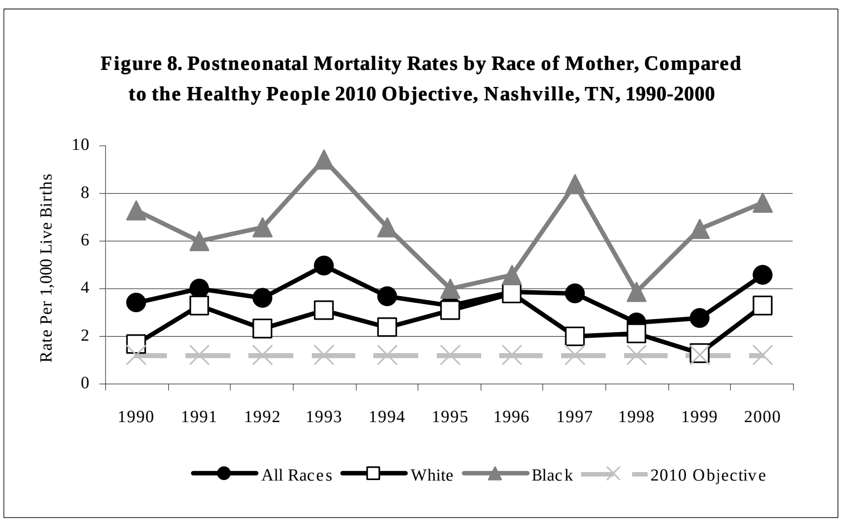
Postneonatal Mortality in Nashville

Postneonatal mortality is defined as deaths occurring to children between 28 and 364 days old. For all races combined, Nashville had a postneonatal mortality rate of 4.6 deaths per 1,000 live births. Once again, the disparity between whites and blacks is plainly visible. White postneonates died at the rate of 3.3 per 1,000 live births during 2000, while black postneonates died at the rate of 7.6 per 1,000 live births (Figure 7). Black postneonates were approximately twice as likely to die than white postneonates.



The Healthy People 2010 Objective (16-1e) is to reduce the postneonatal mortality rate to 1.2 deaths per 1,000 live births. Examining postneonatal mortality rates through the past decade, in comparison to the Healthy People 2010 Objective, reveals that no group in Nashville has met this goal (Figure 8). Overall, in 2000, Nashville's rate was approximately 4 times higher than the objective. The rate for whites is nearly 3 times higher than the objective, and the rate for blacks is approximately 6 times higher than the 2010 objective.

The trend for postneonatal deaths is similar to the trend for infant mortality. The relative ranking indicates that black postneonates are more likely to die than white postneonates, and whites consistently have the lowest postneonatal mortality rates in Nashville. Since 1999, the postneonatal mortality rate has been increasing for all groups.

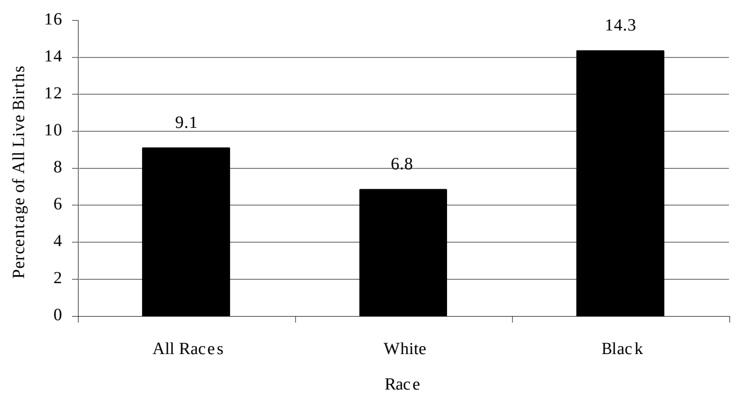


Low Birth Weight

Low birth weight is defined as a weight at birth of less than 2,500 grams. Birth weight has a strong association with both mortality and morbidity. Research indicates a death during the neonatal period is nearly 40 times more likely to occur among low birth weight infants than infants of normal weight.[9] Additionally, children born at low birth weight are at an increased risk of general morbidity and other disorders such as severe mental retardation and neurological problems.[9]

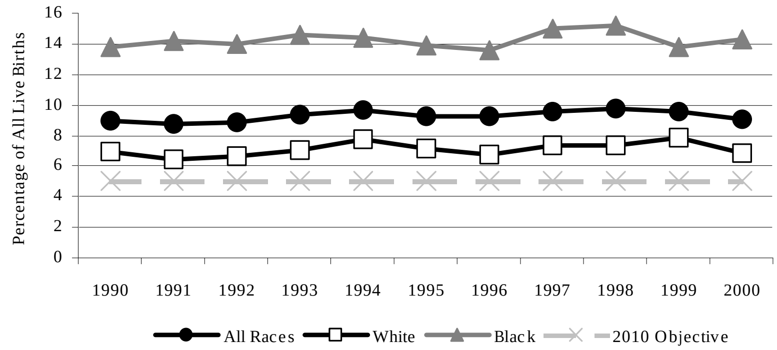
In Nashville, 9.1% of all live births during the year 2000 weighed less than 2,500 grams. When stratified by race, 14.3% of blacks born that year were low birth weight compared to 6.8% of whites (Figure 9).

Figure 9. Percentage of All Live Births Born Low Birth Weight by Race of Mother, Nashville, TN, 2000



Nationally, there has been little change in the proportion of low birth weight babies over the past few decades.[9] The disparity between whites and blacks has remained fairly steady during the past decade, and Nashville's trend mimics the national trend. The percentage of black babies born less than 2,500 grams hovers between 14 and 15 percent. For whites, the proportion is smaller with only 6 to 8 percent of babies being born low birth weight. Overall, between 8 and 10 percent of births in Nashville each year weigh less than 2,500 grams. The Healthy People 2010 Objective (Objective 16-10a) for this indicator is to reduce the percentage of births weighing less than 2,500 grams to 5%. As indicated in Figure 10, there is much work needed in Nashville to achieve that goal by 2010.

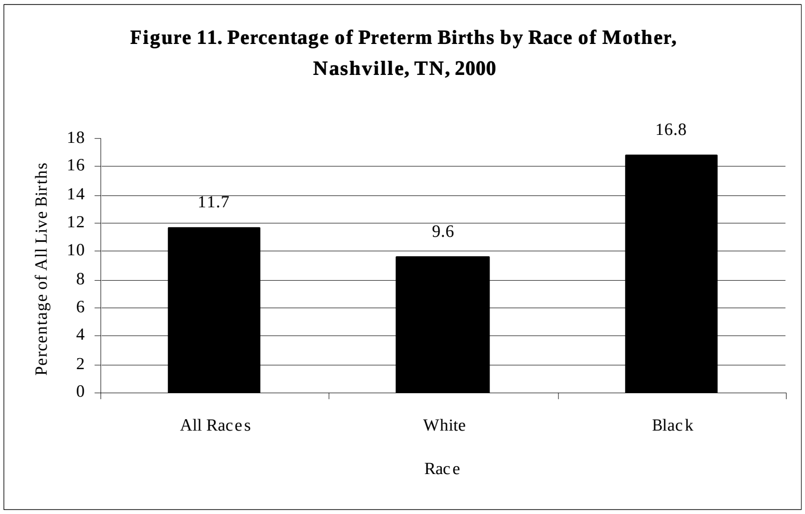
Figure 10. Percentage of All Live Births Born Low Birth Weight by Race of Mother, Compared to the Healthy People 2010 Objective, Nashville, TN, 1990-2000



Preterm Birth

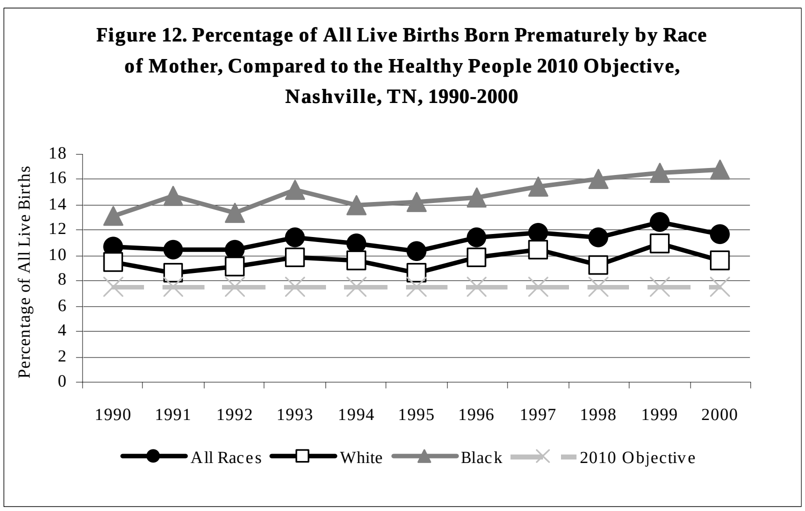
Preterm delivery is defined as the termination of pregnancy before the completion of the 37th week of gestation. Preterm birth is a major cause of low birth weight, and combined with low birth weight, is a predominant cause of infant mortality and morbidity.[10] The overall rate of preterm births is gradually increasing nationwide. Research indicates that from 1989 through 1996, there was a 4 percent increase in preterm delivery rates.[11] This phenomenon seems to be evident in industrialized nations around the world.[11] Although the exact causes of preterm birth are unknown, risk factors for preterm birth include low socioeconomic status, previous preterm delivery, smoking, and inadequate weight gain during pregnancy.

During the year 2000, 11.7% of babies born in Nashville were premature. When examined by race, 9.6% of white babies born that year were premature compared to 16.8% of black babies (Figure 11).



During the 1990's, in the U.S. the number of preterm deliveries increased among whites by 8%, and the number for blacks decreased by 10%.[11] Nashville does not mimic the national data. Blacks have the highest percentage of preterm births, and since 1990, that percentage has increased 28%. The percentage of preterm births has also been increasing for whites since 1990, but the degree of increase is considerably less than that for blacks.

The Healthy People 2010 objective (Objective 16-11a) is to reduce the percentage of preterm births to 7.6 percent. As is clearly indicated in Figure 12, Nashville falls short of this goal on all accounts. Overall, Nashville must reduce preterm birth by 35% to reach the Healthy People 2010 goal. Whites exceed the goal by nearly 21%, and blacks exceed the goal by nearly 55%.



CHAPTER 2
Perinatal Periods of Risk (PPOR)

The Initiative

Originally developed by Dr. Brian McCarthy from the Centers for Disease Control and Prevention (CDC) with collaborators from the World Health Organization (WHO), the PPOR approach has been used for decades in developing countries to address infant mortality. In 1997, CityMatCH partnered with CDC, the March of Dimes, and several major urban cities to validate, enhance, and adapt this approach for use in U.S. cities.

Examining infant mortality in U.S. cities revealed four primary factors that the PPOR approach could help address. First, there is no simple, widely accepted approach for communities to examine infant mortality. The lack of a standard approach leaves communities in the position of either developing their own methods, or utilizing the information provided to them from other sources. Second, most approaches focus on infant mortality as a whole, and as such, do not identify potential gaps in the community where further reductions in infant mortality may be possible. Third, current approaches do not directly lead a community to appropriate actions such as targeted investigations and preventative activities. Fourth, infant mortality approaches are not easily communicated to the community, inhibiting the ability of the community to mobilize for action.

In the year 2000, CityMatCH, along with its partners, launched the National Perinatal Periods of Risk Practice Collaborative and provided the materials detailing the approach in order to generate effective, evidence-based PPOR practice in U.S. cities. (Additional information and materials may be obtained through the CityMatCH website: www.citymatch.org.) Nashville has been an active part of the practice collaborative since November 2000. The objectives of the collaborative are as follows:

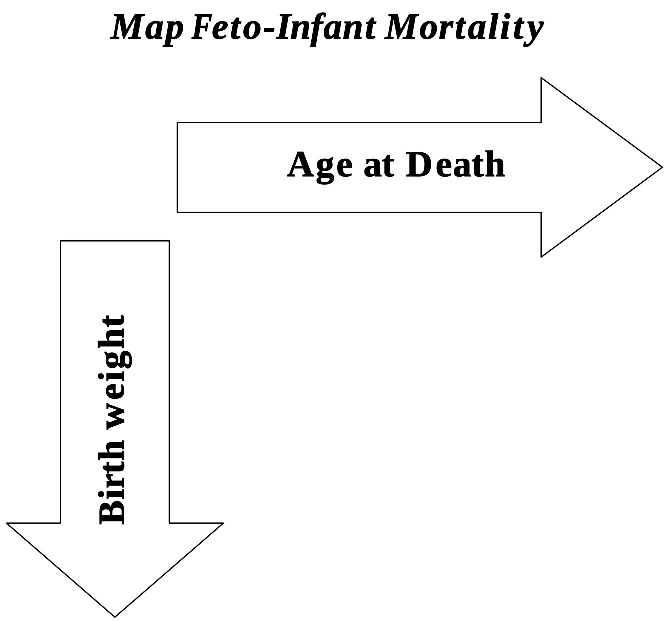
1. Develop the PPOR approach as a community tool to improve the health of women and infants;
2. Describe and encourage best practices in using PPOR as a community tool;
3. Develop easy-to-use materials and services to support communities interested in using PPOR;
4. Assure strategic linkage of the PPOR approach with related existing efforts.

The Approach

The PPOR approach is a multi-disciplinary process aimed at empowering communities to mobilize and prioritize prevention efforts. The approach itself can be divided into two different components: community engagement and data analysis. This report will focus on the data analysis component.

PPOR analysis begins with the creation of a feto-infant mortality map. As shown in Figure 13, the feto-infant mortality map consists of two dimensions: age at death and birth weight.

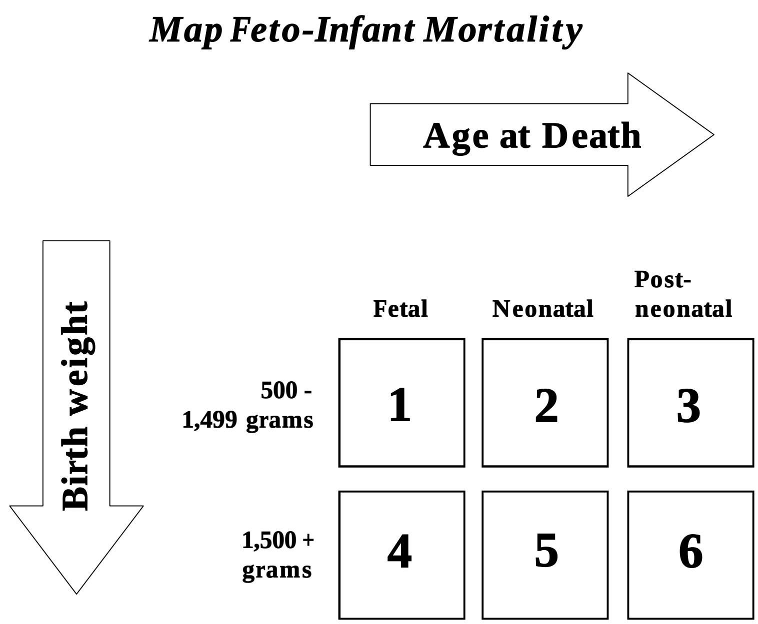
Figure 13. PPOR Two-dimensional Framework



Age at death is a universally accepted indicator for examining infant mortality. There is a tremendous amount of growth and development that occurs throughout pregnancy and after birth, and such development usually follows a predictable pattern. Risk factors acting upon the developmental process at specific time intervals can yield predictable adverse outcomes. From observations such as these, neonatal and postneonatal age groupings were defined and came into common usage within the Maternal and Child Health (MCH) community.[12] Such groupings not only improved scientific understanding, but also labeled windows of opportunity for intervention.[12]

Birth weight is recognized as the strongest predictor of survival. Put simply, small babies have a higher risk of mortality than babies of normal weight. It has been estimated, for example, that a neonate less than 2,500 grams is 40 times more likely to die than a neonate 2,500 grams or more. The risk increases to 200 times greater for neonates born less than 1,500 grams.[9]

Figure 14. PPOR Feto-infant Mortality Map



As illustrated in Figure 14, combining age at death and birth weight yields the two dimensional map of feto-infant mortality. The three categories for age at death are fetal, neonatal, and postneonatal. Birth weight is divided into two categories: less than 1,500 grams, referred to as very low birth weight (VLBW), and 1,500 grams or more, referred to as higher birth weight (HBW). The end result is a 2 by 3 matrix of 6 cells. Deaths are then partitioned into the correct cell.

However, not all infant and fetal deaths are included within the matrix. It is important to note which adverse pregnancy events are not included in the PPOR feto-infant mortality map in order to understand the limitations of the PPOR approach. First, all fetal deaths under 24 weeks gestational age are excluded. This criteria allows the inclusion of some early fetal deaths (20-27 weeks gestational age), but also limits any bias associated with issues of data quality inherent in the process of classifying and reporting fetal deaths.

One of the primary data quality issues with fetal death data is the lack of standardization. Although the National Center for Health Statistics (NCHS) assesses fetal deaths at 20 weeks gestational age and greater, individual states may have different reporting requirements.[13] Tennessee, for example, requires all fetal deaths greater than or equal to 22 weeks of gestation to be reported.[7]

In addition to differing reporting requirements, there is considerable evidence of underreporting. Not all fetal deaths that meet reporting requirements are actually reported.[13] It has been shown that there is an inverse relationship between gestational age and the likelihood of being reported. Fetal deaths that occur at younger gestational ages are less likely to be reported; therefore, underreporting most likely occurs among the youngest fetal deaths of the required reporting period for each state.[13]

The PPOR approach also excludes fetal deaths and live births less than 500 grams. Although this may exclude many reported fetal and infant deaths, infants less than 500 grams are generally considered only marginally viable.[9] As such, any information gained from the examination of these infants may not be useful in crafting interventions aimed at reducing mortality.

Two other important groups of adverse reproductive events are excluded from the analysis: spontaneous and induced abortions. Spontaneous abortions are not routinely reported through vital records systems and are difficult to measure. Legally induced abortions account for a significantly large group of pregnancy terminations. The CDC estimated that in the U.S. there were 264 abortions per 1,000 live births during 1998.[14] Together, spontaneous abortions and induced abortions clearly outnumber the reported fetal and infant deaths included in the six-cell approach.

As we have seen in Figure 14, the PPOR approach uses age at death and two levels of birth weight to form a matrix of 6 cells. These six cells are then clustered into four primary groupings, as illustrated in Figure 15. First, the 500 to 1,499 gram fetal, neonatal, and postneonatal deaths become one group. The HBW cells form the three remaining groups. Each of these four groups is given a label that suggests the primary preventive direction for the deaths in that group. For example, VLBW related deaths could best be prevented by addressing maternal health issues and preventing and treating prematurity. For HBW related deaths, fetal deaths can best be prevented by providing maternal care; neonatal deaths by providing newborn care; and postneonatal deaths by improving infant health.

The category labels were designed to suggest preventative action (Figure 16). For maternal health and prematurity, prevention may focus on preconceptional health, unintended pregnancy, smoking, and drug abuse. Issues related to maternal care may need a preventative focus on early and continuous prenatal care, referral of high-risk pregnancies, and good medical management of underlying conditions. For newborn care, the focus may be on advanced neonatal care and the treatment of congenital anomalies. Lastly, to address infant health issues, communities may need to focus on Sudden Infant Death Syndrome (SIDS) prevention activities such as sleep position education, or injury prevention.

Before a community undertakes the PPOR analysis, it must ensure access to the proper data. Application of the PPOR framework requires access to vital records information. Specifically, it requires a linked birth and infant death certificate file as well as a fetal death file. Additionally, this approach requires at least 60 feto-infant deaths be present among the four feto-infant mortality groups, and that the information on those 60 deaths be of a high quality. With fewer deaths, the group rates become unstable and cannot be used as reliable estimates. For this reason, it may be necessary to obtain data from multiple years.

Once the data has been obtained and assessed for completeness, cell and group specific rates can be calculated (Figure 17). The actual calculation is simple and straightforward. The rate is the number of feto-infant deaths in a cell or group divided

Figure 15. Final PPOR Feto-infant Mortality Map

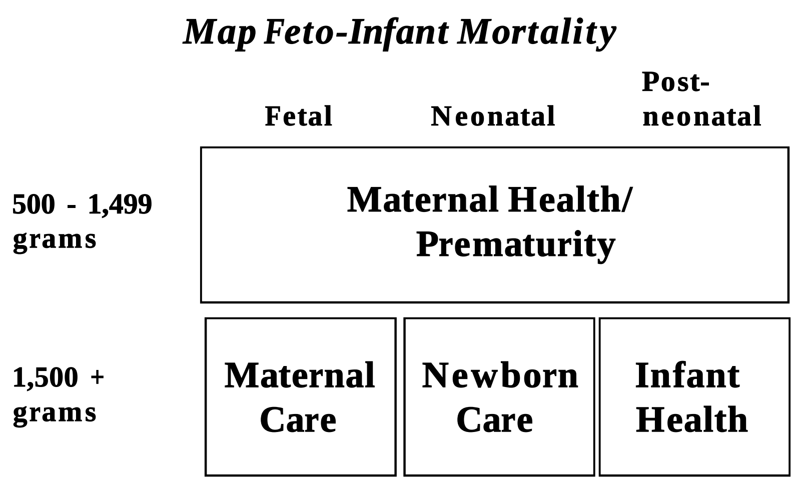
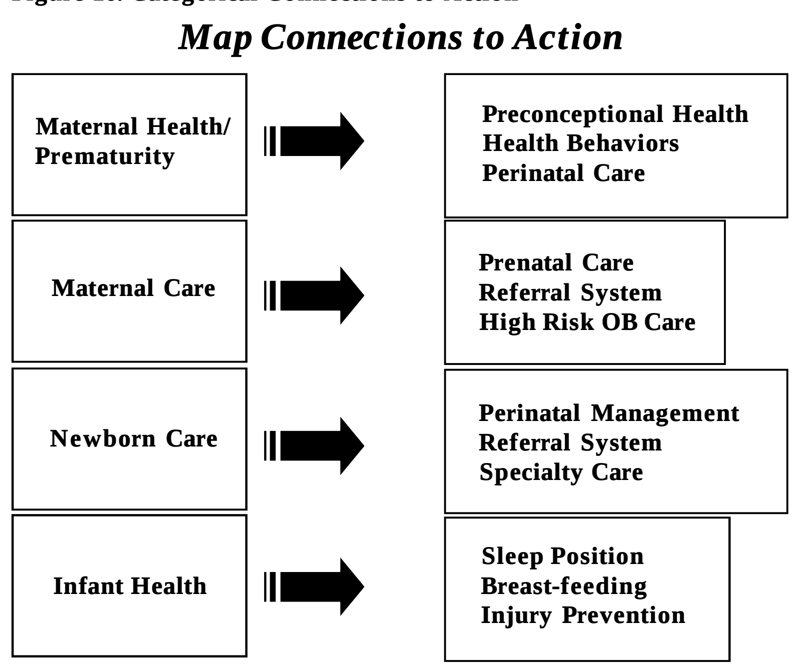


Figure 16. Categorical Connections to Action



by the total number of all live births and fetal deaths that meet the inclusion criteria. Each rate has the same denominator so the rates can be directly added together to equal the overall feto-infant mortality rate.

Figure 17. Formulas for Cell or Group-specific Mortality Rates

Focus on Overall Mortality

Cell- or Group-specific Mortality Rates

$$\frac{\textbf{Number of deaths in cell}}{\textbf{Number of live births \& fetal deaths}} \quad \textbf{Cell-specific Mortality Rate}$$

$$\frac{\textbf{Number of deaths in a group}}{\textbf{Number of live births \& fetal deaths}} \quad \textbf{Group-specific Mortality Rates}$$

Since all calculated rates use the same denominator, a group-specific mortality rate, such as infant health, for example, is a direct reflection of the contribution that group makes to the overall rate. This allows communities to tailor interventions that appropriately reflect their own needs.

However, the usefulness of this tool is not limited to a single analysis. Feto-infant mortality maps can be constructed to examine change over time, as well as provide comparisons across a variety of sub groups. Comparisons of feto-infant mortality can be made across maternal race and ethnic groups, maternal age and education groups, geographical location, and health care payment sources to name but a few.

The PPOR feto-infant mortality map may also be used as a tool to identify opportunity gaps between population groups. By identifying a reference group with good mortality rates, excess mortality can then be calculated, and the potential for mortality reduction can then be estimated.

Reference groups can either be internal, meaning a sub population within the community itself, or external such as state or national rates. There are benefits to both choices. An internal reference group suggests that it is both possible and desirable for any population group within the community to reach a lower level of adverse pregnancy outcomes. An external reference group holds all communities to the same standard and allows for ready comparisons across different cities.

As seen thus far, PPOR is a simple population-based approach to examine the distribution of fetal and infant deaths by birth weight and age at death. Areas where improvement in mortality rates is possible can be identified and appropriate interventions crafted. Chapter three presents the results of the PPOR analysis in Nashville.

CHAPTER 3
PPOR Analysis in Nashville

Phase I Analysis

Background

Nashville has been an active member of the PPOR practice collaborative since November 2000. As part of the collaborative, the PPOR approach has been applied to Nashville data. It is hoped that the results of this analysis will provide further insight into the problem of feto-infant mortality within Nashville.

Methods

The PPOR analysis was conducted on fetal death files and linked birth and death certificate files from 1995-1997 provided by the Tennessee Department of Health (TDH). It was decided to use multiple years of data in order to create reliable mortality estimates for the feto-infant mortality map. All analyses for both Phase I and II were performed using the SAS system.

The separate fetal death files were combined into one data set, and all fetal analysis was conducted on this single data set. Birth weight for most of the fetal deaths was recorded in pounds and ounces. Before analysis of the data set could begin, pounds and ounces were converted to grams. Any fetal deaths less than 24 weeks gestational age or less than 500 grams were excluded from the analysis. If birth weight was missing, a birth weight category was assigned by imputation based on the gestational age. If both birth weight and gestational age were missing, the record was excluded from the analysis. Similarly, the multiple linked birth-death files were also combined into one data set. Any birth less than 500 grams was excluded from the analysis. Frequencies were then calculated to partition the numbers and mortality rates according to the PPOR feto-infant mortality categories.

Through the analytic process, it was determined that there were not enough deaths in the Hispanic or other races categories to construct feto-infant mortality maps for these population groups for the years under study. In order to compensate for the small number of deaths in racial categories other than white or black, a white versus non-white comparison was conducted in the preliminary stages of Phase I analysis.

After the creation of both overall and stratified feto-infant mortality maps, comparisons were made to two different reference groups - one internal to the population under study, and one external. The internal reference group consists of Nashville white women 20 years of age or older with 13 years of education or more during 1995-1997. The external reference group consists of U.S. white, non-Hispanic women 20 years of age or older with 13 years of education or more during those same years. Excess mortality between Nashville and each reference group was then calculated by subtracting the numbers and rates of the reference group from the corresponding cells of the population under consideration.

Results

There were 116 fetal deaths reported in Nashville during 1995-1997. Sixteen records did not meet the gestational age inclusion criteria. Imputation based on gestational age was performed on 4 records with missing birth weight. The results indicated that all 4 were less than 500 grams, and were therefore excluded. Thus, a total of 96 fetal deaths were included in the PPOR analysis. Among the 24,766 records in the linked birth and death certificate file, a total of 26 records did not meet inclusion criteria, leaving a total of 24,740 records in the analysis. Of those 24,740 live births, there were 147 infant deaths that met inclusion criteria. Descriptive characteristics of the population are shown in Table 2.

Table 2. Descriptive Characteristics of the Fetal Death and Live Birth Populations, Nashville, TN, 1995-1997

	Fetal Deaths		Live Births		Infant Deaths	
Characteristic	**N**	**%**	**N**	**%**	**N**	**%**
Total Records	116		24,766		147	
Maternal age group:						
< 20 years of age	21	18.1	3,638	14.7	27	18.4
> 34 years of age	18	15.5	2,672	10.8	9	6.1
Unknown age	2	1.7	0	0	0	0
Maternal education						
< 13 years of education	62	53.4	13,134	53	102	69.4
>=13 years of education	33	28.4	11,572	46.7	42	28.6
Unknown education	21	18.1	60	0.25	3	2
Maternal Race						
White	56	48.2	16,413	66.3	85	57.8
Black	56	48.2	7,386	29.8	60	40.8
Other	2	1.7	961	3.9	2	1.4
Unknown Race	2	1.7	6	0.02	0	0
Maternal Ethnicity						
Hispanic	5	4.3	948	3.8	3	2
Unknown Ethnicity	3	2.6	6	0.02	1	0.7
Missing information						
Birth weight	4	3.4	6	0.02	1	0.7
Gestational age	3	2.6	412	1.7	0	0

Among fetal deaths, 18.1% of mothers were under the age of 20, and 53.4% had less than 13 years of education. The maternal racial distribution was equally split between whites and blacks with 48.2% falling into each category. Mothers of other racial categories were in the extreme minority with only a 1.7% representation. Similarly, only 4.3% of the maternal population under consideration was Hispanic.

Among live births, 14.7% of mothers were under the age of 20, and 53% had less than 13 years of education. The maternal racial distribution was 66.3% white and 29.8% black. Mothers of other racial categories represented 3.9% of the maternal population. Similarly, only 3.8% of the maternal population under consideration was Hispanic.

Among infant deaths, 18.4% of mothers were under the age of 20, and 69.4% had less than 13 years of education. The maternal racial distribution was 57.8% white and 40.8% black. Mothers of other racial categories represented 1.4% of the maternal population. Similarly, only 2.0% of the maternal population under consideration was Hispanic.

Comparing the percentage of missing information reveals that fetal death data is the least complete. For example, 18.1% of fetal death records do not record maternal education compared to .25% of live births, and 2.0% of infant deaths. Additionally, fetal death data has the highest percentage of missing birth weight and gestational age data, 3.4% and 2.6% respectively.

Figures 18 and 19 present the number of deaths and the mortality rates per 1,000 live births and fetal deaths for Nashville during 1995-1997. During those years, there were a total of 243 feto-infant deaths. Of those 243 deaths, 91 were VLBW and fall into the Maternal Health and Prematurity category, 52 into Maternal Care, 25 into Newborn Care, and 75 into Infant Health. The corresponding mortality rates are 3.7 for Maternal Health and Prematurity, 2.1 for Maternal Care, 1.0 for Newborn Care, and 3.0 for Infant Health. Judging from this initial analysis, Maternal Health and Prematurity and Infant Health are the categories that contribute the most to the overall mortality rate (9.8).

Figure 18. Feto-infant Mortality Map: Number of Deaths for All Races, Nashville, TN, 1995-1997

	Fetal	**Neonatal**	**Postneonatal**
500-1,499g VLBW		**Maternal Health/Prematurity 91**	
1,500+g HBW	**Maternal Care 52**	**Newborn Care 25**	**Infant Health 75**

Total Feto-infant deaths: 243

Total Fetal Deaths and Live Births: 24,836

Figure 19. Feto-infant Mortality Map: Mortality Rates per 1,000 Fetal Deaths plus Live Births for All Races, Nashville, TN, 1995-1997

	Fetal	Neonatal	Postneonatal
500-1,499g VLBW	**Maternal Health/Prematurity 3.7**		
1,500+g HBW	**Maternal Care 2.1**	**Newborn Care 1.0**	**Infant Health 3.0**

Total Feto-infant deaths: 243
Total Fetal Deaths and Live Births: 24,836
Total Feto-infant mortality rate: 9.8

Examining mortality by race produces the feto-infant mortality maps depicted in Figures 20-22. Blacks have the highest overall mortality rate of 14.0 per 1,000 live births and fetal deaths, compared to 8.1 for whites and 12.9 for non-whites. By category, Maternal Health and Prematurity and Infant Health continue to be the largest contributors to mortality across racial categories. Blacks have the highest rates with a mortality rate of 6.1 for Maternal Health and Prematurity and 3.8 for the Infant Health category. Non-whites display the same pattern with a 5.6 for Maternal Health and Prematurity and a 3.6 for Infant Health. Whites have the same feto-infant mortality rate of 2.7 for both categories.

Figure 20. Feto-infant Mortality Map: Number of Deaths and Mortality Rates per 1,000 Fetal Deaths plus Live Births, Whites, Nashville, TN, 1995-1997

	Fetal	Neonatal	Postneonatal
500-1,499g VLBW	**Maternal Health/Prematurity 44 deaths 2.7**		
1,500+g HBW	**Maternal Care 28 deaths 1.7**	**Newborn Care 17 deaths 1.0**	**Infant Health 45 deaths 2.7**

Total Feto-infant deaths: 134
Total Fetal Deaths and Live Births: 16,462
Total Feto-infant mortality rate: 8.1

Figure 21. Feto-infant Mortality Map: Number of Deaths and Mortality Rates per 1,000 Fetal Deaths plus Live Births, Non-whites, Nashville, TN, 1995-1997

	Fetal	Neonatal	Postneonatal
500-1,499g VLBW	**Maternal Health/Prematurity 47 deaths 5.6**		
1,500+g HBW	**Maternal Care 23 deaths 2.7**	**Newborn Care 8 deaths 1.0**	**Infant Health 30 deaths 3.6**

Total Feto-infant deaths: 108
Total Fetal Deaths and Live Births: 8,393
Total Feto-infant mortality rate: 12.9

Figure 22. Feto-infant Mortality Map: Number of Deaths and Mortality Rates per 1,000 Fetal Deaths plus Live Births, Blacks, Nashville, TN, 1995-1997

	Fetal	Neonatal	Postneonatal
500-1,499g VLBW	**Maternal Health/Prematurity 45 deaths 6.1**		
1,500+g HBW	**Maternal Care 23 deaths 3.1**	**Newborn Care 8 deaths 1.1**	**Infant Health 28 deaths 3.8**

Total Feto-infant deaths: 104
Total Fetal Deaths and Live Births: 7,430
Total Feto-infant mortality rate: 14.0

Stratification was also performed on maternal age. The resulting tables are depicted in Figures 23 and 24. Comparing mothers less than age 20 to mothers aged 20 and older yields the same theme seen in the overall table. Maternal Health and Prematurity and Infant Health are the two categories that contribute the most deaths to the overall mortality rate. Mothers less than 20 have a feto-infant mortality rate of 12.9 compared to a rate of 9.3 among those 20 and older. Similarly, the cell-specific rates for the Maternal Health and Prematurity category are also higher for mothers less than 20 years of age compared to those aged 20 and older, 6.3 and 3.2 respectively. Infant Health mortality rates, however, are the same for both groupings (3.0). It is important to note that the map for mothers less than 20 years old contains 47 deaths. This number is smaller than the 60 deaths required for stable estimates according to the PPOR approach; therefore, the resultant rates for this age category may be unstable.

Figure 23. Feto-infant Mortality Map: Number of Deaths and Mortality Rates per 1,000 Fetal Deaths plus Live Births, Maternal Age <20, Nashville, TN, 1995-1997

	Fetal	Neonatal	Postneonatal
500-1,499g VLBW		**Maternal Health/Prematurity 23 deaths 6.3**	
1,500+g HBW	**Maternal Care 9 deaths 2.5**	**Newborn Care 4 deaths 1.1**	**Infant Health 11 deaths 3.0**

Total Feto-infant deaths: 47
Total Fetal Deaths and Live Births: 3,655
Total Feto-infant mortality rate: 12.9

Figure 24. Feto-infant Mortality Map: Number of Deaths and Mortality Rates per 1,000 Fetal Deaths plus Live Births, Maternal Age >=20, Nashville, TN, 1995-1997

	Fetal	Neonatal	Postneonatal
500-1,499g VLBW		**Maternal Health/Prematurity 68 deaths 3.2**	
1,500+g HBW	**Maternal Care 43 deaths 2.0**	**Newborn Care 21 deaths 1.0**	**Infant Health 64 deaths 3.0**

Total Feto-infant deaths: 196
Total Fetal Deaths and Live Births: 21,181
Total Feto-infant mortality rate: 9.3

In order to account for maternal education, the feto-infant mortality map was stratified on a combined variable of maternal age and education. A distinction is made between mothers aged 20 and older with less than 13 years of education and mothers aged 20 and older with 13 years of education or more. The resultant feto-infant mortality maps are depicted in Figures 25 and 26. Total mortality is less among women with 13 or more years of education (7.6) than women with less than 13 years of education (11.3).

Those with 13 years of education or more have better outcomes than those with less than 13 years of education in both Maternal Health and Prematurity and Infant Health categories. Examining the cell-specific rates for the Maternal Health and Prematurity grouping, those with 13 years of education or more have a mortality rate of 2.8 compared to a rate of 3.7 for mothers with less than 13 years of education. Similarly, women with more education have a rate of 1.9 in the Infant Health category compared to 4.3 among women with less education. It is interesting that among women with less education, Infant Health deaths contribute more to the overall feto-infant mortality rate than Maternal Health and Prematurity deaths.

Figure 25. Feto-infant Mortality Map: Number of Deaths and Mortality Rates per 1,000 Fetal Deaths plus Live Births, Maternal Age >=20 and Education <13 Years, Nashville, TN, 1995-1997

	Fetal	Neonatal	Postneonatal
500-1,499g VLBW	**Maternal Health/Prematurity 36 deaths 3.7**		
1,500+g HBW	**Maternal Care 20 deaths 2.1**	**Newborn Care 11 deaths 1.1**	**Infant Health 42 deaths 4.3**

Total Feto-infant deaths: 109
Total Fetal Deaths and Live Births: 9,658
Total Feto-infant mortality rate: 11.3

Figure 26. Feto-infant Mortality Map: Number of Deaths and Mortality Rates per 1,000 Fetal Deaths plus Live Births, Maternal Age >=20 and Education >=13 Years, Nashville, TN, 1995-1997

	Fetal	Neonatal	Postneonatal
500-1,499g VLBW	**Maternal Health/Prematurity 32 deaths 2.8**		
1,500+g HBW	**Maternal Care 23 deaths 2.0**	**Newborn Care 10 deaths 0.9**	**Infant Health 22 deaths 1.9**

Total Feto-infant deaths: 87
Total Fetal Deaths and Live Births: 11,523
Total Feto-infant mortality rate: 7.6

A summary of the mortality rates from the feto-infant mortality maps created thus far is provided in Table 3. A cursory glance clearly indicates that Maternal Health and Prematurity and Infant Health are the primary contributing categories to feto-infant mortality in Nashville. Black rates are higher than white rates, and older women with some college education have better rates than younger or less educated women.

Table 3. Feto-infant Mortality Rates per 1,000 Live Births and Fetal Deaths by Maternal Age, Race, and Education Groups, Nashville, TN, 1995-1997

Group	Maternal Health	Maternal Care	Newborn Care	Infant Health	Total Rate
All	3.7	2.1	1	3	9.8
White	2.7	1.7	1	2.7	8.1
Non-white	5.6	2.7	1	3.6	12.9
Black	6.1	3.1	1.1	3.8	14
< 20 years	6.3	2.5	1.1	3	12.9
>= 20 years	3.3	2.2	1	3	9.2
>= 20 years, <13 years education	3.7	2.1	1.1	4.3	11.3
>= 20 years, >= 13 years education	2.8	2	0.9	1.9	7.6

Although these numbers reveal the groups with the highest mortality rates, they do not adequately depict the potential amount of mortality reduction. In order to determine how much of a reduction in feto-infant mortality is possible, it is necessary to compare these numbers with those of a reference group. If Nashville had high mortality across all groups and subpopulations, using only an internal reference group for comparison would not reveal the true potential for mortality reduction. Comparisons of both an internal and external reference group accounts for that possibility.

The feto-infant mortality rates and numbers for each reference group are depicted in Table 4. It is important to note that the total number of deaths in the internal reference group is less than the required 60; therefore, the estimates may be unstable. Comparing the maps of the two reference groups, however, indicates that the rates do not vary greatly.

Assuming that all subgroups in Nashville have the potential to achieve the same perinatal outcomes as the group with the best outcomes, mortality rates can be much lower than they are currently. According to the internal reference group, all subpopulations in Nashville should be able to reach a Maternal Health and Prematurity mortality rate of 2.3, an Infant Health mortality rate of 1.6, and an overall mortality rate of 6.3. If we base our comparisons on the external reference group, then all subgroups in Nashville should be able to reach a Maternal Health and Prematurity mortality rate of 2.3, an Infant Health mortality rate of 1.1, and an overall mortality rate of 6.3.

Table 4. Feto-infant Mortality Numbers and Rates per 1,000 Fetal Deaths plus Live Births for Each of the Four Map Components for the Nashville Internal Reference Group and the U.S., 1995-1997

Reference	Maternal Health		Maternal Care		Newborn Care		Infant Health		Total	
	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.
Internal[1]	2.3	18	1.7	15	0.8	7	1.6	14	6.3	54
U.S.[2]	2.3	8,752	1.7	6,214	1.2	4,516	1.1	4,233	6.3	23,715

[1]The internal reference group for Nashville is white women greater than 19 years of age with more than 12 years of education

[2]The U.S. reference group is comprised of non-Hispanic white women greater than 19 years of age with more than 12 years of education

The results of calculating excess mortality for Nashville compared to both reference groups is shown in Table 5. If all sub-groups in Nashville were to achieve the mortality rates of the internal reference group, the overall feto-infant mortality rate would reduce by 3.5 per 1,000 fetal deaths plus live births and by 88 deaths. Thirty-eight of those deaths would be among VLBW infants, and 35 would fall in the Infant Health category. In other words, overall feto-infant mortality in Nashville could be reduced by nearly 34%. The results are similar when comparing Nashville to the external reference group. In that case, the overall mortality rate would reduce by the same amount, though there would be 87 fewer deaths instead of 88. The Maternal Health and Prematurity category would have 52 fewer deaths, and the Infant Health category would have 47 fewer deaths.

Table 5. Overall Excess Mortality Numbers and Rates per 1,000 Fetal Deaths plus Live Births for Each Mortality Category, Nashville, TN, 1995-1997

Reference group	Maternal Health		Maternal Care		Newborn Care[3]		Infant Health		Total	
	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.
Internal[1]	1.6	39	0.4	9	0.2	5	1.4	35	3.5	88
U.S.[2]	1.3	33	0.4	11	-0.2	-5	1.9	47	3.5	87

[1]The internal reference group for Nashville is white women greater than 19 years of age with more than 12 years of education

[2]The U.S. reference group is comprised of non-Hispanic white women greater than 19 years of age with more than 12 years of education

[3]The negative results from the excess mortality calculation indicates that Nashville has fewer deaths in the Newborn Care category than the U.S. reference group

Although the actual number of deaths is smaller among blacks, the potential for rate reduction is much greater (Table 6). For example, black feto-infant mortality would reduce by 57 to 58 deaths if this population group were able to achieve the same perinatal outcomes as either reference group. However, the feto-infant mortality rate would reduce by 7.7 per 1,000 live births plus fetal deaths. In other words, there is the potential to reduce overall feto-infant mortality among blacks in Nashville by 53%.

Table 6. Black Excess Mortality Numbers and Rates per 1,000 Fetal Deaths plus Live Births for Each Mortality Category, Nashville, TN, 1995-1997

Reference group	Maternal Health		Maternal Care		Newborn Care[3]		Infant Health		Total	
	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.
Internal[1]	4	30	1.4	10	0.3	2	2.1	16	7.7	58
U.S.[2]	3.7	28	1.4	11	-0.1	-1	2.6	20	7.7	57

[1]The internal reference group for Nashville is white women greater than 19 years of age with more than 12 years of education

[2]The U.S. reference group is comprised of non-Hispanic white women greater than 19 years of age with more than 12 years of education

[3]The negative results from the excess mortality calculation indicates that Nashville has fewer deaths in the Newborn Care category than the U.S. reference group

Discussion

According to the PPOR Phase I results, the major contributors to the overall feto-infant mortality rate in Nashville are deaths among VLBW babies and postneonatal deaths greater than 1,500 grams. Additionally, mortality is not evenly distributed between population groups. On the contrary, younger and less educated women tend to have poorer outcomes than their older and more educated counterparts. Additionally, blacks have both the highest mortality rates in Nashville and the highest potential for mortality reduction.

Comparing Nashville's component-specific mortality rates to two different reference groups yields similar results. Reductions in the overall feto-infant mortality rate in Nashville are possible along the magnitude of nearly 34%. This potential for reduction jumps to 53% when comparing blacks to the reference groups.

There are some limitations to this analysis. For stable mortality estimates from the feto-infant mortality maps, each matrix must contain at least 60 deaths. As maps are stratified on a gradually increasing number of variables, there is the increased likelihood that a map will contain fewer than the required 60 deaths. This phenomenon is evident in two feto-infant mortality maps: women less than 20 years of age and the internal reference group.

To compensate for the possibility of unstable estimates in the internal reference group, a second reference group, U.S. non-Hispanic white women older than 19 years of age with more than 12 years of education, was used. Results from comparisons using both reference groups showed no marked difference; therefore, it is unlikely there is bias in these estimates.

The second limitation of this analysis is its limited scope. Although the feto-infant mortality maps clearly indicate the areas where mortality is concentrated, and to a certain extent which groups are most affected, Phase I results do not provide specific information on which interventions would best address the issue within any single community. In order to gain further insight, a more complex and in-depth analysis is necessary (Phase II).

Phase II Analysis

Background

The purpose of Phase I analysis is to provide a general guide towards identifying the areas where mortality reduction is possible in Nashville. The purpose of Phase II analysis is to further investigate the two categories of concern, namely Maternal Health and Prematurity and Infant Health, to determine specific risk factors that may be targeted with interventions.

Methods

The Kitigawa[15] method of differentiating the components of a difference between two rates was applied to Nashville's Maternal Health and Prematurity mortality. This method explains the differences between the overall rates of two groups in terms of differences between their specific rates and composition.[15] In terms of this analysis, the difference between Nashville's feto-infant mortality rate and the U.S. reference group of white, non-Hispanic women greater than 20 years of age with 13 or more years of education is calculated based on the differences between the rates for 7 categories of birth weight. These differences are attributable to either birth weight distribution or birth weight specific mortality. The birth weight categories in grams are 500-749; 750-999; 1,000-1,249; 1,250-1,499; 1,500-1,999; 2,000-2,499; and 2,500 and greater. Actual calculations were performed using an Excel spreadsheet created and provided by CityMatCH.

Results from the Kitigawa portion of the analysis were used to direct further analyses. Once it was determined whether future analyses should target risk factors for VLBW or risk factors for birth weight specific mortality, prevalences of the chosen set of risk factors in the population were calculated.

Adjusted odds ratios for the risk factors under investigation were obtained by creating a logistic regression model. Modeling the risk of VLBW, selected risk factors were examined while controlling for gestational age, maternal race, age, and education level. The logistic analysis was restricted to the linked birth-death certificate file. Categorical variables were created for maternal age, maternal education, and prenatal care.

Communities vary according to risk factor distribution, such that one factor that may figure prominently in one community, may have little to no impact in another community. For this reason, population attributable risk percents (PAR%) were calculated for each risk factor based on the adjusted odds ratio and the prevalence of that risk factor in the community. The purpose was to determine the proportion of cases in the population that can be attributed to the risk factor in question. Actual calculations were made via an Excel spreadsheet using the following formula:

$$PAR\% = P(OR-1)/[P(OR-1) + 1]$$

where P = the proportion of the population exposed and OR = the odds ratio.

Results

Maternal Health and Prematurity

Deaths in the Maternal Health and Prematurity category have a birth weight between 500 and 1,500 grams. This VLBW mortality can be divided into two major components: deaths due to birth weight distribution and mortality at those birth weights. In other words, is the high mortality rate due to a high frequency of VLBW births, or is it due to a high mortality of VLBW babies? The Kitigawa portion of the analysis attempts to answer this question.

Figure 27 shows the results of using the Kitigawa method of calculating the components of a difference between two rates. Birth weight distribution constitutes 73.5% of the overall feto-infant mortality in Nashville when compared to the U.S. reference group. Among VLBW births, 55.9% of the mortality can be attributed to birth weight distribution (Table 7). In fact, Nashville has a deficit of VLBW deaths attributable to birth weight specific mortality compared to the U.S. reference, indicated by the negative percentage.

Figure 27. Percentage Contribution of Birth Weight Distribution and Birth-specific Mortality, All Races, Nashville, TN, 1995-1997

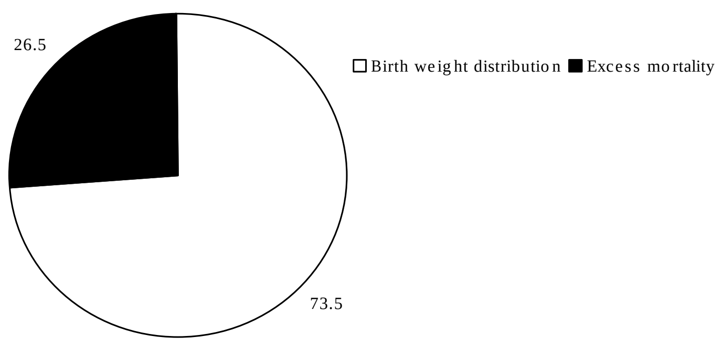


Table 7. Percentage Contribution to the Difference in Excess Mortality Rates[1], All Races, Nashville, TN, 1995-1997

Birth Weight (grams)	Birth Weight Distribution	Excess Mortality Rate	Total Contribution
500-749	27.9	-11.6	16.3
750-999	13.1	-3.9	9.2
1,000-1,249	10.5	0.3	10.8
1,250-1,499	4.3	-4.5	-0.2
VLBW Total	55.9	-19.7	36.1
1,500-1,999	9.9	-2.4	7.5
2,000-2,499	11.9	-3.8	8.1
2,500+	-4.1	52.5	48.4
Total	73.5	26.5	100.0

[1]The reference group is U.S. white, non-Hispanic women greater than 20 years of age with 13 or more years of education.

Among blacks, 71.6% of mortality among VLBW births is attributable to birth weight distribution compared to 10.9% due to birth weight specific mortality (Figure 28). Overall, birth weight distribution accounts for 89.1% of feto-infant mortality among blacks when compared to the U.S. reference group (Table 8). Clearly, Nashville has a high frequency of VLBW babies being born; therefore, further analysis focuses on evaluating risk factors for VLBW.

Figure 28. Percentage Contribution to Birth Weight Distribution and Birth-specific Mortality to Maternal Health and Prematurity, Blacks, Nashville, TN, 1995-1997

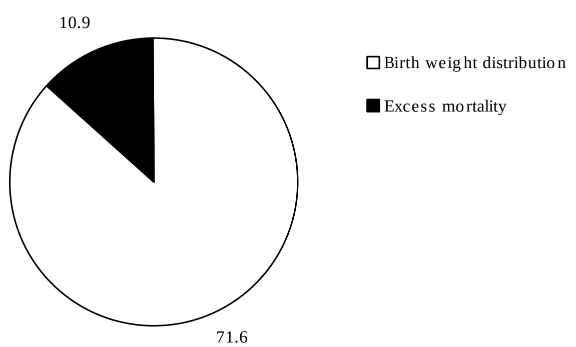


Table 8. Percentage Contribution to the Difference in Excess Mortality Rates[1], Blacks, Nashville, TN, 1995-1997

Birth Weight (grams)	Birth Weight Distribution	Excess Mortality Rate	Total Contribution
500-749	40.5	-13.4	26.8
750-999	14.7	-7.7	7.0
1,000-1,249	10.2	-2.2	8.0
1,250-1,499	6.2	-3.2	3.0
VLBW Total	71.6	10.9	44.8
1,500-1,999	12.0	-0.3	11.7
2,000-2,499	11.2	-8.7	2.5
2,500+	-5.7	46.6	40.9
Total	89.1	-26.7	100.0

[1]The reference group is U.S. white, non-Hispanic women greater than 20 years of age with 13 or more years of education.

The prevalence of selected risk factors for VLBW in Nashville is presented in Table 9. Among the population of women with live births or fetal deaths, over half had less than 13 years of education, less than 15% were under the age of 20, and 38.9% were unmarried. Among black women with live births or fetal deaths, 65.3% had less than 13 years of education, nearly 25% were under the age of 20, and nearly 73% were unmarried. Such racial disparities in education, age, and marital status are also noted for prenatal care. The prevalence of no prenatal care among the entire population is 9.5%, compared to 12.4% for the black population.

When considering possible medical risk factors for VLBW within the population there is only a slight difference between the entire population and blacks for having any risk factor; 12.8% for the population and 13.9% for blacks. Similarly, the differences between the two populations for specific conditions such as anemia, diabetes, previous preterm birth, chronic hypertension, and pregnancy-induced hypertension are very small.

Behavioral risk factors are also considered. Black women have a lower prevalence of self-reported tobacco use than the population as a whole; 8.5% compared to 13.1% respectively. Self-reported alcohol use during pregnancy exists in only 1% of the entire population under consideration, and 1.4% for blacks. The prevalence among blacks of high parity for maternal age is 41% higher than the prevalence for the entire population.

Logistic regression methods were applied to the linked birth-death certificate file to evaluate the magnitude of association these risk factors might have with VLBW in Nashville. The results of this analysis are shown in Table 10. The risk factors with the highest associations with VLBW are pregnancy-induced hypertension (2.5), multiple pregnancy (2.3), chronic hypertension (2.0), and black race compared to whites (1.6). Of those, only multiple pregnancy, pregnancy-induced hypertension, and maternal black race proved to be significant. Although high parity proved to have a positive association with VLBW along the magnitude of 1.8, this was not significant at the 95% confidence level.

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The odds ratios obtained from the logistic regression model were then combined with the proportion of exposure in the population to calculate the population attributable risk percent (Table 11). Simply defined, a population attributable risk percent represents the proportion of the outcome (VLBW) that can be attributed to a particular risk factor within the population. Thus, 16.0% of VLBW babies can be attributed to black race. Four percent can be attributed to pregnancy-induced hypertension, and 3.7% can be attributed to multiple pregnancies. Traditional risk factors such as smoking, low levels of education, and no or late prenatal care do not appear to contribute significantly to the high frequency of VLBW babies in Nashville.

Table 10. Odds Ratios and 95% Confidence Intervals for Risk Factors for Very Low Birth Weight, Nashville, TN, 1995-1997

Risk Factor	Odds Ratio	95% CI
Gestational Age	0.45	(0.43, 0.47)
Maternal Education < 13 years	1.03	(0.74, 1.59)
Maternal Age: < 20	1.05	(0.67, 1.65)
Maternal Age: > 34	0.84	(0.46, 1.35)
Maternal Race: Black	1.64	(1.15, 2.31)
Maternal Race: Other	1.33	(0.57, 3.26)
No Prenatal Care	0.62	(0.29, 1.50)
Late Prenatal Care	0.58	(0.33, 1.06)
High Parity for Age	1.82	(0.62, 5.26)
Tobacco Use[1]	0.59	(0.37, 0.84)
Anemia	0.75	(0.16, 2.83)
Previous preterm birth	0.38	(0.04, 3.99)
Multiple pregnancy	2.34	(1.61, 3.51)
Chronic Hypertension	2.01	(0.70, 5.77)
Pregnancy-induced Hypertension	2.49	(1.45, 4.29)

[1]Although the odds ratio of self-reported tobacco use indicates a significant protective effect, it is an artifact of blacks smoking less than whites in Davidson County, as well as the poor quality of self-reported data on birth certificates.

Table 11. Odds Ratios, Prevalence Estimates, and Population Attributable Risk Percents for Selected Risk Factors Associated with Very Low Birth Weight, Nashville, TN, 1995-1997.

Risk Factor	Odds Ratio	Prevalence	PAR%
Maternal Education < 13 years	1.03	0.53	1.36
Maternal Age: < 20	1.05	0.15	0.77
Maternal Age: > 34	0.84	0.11	-1.78
Maternal Race: Black	1.64	0.30	16.10
Maternal Race: Other	1.33	0.04	1.22
No Prenatal Care	0.62	0.10	-3.73
Late Prenatal Care	0.58	0.04	-1.69
High Parity for Age	1.82	0.02	1.30
Tobacco Use	0.59	0.13	-5.65
Anemia	0.75	0.01	-0.22
Previous preterm birth	0.38	0.00	-0.19
Multiple pregnancy	2.34	0.03	3.73
Chronic Hypertension	2.01	0.01	0.60
Pregnancy-induced Hypertension	2.49	0.03	4.15

Infant Health

Methods

All postneonatal deaths greater than 1,500 grams were subjected to a cause of death analysis. Using the death categorization scheme proposed by the CDC Postneonatal Mortality Surveillance System[16], the underlying cause of death was grouped by ICD-9 codes into 7 categories: perinatal conditions, congenital anomalies, infections, injury, ill-defined, sudden infant death syndrome (SIDS), and other.

Results

Table 12 presents the distribution of underlying causes of death for Infant Health deaths from 1995-1997. SIDS is defined as "the sudden death of an infant under 1 year of age which remains unexplained after a thorough case investigation, including performance of a complete autopsy, examination of the death scene, and review of clinical history".[17] Although a diagnosis of exclusion, SIDS accounted for one-third of all Infant Health deaths in Nashville. The percentage is nearly as high for blacks, with nearly 29% of Infant Health deaths attributable to SIDS.

Table 12. Underlying Causes of Infant Health Death by Race, Nashville, TN, 1995-1997

Underlying Cause of Death	Infant Health Deaths		Black Infant Health Deaths	
	N	%	N	%
Perinatal Conditions	3	4	2	7.1
Congenital Anomalies	8	10.7	2	7.1
Infections	7	9.3	4	14.3
Injury	12	16	6	21.4
Ill-Defined	3	4	1	3.6
Sudden Infant Death Syndrome	24	32	8	28.6
Other	18	24	5	17.9
Total	75		28	

The second leading cause of death in Nashville is the category "Other", accounting for 18% of Infant Health deaths in Nashville. The "Other" category, however, is designed to catch any cause of death that does not fall within any of the other 6 categories. It is likely that these causes of death if examined individually would not have the impact on cause of death distribution that they do as a group. Therefore, it is likely that the true second leading cause of death is actually injury, accounting for 16% of Infant Health deaths. Injury is also the second leading cause of death among black postneonates greater than 1,500 grams, accounting for 21.4% of deaths in that category.

Discussion

Phase II analysis of the Maternal Health and Prematurity category of Nashville's feto-infant mortality map started with the Kittigawa method of partitioning the components of the mortality rates into those attributable to birth weight distribution or birth weight specific mortality. The results clearly indicate that a large part of feto-infant mortality in Nashville is due to a high frequency of VLBW births. In fact, Nashville demonstrated a deficit of birth weight specific deaths when compared to the U.S. reference group.

An attempt to determine the underlying factors creating the high frequency of VLBW babies was made by examining well recognized risk factors for low birth weight within this population. Through logistic regression modeling methods, and the subsequent calculation of population attributable risk percents, it was determined that the traditional risk factors for VLBW are not adequate to answer the question concerning the high frequency of VLBW babies in Nashville.

Admittedly, there are some issues with the analysis itself that need to be addressed. The primary issue is small numbers. In each of the three years under investigation, the percentage of VLBW births in Nashville is very small. In 1995, for example, only 1.8% of all live births were classified as VLBW, 1.9% in 1996, and 1.7% in 1997. The percentage of VLBW births for blacks during those years, while greater than the overall percentage, is still very small. In 1995, only 3.1% of all black live births in Nashville were classified as VLBW, 3.5% in 1996, and 2.8% in 1997. When attempting to model so few events, it becomes difficult to obtain statistically significant results.

The obvious solution to small numbers is to continue to increase the sample size. Therefore, it may prove beneficial to perform the analysis again once subsequent linked birth-death certificate files become available.

Another issue to consider is the type of data sources available in Nashville. As this analysis seems to indicate that Maternal Health and Prematurity deaths cannot be reduced by pursuing the usual avenues of intervention, population-based information on other risk factors needs to be collected and analyzed. Information currently collected on vital records certificates is rather limited in scope. It cannot be used effectively to analyze risk factors such as socioeconomic status, nutritional status, sexually transmitted diseases and other infections, exposure to environmental toxins, or physical and psychosocial stress. The establishment of a comprehensive MCH data surveillance system in Nashville would help provide the information necessary to address these and many other risk factors.

Phase II analysis of underlying causes of death for postneonates greater than 1,500 grams clearly indicates that efforts aimed at reducing SIDS and injury would reduce Infant Health mortality. The reason for high SIDS rates in Nashville is unknown. At this time it is difficult to determine if improved, culturally appropriate education on sleep position is needed, or if efforts should concentrate on smoking cessation, for example.

Nashville currently has a mandated Child Death Review team that represents a cross-disciplinary effort that works to understand the causes of all child deaths under the age of 18. Forging a data infrastructure that encompasses information from this process may provide an avenue for further investigation into SIDS and injury.

CHAPTER 4
Recommendations

The PPOR analysis clearly points to some deficiencies in the current data infrastructure of Nashville. Simply stated, the information needed to adequately pinpoint the cluster of risk factors driving the large Maternal Health and Prematurity rates is not available. With this in mind, the PPOR steering committee proposes the implementation of both a Fetal and Infant Mortality Review (FIMR) and a Pregnancy Risk Assessment Monitoring System (PRAMS) as a means of improving the data infrastructure in Nashville.

The FIMR utilizes an intensive records review process as a means of investigating the social, economic, cultural, and systems factors that may contribute towards fetal and infant mortality. The knowledge gained through this process is used to plan, implement, and evaluate the results of interventions, policies, and service delivery improvements within the community. Part of the implementation process involves a community action team. This team is comprised of people with the political will, financial resources, or the community perspective needed to implement the suggested changes.[18]

PRAMS is a continuous, population-based surveillance system. It is designed to measure self-reported maternal behaviors and experiences that occur before, during, and after pregnancy. The surveillance system achieves its goals through the administration of surveys among a sample of women whose pregnancy results in a live-born infant.[19] This information allows the community to monitor trends and understand the relationship between maternal behaviors and pregnancy outcomes. Such understanding, in turn, leads to new and improved interventions, changes in policy, and progress towards the Healthy People 2010 objectives.

The PPOR steering committee also sees the need to strengthen bonds with the current Child Fatality Review. Information gleaned through this review process can suggest modes of intervention that will decrease mortality rates among postneonates with a birth weight greater than 1,500 grams.

Data systems are not the only areas in Nashville that can be improved. The PPOR team sees a need to continue to identify and engage new and non-traditional partners in the fight against fetal and infant mortality. It is only by including a diverse group of people in the continuing PPOR effort that new and alternative approaches to addressing infant mortality can be created.

In summary, the PPOR team strongly believes that the actions listed above will greatly increase Nashville's ability to address the persistent problem of fetal and infant mortality in a manner that will yield successful results.

Recommendations

- Establish a Fetal and Infant Mortality Review
- Establish a Pregnancy Risk Assessment Monitoring System
- Improve bonds with Child Fatality Review
- Identify and engage new and non-traditional partners

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