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Fetal and early neonatal death: Do the determinants vary?

by

Ashley Carter

Derek Chapman, PhD

Department of Epidemiology and Community Health
Master of Public Health Program
MPH Research Project: EPID 691

Virginia Commonwealth University
Richmond, Virginia

December 2008

Submission Statement
Master of Public Health Research Project

This MPH Research Project report is submitted in partial fulfillment of the requirements for a Master of Public Health degree from Virginia Commonwealth University's School of Medicine. I agree that this research project report be made available for circulation in accordance with the program's policies and regulations pertaining to documents of this type. I also understand that I must receive approval from my Faculty Advisor in order to copy from or publish this document, or submit to a funding agency. I understand that any copying from or publication of this document for potential financial gain is not allowed unless permission is granted by my Faculty Advisor or (in the absence of my Faculty Advisor) the Director of the MPH Program.

Ashley A Carter

Student Signature

12/11/08

Date

Master of Public Health
Research Project Agreement Form
Department of Epidemiology and Community Health

Student name: Ashley O. Carter E-mail address: carterao@vcu.edu

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Home phone: (757) 816-2628 Work phone: ( ) Fax:

Number of semester hours (3-6): 3 Semester: Fall Year: 2008

Please complete the following outline. **Do not exceed 2 pages (A-H).**

A. PROJECT TITLE: Fetal death and neonatal infant mortality: do the determinants vary?

B. PURPOSE (state hypothesis/research question): The purpose of this study is to elucidate any differences in the determinants of fetal death versus neonatal infant mortality.

C. SPECIFIC OBJECTIVES (list major aims of the study):

This study aims to determine the risk factors for both fetal death and neonatal infant deaths based on data from the Commonwealth of Virginia's fetal death and linked birth/death certificates for years 2001 to 2006. Additionally, GIS will be used to pictorially depict the fetal death and neonatal infant mortality rate by county.

D. DESCRIPTION OF METHODS

D.1. Identify source(s) of data (eg, existing data set, data collection plans, etc):

Data will be from the existing Commonwealth of Virginia's fetal death and linked birth and death certificates.

D.2. State the type of study design (eg, cross-sectional, cohort, case-control, intervention, etc):

This study is cross-sectional.

D.3. Describe the study population and sample size:

Fetal deaths (stillbirths) after 20 weeks gestation and neonatal infant deaths 0-29 days old will be included in the study population. The sample size is estimated to be 3554 fetal deaths and 2871 linked neonatal infant deaths dataset.

D.4. List variables to be included (If a qualitative study, describe types of information to be collected)

Sex of child, race of child, date of birth, plurality, place of birth, planning district of birth, place of residence, planning district of residence, race of mother, age of mother, mother's education, race of father, age of father, father's education, live births now living, live births now dead, legitimacy, weight at birth, date last live birth, physician's estimate of gestation, month of pregnancy prenatal care began, number of prenatal visits, Hispanic origin of mother, Hispanic origin of father, medical history for this pregnancy, tobacco use during pregnancy, alcohol use during pregnancy, weight gained during pregnancy, obstetrics procedures, events of labor and/or delivery, method of delivery, conditions of the newborn, congenital anomalies of child, source of prenatal care, method of payment.

D.5. Describe methods to be used for data analysis (If a qualitative study, describe general approach to compiling the information collected)

Odds ratios will be calculated for the various risk factors included in the analysis separately for fetal and neonatal deaths and then based on feto-infant death. The referent group will be total pregnant women (those with pregnancies not ending in abortion).

E. ANTICIPATED RESULTS: It is anticipated that the risk factors for fetal death and neonatal infant deaths will be similar. Therefore, discuss a feto-infant mortality rate instead of exclusively an infant mortality rate when addressing the problem in Virginia.

F. SIGNIFICANCE OF PROJECT TO PUBLIC HEALTH:

G. IRB Status:

1) Do you plan to collect data through direct intervention or interaction with human subjects? ___yes __√__no

2) Will you have access to any existing identifiable private information? ___yes __√__no

If you answered "no" to both of the questions above, IRB review is not required.
If you answered "yes" to either one of these questions, your proposed study must be reviewed by the VCU Institutional Review Board (IRB). Please contact Dr. Vance or Dr. Sridhar for assistance with this procedure.

Please indicate your IRB status:
___ to be submitted (targeted date_____)
___ submitted (date of submission _____; VCU IRB # _____)
___ IRB exempt review approved (date_____)
___ IRB expedited review approved (date_____)
___ IRB approval not required

H. PROPOSED SCHEDULE: Start Date: __8/1/08____Anticipated End Date:___12/1/08__

I. INDICATE WHICH OF THE FOLLOWING AREAS OF PUBLIC HEALTH KNOWLEDGE WILL BE DEMONSTRATED:

1. Biostatistics – collection, storage, retrieval, analysis and interpretation of health data; design and analysis of health-related surveys and experiments; and concepts and practice of statistical data analysis. _√_ yes ___ no (if yes, briefly describe):
   I will use Biostatistics to analyze the data set. Using SAS I will calculate odds ratios.

2. Epidemiology – distributions and determinants of disease, disabilities and death in human populations; the characteristics and dynamics of human populations; and the natural history of disease and the biologic basis of health. _√_ yes ___ no (if yes, briefly describe):
   Determinants of fetal death and neonatal infant mortality will be analyzed.

   Using GIS I will using a map of Virginia to display the fetal and neonatal infant deaths separately to depict any similarities in rates throughout the Commonwealth.

3. Environmental Health Sciences – environmental factors including biological, physical and chemical factors which affect the health of a community. ___ yes _√_ no (if yes, briefly describe):

4. Health Services Administration – planning, organization, administration, management, evaluation and policy analysis of health programs. ___ yes _√_ no (if yes, briefly describe):

5. Social/Behavioral Sciences – concepts and methods of social and behavioral sciences relevant to the identification and the solution of public health problems. ___ yes _√_ no (if yes, briefly describe):

SIGNATURE PAGE
Master of Public Health Research Project

Student: Name: Ashley O. Carter

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Student: Ashley O Carter Date: 8/12/08

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Faculty Advisor: _____ Date: 8/12/08

MPH Program Director: Lisa S Ahl Date: 9/10/08

MPH Program Coordinator: _____ Date: 12-05-08

MPH Research Project Approval Form

Fetal and Early Neonatal Death: Do the Determinants Vary?

Submitted to the Graduate Faculty of the
Department of Epidemiology and Community Health
Virginia Commonwealth University

In partial fulfillment of the requirements for the degree of
Master of Public Health

by: Ashley Carter

Comments:

Approval signatures:

Ashley Carter	12/9/08
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MPH Program Coordinator	Date

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ABSTRACT

Purpose: To compare the determinants and distribution of fetal and early neonatal deaths in the Commonwealth of Virginia.

Background: Much attention is devoted to reducing the infant mortality rate which was declining up until 2002. The recent rise was parsed and found to stem from an increase in deaths during the early neonatal period. Fetal deaths are not well understood and are not routinely included when evaluating infant mortality.

Methods: Using data collected from 2001 to 2006 fetal death and linked infant birth and death certificates by the Virginia Department of Health, crude mortality rates and leading causes of death were calculated for fetal and early neonatal mortality. Rates were calculated for each period of death by locality and mapped to determine if the distribution differed. Logistic regression was also used to evaluate sociodemographic and pregnancy risk factors and chi-square analyses were used to determine if the determinants varied significantly by timing of death outcome.

Results: During the study period, the fetal death rate was 5.4 per 1,000 fetal deaths plus live births, the early neonatal death rate was 2.5 deaths per 1,000 live births and perinatal mortality rate was 7.9 deaths per 1,000 fetal deaths plus live births. Trends over time, gestational age specific mortality, geographic distribution, cause of death and many determinants were comparable between both death periods. Extremely low birth weight was the most significant risk factor for early neonatal death (OR = 1747.06). Congenital anomalies of the child were the leading predictor of fetal death (OR = 26.24, 95% CI: 19.62, 35.10) and second highest for early neonatal death (OR = 52.26, 95% CI: 35.21, 77.56).

Conclusions: Because of the similarities in geographic distribution, sociodemographic factors, pregnancy risk factors and causes of death, analyzing neonatal and infant mortality rates in isolation from fetal deaths does not accurately depict the burden of adverse pregnancy outcomes.

Introduction

Perinatal mortality, the combination of fetal deaths and death of a live birth surviving only briefly, is a complex and multifactorial outcome requiring a research paradigm appropriately reflecting this reality. Preterm birth and low birth weight are important predictors of perinatal mortality.[1-3] A birth weight of less than 2500 grams is generally classified as low and a gestational period of less than 37 weeks is defined as preterm. A birth at term generally confers on the infant less risk of serious morbidity and long-term neurocognitive disability.[2] The National Institutes of Health estimate that preterm births occur in approximately 12% of pregnancies in the United States and is second to congenital anomalies as one of the top causes of infant mortality.[4] Very preterm birth is defined as less than 32 weeks gestation and extremely preterm as less than 28 weeks gestation. Epidemiologic studies have determined risk factors associated with any preterm delivery. Pregnancy interval less than one year, previous preterm birth, advanced maternal age (greater than 35 years), maternal age less than 18 years, preeclampsia, premature rupture of the membranes, uterine bleeding, infection, cervical incompetence and cervical trauma are associated with an increased risk of preterm delivery.[5-8] In addition to the aforementioned risks, preterm induction of labor and changes in obstetrical practices have resulted in a greater number of infants born at lower birth weights.[1] Though many preterm births are spontaneous, others are the result of ruptured membranes or medical indications.[2]

Rates of fetal and infant mortality in the United States experienced a substantial decline during the years of 1980-2001.[1] Among all births, the infant mortality rate (death of a live birth prior to 1 year after birth) declined 45.2% from 12.6 in 1980 to 6.8 deaths per 1,000 live births in 2001.[1] Neonatal mortality (death of live birth prior to 28 days after birth) declined 47% from 8.5

in 1980 to 4.5 per 1,000 live births in 2001.[9] Fetal mortality, or fetal death after 20 or more weeks of gestation, declined 29% from 9.1 in 1980 to 6.5 per 1,000 live births and fetal deaths in 2001. Rates of infant mortality have generally improved, but recent research suggests that this trend is stagnating or reversing. After over 40 years of improvements in infant mortality, the rate unexpectedly rose in 2002 to 7.0 infant deaths per 1,000 live births; the first increase since 1958.[10] Upon further investigation, researchers identified the neonatal period as the source of the three percent increase in infant mortality rate. More specifically, the deaths were concentrated during the early neonatal period (live birth between 0 and 6 days after birth).

Many of the improvements in infant survival are attributed to technological and medical advances. High-risk obstetric and neonatal intensive care, antenatal steroids, high-frequency ventilation and exogenous surfactant are among the interventions credited with increased survival of live births.[6,8,11-13] Regionalization of specialized neonatal intensive care resulted in these services being available principally at university medical centers in the 1970s but since then have increased in their availability in nonuniversity hospitals.[11] Within the last few decades the rate of preterm birth and low birth weight has risen though through the increased availability of these medical advances infant survival has improved.[14]

A persistent disparity in mortality rates has been documented among pregnancies in black compared to white mothers.[1,2,4,7,9,14,15] As the overall fetal and infant survival rates have improved, however, this racial disparity has grown between 1980 to 2001. With respect to infant mortality, black women had a rate 2.0 times greater than white women in 1980 as compared to 2.5 times greater in 2001.[1] For fetal mortality, black women had a rate 1.8 times greater than white women in 1980 and 2.2 times greater in 2001. This disparity is not adequately understood.[16]

Though much has been done to investigate determinants of infant mortality, less attention has been devoted to fetal deaths at 20 or more weeks of gestation. It is speculated that fetal and early neonatal infant deaths may share commonalities with regard to potential determinants including maternal, infant and pregnancy characteristics because of the similarities in gestational age specific mortality. Relying on an infant mortality rate may not accurately represent the scope of the problem or the attributes of those at risk. If this is the case, using a perinatal mortality rate, in addition to the infant mortality rate, may be a better representation of the burden of poor pregnancy outcomes demanding further surveillance and intervention. Parsing late fetal, early neonatal and neonatal mortality as separate from those deaths after 28 days after birth allows for public health programs to better focus on the risks associated with this critical period. Including these perinatal deaths with those of infant deaths up to one year masks potentially different risk factors for each.

The purpose of this study is to compare determinants of fetal and early neonatal infant mortality, compute a perinatal mortality rate and examine the distribution of fetal and neonatal mortality throughout the Commonwealth of Virginia. Results of this study are essential for public health practice ensuring the limited resources allocated to maternal and child health programs are utilized in the highest risk groups to improve pregnancy outcome. This analysis is limited to singleton pregnancies because of the drastic differences between preterm birth rates and risks inherent in multiple gestation pregnancies.[7]

Methods

Virginia resident live birth, infant death and fetal death data collected by the Division of Vital Records within the Virginia Department of Health (VDH) were used to conduct this study. The full dataset consists of 595,184 mother-child pairs, including singleton fetal deaths

(n=3,229) and linked live birth and early neonatal deaths (n=1,465) recorded between January 1, 2001 and December 31, 2006 inclusive. These data were de-identified and extracted from the VDH Maternal & Child Health Data Mart by Office of Family Health Services staff. All references to total pregnancies in this paper do not include induced terminations because of concerns regarding the quality of the data. For the purposes of this analysis, fetal death was defined as greater than or equal to 20 weeks of gestation and early neonatal death as a death less than 7 days after live birth. Also referred to as Perinatal Period III, this is the mortality indicator of interest in this study.[17]

Trends in fetal and early neonatal death were examined across all years of data. In addition, the distribution of frequency of fetal and early neonatal death by gestational age was considered to determine any similarities. Rates by health district for each outcome were calculated and depicted throughout the state using ArcGIS v9.2. The Commonwealth of Virginia is divided into 35 local health districts comprising one or more independent cities or counties. The denominator for the calculation of the rates comprised fetal deaths and live births for the fetal death rate and live births for the early neonatal mortality rate. Leading causes of death were determined for both early neonatal and fetal death using the group ACME (Automated Classification of Medical Entry). The ACME software identifies an underlying cause of death that is recorded on the death certificate using the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) code set.

Descriptive analyses were also conducted for all determinants. Determinants examined from the linked live birth/death and fetal death certificates included: sex, race/ethnicity, mother's age, mother's education, previous live births now living, previous live births now dead, marital status, birth weight, method of delivery, adverse events of labor/delivery, congenital anomalies

of child, tobacco use, alcohol use, drug use, source of prenatal care, method of payment, trimester of prenatal care initiation and previous preterm birth. For the purpose of this analysis, race/ethnicity was categorized as white non-Hispanic, black non-Hispanic, Hispanic any race and other non-Hispanic. Mother's age was divided into five categories: less than 19 years, 19-24 years, 25-34 years, 35-44 years and 45 years and older. Mother's education was grouped into three categories: less than 12 years, 12 years and greater than 12 years. Live births now living was categorized as none, one or two or more and live births now dead as none or one or more. Birth weight was not available for fetal deaths but was divided into extremely low birth weight (<1000g), very low birth weight (1000-1499g), low birth weight (1500-2499g) and normal birth weight (2500g+) for live births. Method of delivery was divided into vaginal or caesarean section. These categories do not discriminate vaginal from a vaginal birth after a previous caesarean section or a primary versus repeat caesarean section. Adverse events of labor/delivery was dichotomized as either having reported none or one or more of the following: febrile, meconimum, premature rupture of membrane, abruptio placenta, placenta previa, other excessive bleeding, seizures during labor, precipitous labor (<3 hours), prolonged labor (>20 hours), dysfunctional labor, breech/malpresentation, cephalopelvic disproportion, cord prolapse, anesthetic complications, fetal distress or other. The presence of congenital anomalies of the child at birth was also dichotomized as none or presenting any of the following: anencephalus, spina bifida/meningocele, hydrocephalus, microcephalus, other central nervous system anomalies, heart malformations, other circulatory/respiratory anomalies, rectal atresia/stenosis, tracheo-esophageal fistula/esophageal atresia, omphalocele/gastroschisis, other gastrointestinal anomalies, malformed genitalia, renal agenesis, other urogenital anomalies, cleft lip/palate, polydactyly/syndactyly/adactyly, club foot, diaphragmatic hernia, other

musculoskeletal/integumental anomalies, Down's syndrome, other chromosomal anomalies or other anomalies not specified. Tobacco and alcohol use was dichotomized by any use of these substances during pregnancies. Drug use included use of heroin, methadone, marijuana, cocaine, amphetamines or other. Source of prenatal care was divided by no care, private physician, health department or other. Method of payment was separated by Medicaid, self-pay or private insurance. Trimester of prenatal care initiation was not available for fetal deaths.

Multiple logistic regression was used to calculate the crude and adjusted risk of fetal and early neonatal mortality to determine any differences in risk factors. The adjusted model included all sociodemographic, pregnancy history, behavioral risk factors and prenatal care usage variables previously described. For all odds ratios, 95% confidence intervals were calculated. A model was constructed separately for fetal and early neonatal death for calculating odds ratios with respect to live births. To allow for a comparison of the various determinants by death outcome, chi-square analyses were carried out and limited to only those pregnancies resulting in each outcome. All statistical analyses were conducted using SAS v9.1 using an alpha level of 0.05.

Results

The analysis was based on 595,184 singleton live births and fetal deaths in Virginia between 2001 and 2006. During the study years there were 3,229 fetal deaths and 1,465 early neonatal deaths. There are significantly more fetal deaths than early neonatal deaths but no significant differences in the trends of fetal ($F = 1.1841$, $p = 0.3377$) and early neonatal death ($F = 1.5613$, $p = 0.2796$) across the six-year study period though fetal deaths appeared to have more variability across the years (Figure 1). Gestational age distribution of each death outcome was also similar; deaths were greatest prior to 25 weeks of gestation and leveled off after 27 weeks

(Figure 2). While the early neonatal deaths continued to remain stable through the end of a term gestation, fetal deaths again rose from 34 weeks to 39 weeks. During the study period, the fetal death rate was 5.4 per 1,000 fetal deaths and live births and the early neonatal death rate was 2.5 deaths per 1,000 live births. When combining both fetal and early neonatal deaths, the perinatal period III mortality rate was 7.9 per 1,000 fetal deaths and live births.

The most frequent underlying causes of death are reported in Table 1. The leading reported cause of death for fetal demise after 20 weeks gestation was of unspecified cause (38.2%). Disorders of short gestation and low birth weight were indicated most frequently as the underlying cause of early neonatal deaths (40.0%) and fourth for fetal deaths. Effects of maternal complications of pregnancy were identified as the underlying cause of death for 27.5% and 14.8% of fetal and early neonatal deaths, respectively. It was the second leading cause of death for fetal demise and third for early neonatal death. Complications of placenta, cord and membrane were also similar for both outcomes as the third leading cause for fetal death and fourth leading cause of early neonatal death. Though congenital malformations, deformations and chromosomal abnormalities were the second leading cause of death for infants less than seven days old, it was fifth among fetal deaths.

Descriptive analyses for all determinants are presented in Table 2. Though black non-Hispanic mothers comprised 21.67% of all pregnancies, they were 36.87% and 47.31% of fetal and early neonatal deaths, respectively. Also, only 1.14% of mothers reported the death of a previous child but 24.82% of fetal deaths and 5.67% of early neonatal deaths reported this risk factor. Infants born <1000g accounted for less than one percent of births but 72.94% of early neonatal deaths. Though not as striking of a margin, infants of very low birth weight comprised 6.34% of births but 11.31% of early neonatal deaths. Mothers in 22.01% of pregnancies

indicated adverse events of labor or delivery on the fetal death or birth certificate. However, 43.02% and 51.47% of fetal and early neonatal deaths, respectively, involved at least one of these adverse events. Also, less than one percent of total pregnancies specified a congenital anomaly but 12.16% of fetal deaths and 15.36% of early neonatal deaths reported at least one of these. Less than one percent of mothers received no prenatal care though 4.23% of mothers experiencing a fetal death and 12.01% with a live birth resulting in an early neonatal death reported no care.

Non-Hispanic black women had 2.10 times higher odds to have a pregnancy end in fetal death compared to white women and 3.40 times higher odds of an infant death within the first seven days of life. After adjusting for other determinants, however, race and ethnicity were no longer significant risk factors for early neonatal death but remained significant for fetal deaths. Maternal age and education were not significant predictors of early neonatal death after adjustment. Only the maternal age category of 35-44 years was significant in predicting fetal death as compared to the 25-34 year category. Mothers having had 12 years of education has 1.41 times greater odds of having a pregnancy end in fetal death than those having greater than 12 years of education. Mothers with a previous child fatality had 56.10 times greater odds of a fetal death than those without this risk factor. The effect of a previous death was smaller in magnitude but still significant at 4.24 for early neonatal deaths. Delivery by means of cesarean section was protective against both fetal and early neonatal death both before and after adjustment. Tobacco, alcohol and illicit drug use were not significant in the adjusted model. Neither source of prenatal care, trimester of prenatal care initiation nor method of payment remained a significant contributor to either fetal or early neonatal mortality. A previous preterm birth was moderately protective against an early neonatal death but not significant for fetal death.

Extremely low birth weight was associated with the highest odds of early neonatal death in the logistic regression model (OR = 1747.06, 95% CI: 1388.40, 2200.80). Both occurrence of adverse events of labor and delivery and congenital anomalies of the child were significant predictors of fetal and early neonatal mortality. Congenital anomalies of the child were particularly strong predictors for both fetal and early neonatal death with odds ratios of 26.24 and 52.26, respectively.

The effects of sex, mother's education, previous live births still living, alcohol use during pregnancy and method of payment were found not to differ with regard to each death outcome (Table 3). The other determinants were found to vary significantly according to fetal or early neonatal death.

Discussion

During the six-year study period, singleton perinatal period III deaths exceeded singleton infant deaths by 1,271 deaths. Fetal and early neonatal deaths are a significant contributor to adverse pregnancy outcomes and of great public health concern. Fetal and early neonatal deaths share many of the same risk factors, specifically birthweight, congenital anomalies and adverse events of labor and delivery. Geographic distribution, gestational age specific mortality, sociodemographic factors, pregnancy risk factors and causes of death were similar for both periods of death. In an effort to prevent these deaths, the risk factors must be understood.

Imprecise or inconsistent assessment of signs of life at birth resulting in systematic variations in reporting may have influenced this analysis.[14] Though out of the scope of the current study, an analysis limited to perinatal period III must consider the possibility of a blurred line between a fetal death or life sustaining measures prolonging a newborn's life but resulting in an early neonatal death. Systematic variations in hospital policy, immediate availability of

advanced life sustaining equipment or another factor may result in inconsistent reporting of each outcome across the state. The six-year trends in fetal and early neonatal death, however, remained stable thereby not indicating a decrease in fetal deaths leading to an increase in early neonatal deaths. From this analysis, it does not appear that a large number of early neonatal deaths are the result of these systematic variations.

Similarities in when and why fetal and early neonatal deaths occur indicate that approaching each of them in isolation is not a sound approach to addressing the problem. The distribution of fetal and early neonatal deaths in Figure 2 with most deaths occurring prior to 25 weeks of gestation also coincides with the estimated limit of viability in the literature of 23-24 weeks.[15] Both fetal and early neonatal death cite short gestation as one of the leading causes of death.

Determinants often found to contribute significantly to infant mortality were not found to be significant in the current study. Several studies have found race/ethnicity, specifically black race, to be a significant risk factor for fetal and infant mortality.[15,16,18] Contrary to those findings, the current study only found this association prior to adjustment. The higher rates of perinatal death for black mothers may be the result of other mediating factors rather than race. Though race/ethnicity was not significant, the conclusions from previous research on low birth weight and black race are applicable here. Black mothers are almost twice as likely to deliver infants of low birth weight and nearly three times as likely to have very low birth weight infants as compared to white mothers.[16] Maternal psychological stress, particularly as the result of persistent racial discrimination over the life course, has been hypothesized to be influential in the racial disparity of low birth weight and preterm births.

Many interventions to reduce adverse birth outcomes have focused on the provision of prenatal care to at risk populations.[18,19] The data in this analysis indicate that less than one percent of mothers received no care. Though falling short of the Healthy People 2010 objective of 90%, 85% of women in Virginia initiated prenatal care in the first trimester.[20] Prenatal care services during pregnancy, while important, have not resulted in substantial differences in the trend of fetal and early neonatal deaths.

There are several strengths of the current study, specifically the large study population and expected high reporting of fetal deaths greater than 20 weeks gestation in Virginia. While other states do not mandate reporting of fetal death until a certain gestation, Virginia requires that all fetal deaths be reported. Previous research indicates that underreporting is most significant in the gestational age closest to the cut off.[21] Lowering the cutoff for required reporting to four weeks prior to that which is essential has the effect of ensuring more complete reporting. Some fetal demises may be under reported early in the pregnancy; by 20 weeks of gestation this data is thought to be nearly complete.[22] Data quality issues are of great concern to researchers seeking to examine population based risk for fetal death.

Due to the large sample size, there is a high power to detect small differences. This should be considered when evaluating the differences found in the risk factors according to either fetal or early neonatal death in Table 3. A comparison of the actual percents is a better strategy for determining differences in risk factors by period of death. There were a few limitations in the current study. In the analysis of leading causes of death for fetal and early neonatal mortality, the leading cause of death for fetal deaths were unspecified. With 38% of fetal deaths being of unspecified cause, this affects the comparison of causes and results in uncertainty on whether the type of interventions needed to reduce fetal and early neonatal death vary by death period. There

may be an underreporting of adverse events of labor and delivery and congenital anomalies. Also, much of the information on behavioral risk factors is based on self-report and its accuracy cannot be assured.

Although the public health community frequently focuses on infant mortality as a whole, isolating early neonatal deaths and fetal deaths yields important insight into factors affecting healthy pregnancies. Though the etiology is not well understood, there are a large number of fetal deaths.[23] Much of the risk for fetal and early neonatal deaths lies in conditions and risk factors affecting the mother before or during pregnancy and congenital anomalies present in the developing fetus. These fetal deaths after 20 weeks gestation were shown to have causes similar to those of early neonatal deaths occurring shortly after birth. In efforts to reduce the overall infant mortality rate, the etiology of early neonatal deaths must be addressed in tandem with fetal deaths. From an increased understanding of factors contributing to fetal demise or subsequent death shortly after birth provisions to improve both maternal health and fetal development to achieve a healthy infant may be implemented. Public health professionals and researchers are encouraged to use perinatal mortality as the indicator of choice for examining the burden of adverse pregnancy outcomes along the continuum.

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Figure 1. Trends in Fetal and Early Neonatal Death 2001-2006

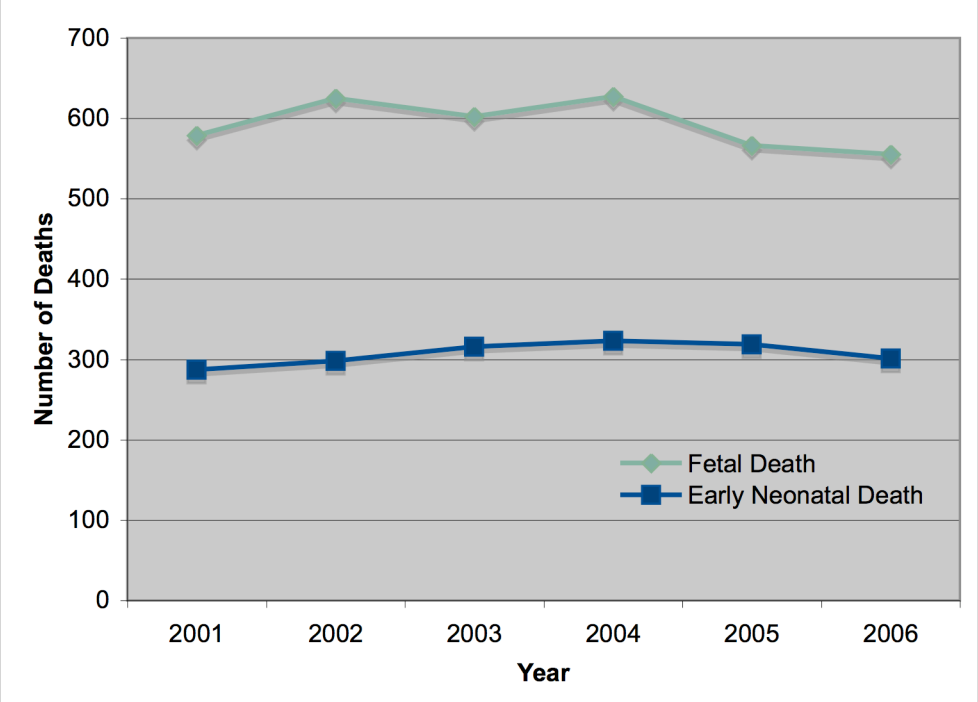

Figure 2. Distribution of Fetal and Early Neonatal Death by Gestational Age

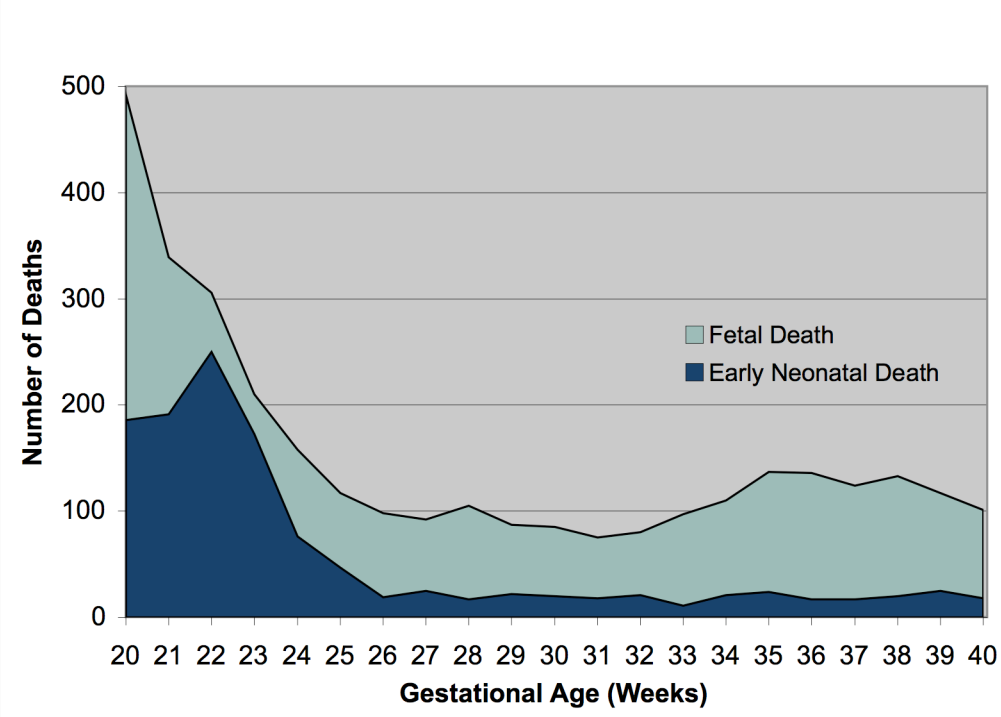

Figure 3. Fetal Death Rates(per 1,000) in the Commonwealth of Virginia by Health District, 2001-2006

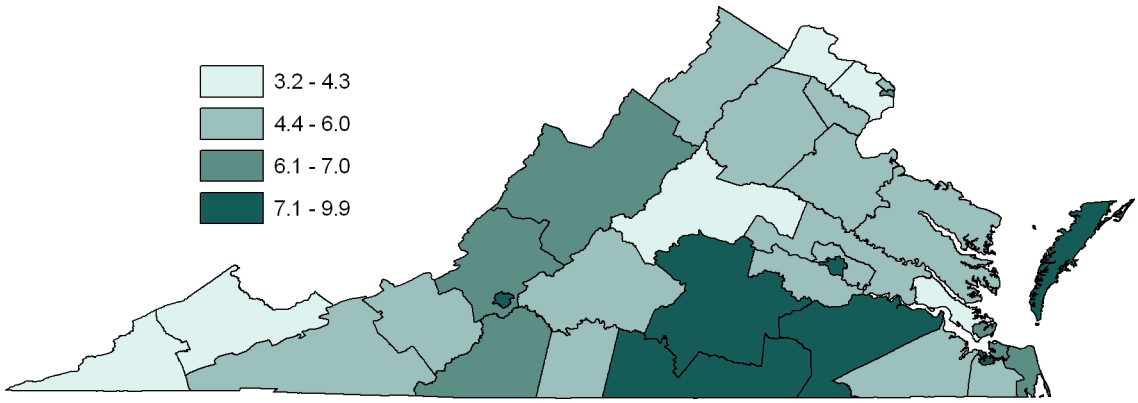

Figure 4. Early Neonatal Mortality Rates (per 1,000) in the Commonwealth of Virginia by Health District, 2001-2006

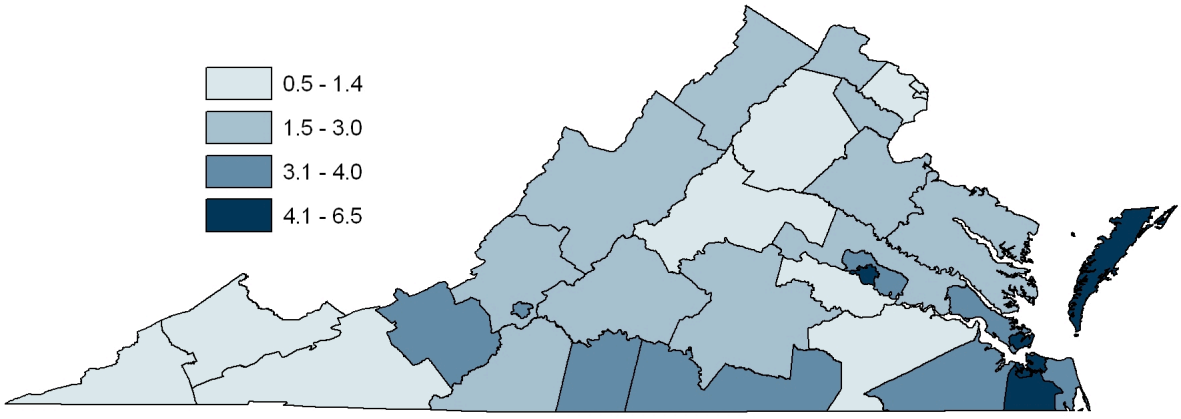

Table 1. Leading Underlying Causes of Fetal and Early Neonatal Mortality, Virginia Residents, 6 Year Average

		Fetal Death			
ICD-10 Code	Underlying cause of death	Rank	6 yr avg n	% of all fetal deaths	Fetal Death rate per 100,000 Fetal Deaths & Live Births
A00-Y89	All causes		539	100.0%	542.5
P95	Fetal death of unspecified cause	1	206	38.2%	207.2
P01	Effect of maternal complications of pregnancy	2	148	27.5%	149.2
P02	Complications of placenta, cord & membrane	3	76	14.1%	76.3
P07	Disorders of short gestation and low birth weight	4	54	9.9%	53.8
Q00-Q99	Congenital malformations deformations & chromosomal abnormalities	5	24	4.4%	23.9
I46	Cardiac arrest	6	8	1.5%	7.9
P20-P21	Intrauterine hypoxia & birth asphyxia	7	8	1.4%	7.7
P00	Effect of maternal conditions	8	7	1.2%	6.2
P83	Other conditions of integument specific to newborn	9	5	0.9%	4.7
P05	Slow fetal growth & fetal malnutrition	10	3	0.6%	3.0
P70	Disorders of carbohydrate metabolism	11	1	0.2%	0.8
RESIDUAL	All other causes	n/a	3	0.5%	2.7

Early Neonatal Death

ICD-10 Code	Underlying cause of death	Rank	6 yr avg n	% of all early neonatal deaths	Early Neonatal Mortality rate per 100,000 Live Births
A00-Y89	All causes		245	100.0%	247.5
P07	Disorders of short gestation and low birth weight	1	98	40.0%	99.0
Q00-Q99	Congenital malformations, deformations & chromosomal abnormalities	2	39	15.8%	39.2
P01	Effect of maternal complications of pregnancy	3	37	14.8%	36.7
P02	Complications of placenta, cord & membrane	4	16	6.4%	15.9
P29	Cardiovascular disorders	5	12	4.6%	11.5
P28	Respiratory conditions	6	6	2.5%	6.1
P22	Respiratory distress	7	6	2.2%	5.4
P96	Other perinatal conditions	8	5	1.9%	4.7
R99	Other ill-defined and unspecified cause of mortality	9	4	1.5%	3.7
P36	Bacterial sepsis of newborn	10	3	1.2%	2.9
P83	Other conditions of integument specific to newborn	11	3	1.2%	2.9
RESIDUAL	All other causes	n/a	20	7.9%	19.6

Table 2 Determinants for Singleton Fetal and Early Neonatal Deaths

Fetal Death

			Crude		Adjusted	
	N	**%**	**OR**	**95% CI**	**OR**	**95% CI**
Sex						
Male	1438	53.94	1.12	1.04, 1.21	1.28	1.08, 1.53
Female	1228	46.06	ref		ref	
Race/Ethnicity						
White, NH	1522	49.27	ref		ref	
Black, NH	1139	36.87	2.10	1.94, 2.27	1.46	1.18, 1.81
Hispanic, any race	284	9.19	0.99	0.87, 1.13	0.76	0.53, 1.10
Other, NH	144	4.66	0.82	0.69, 0.97	0.77	0.50, 1.19
Mother's Age						
< 19 years	223	7.07	1.6	1.39, 1.84	0.95	0.62, 1.44
19-24 years	963	30.54	1.31	1.21, 1.42	1.00	0.79, 1.25
25-34 years	1355	42.97	ref		ref	
35-44 years	604	19.16	1.44	1.31, 1.59	1.48	1.14, 1.91
45+ years	8	0.25	2.42	1.20, 4.87	2.19	0.30, 16.03
Mother's Education						
< 12 years	365	18.76	1.67	1.47, 1.89	1.24	0.90, 1.69
12 years	798	41.01	1.79	1.62, 1.97	1.41	1.14, 1.75
> 12 years	783	40.24	ref		ref	
Live births, now living						
None	1460	50.96	1.49	1.36, 1.62	1.71	1.38, 2.12
One	755	26.35	ref		ref	
2 or more	650	22.69	1.21	1.09, 1.35	0.73	0.56, 0.95
Live births, now dead						
None	1978	75.18	ref		ref	
1 or more	653	24.82	32.02	29.20, 35.10	56.10	45.45, 69.25
Marital Status						
Married	1687	55.68	ref		ref	
Not Married	1343	44.32	1.72	1.60, 1.85	1.11	0.88, 1.40
Method of Delivery						
Vaginal	2546	89.27	ref		ref	
C-Section	306	10.73	0.31	0.28, 0.35	0.14	0.10, 0.20

Adverse Events of Labor/Delivery						
Yes	1387	43.02	2.71	2.53, 2.91	4.20	3.50, 5.03
No	1837	56.98	ref		ref	
Congenital anomalies of child						
Yes	392	12.16	25.33	22.66, 28.31	26.24	19.62, 35.10
No	2832	87.84	ref		ref	
Tobacco use						
Yes	195	6.05	0.83	0.72, 0.96	0.79	0.57, 1.11
No	3029	93.95	ref		ref	
Alcohol use						
Yes	17	0.53	1.33	0.83, 2.15	1.29	0.38, 4.34
No	3207	99.47	ref		ref	
Drug use						
Yes	25	0.78	1.26	0.85, 1.88	0.22	0.05, 1.02
No	3199	99.22	ref		ref	
Source of prenatal care						
No Care	91	4.23	4.91	3.97, 6.07	1.78	0.97, 3.25
Private physician	1576	73.34	ref		ref	
Health department	166	7.72	1.04	0.88, 1.22	0.78	0.52, 1.19
Other	316	14.70	1.17	1.04, 1.32	1.00	0.79, 1.27
Method of payment						
Medicaid	550	27.99	1.34	1.22, 1.49	0.95	0.75, 1.21
Self-pay	224	11.40	2.24	1.94, 2.59	1.14	0.78, 1.66
Private Insurance	1191	60.61	ref		ref	
Previous Preterm Birth						
Yes	28	1.31	1.22	0.84, 1.78	0.63	0.34, 1.17
No	2112	98.69	ref		ref	

Early Neonatal Death

			Crude		Adjusted	
	N	**%**	**OR**	**95% CI**	**OR**	**95% CI**
Sex						
Male	819	56.06	1.22	1.10, 1.35	1.38	1.13, 1.68
Female	642	43.94	ref		ref	
Race/Ethnicity						
White, NH	567	39.10	ref		ref	
Black, NH	686	47.31	3.40	3.04, 3.80	1.12	0.89, 1.41
Hispanic, any race	139	9.59	1.30	1.08, 1.57	1.19	0.80, 1.77
Other, NH	58	4.00	0.88	0.67, 1.15	0.90	0.53, 1.54
Mother's Age						
<19 years	136	9.30	2.15	1.79, 2.59	1.31	0.86, 1.98
19-24 years	480	32.81	1.44	1.28, 1.63	0.91	0.70, 1.17
25-34 years	613	41.90	ref		ref	
35-44 years	232	15.86	1.23	1.05, 1.43	1.30	0.97, 1.75
45+ years	2	0.14	1.34	0.33, 5.36	2.66	0.45, 15.88
Mother's Education						
<12 years	270	20.32	1.93	1.66, 2.24	0.83	0.59, 1.17
12 years	559	42.06	1.96	1.74, 2.21	1.07	0.85, 1.37
>12 years	500	37.62	ref		ref	
Live births, now living						
None	757	51.67	1.57	1.38, 1.78	0.94	0.73, 1.22
One	371	25.32	ref		ref	
2 or more	337	23.00	1.28	1.11, 1.49	1.36	1.03, 1.81
Live births, now dead						
None	1382	94.33	ref		ref	
1 or more	83	5.67	5.83	4.66, 7.28	4.24	2.59, 6.95
Marital Status						
Married	719	49.08	ref		ref	
Not Married	746	50.92	2.24	2.02, 2.48	1.22	0.95, 1.56

Birth weight						
<1000g	690	72.94	1747.06	1388.40, 2200.80	>1000	>1000
1000-1499g	60	6.34	113.85	81.91, 158.23	152.99	96.96, 241.41
1500-2499g	107	11.31	22.23	16.78, 158.23	19.96	13.55, 29.40
2500g+	89	9.41	ref		ref	
Method of Delivery						
Vaginal	1234	84.23	ref		ref	
C-Section	231	15.77	0.48	0.42, 0.56	0.29	0.23, 0.37
Adverse Events of Labor/Delivery						
Yes	754	51.47	3.81	3.44, 4.22	1.69	1.37, 2.08
No	711	48.53	ref		ref	
Congenital anomalies of child						
Yes	225	15.36	33.22	28.71, 38.45	52.26	35.21, 77.56
No	1240	84.64	ref		ref	
Tobacco use						
Yes	111	7.58	1.06	0.87, 1.29	0.95	0.65, 1.40
No	1354	92.42	ref		ref	
Alcohol use						
Yes	11	0.75	1.90	1.05, 3.44	0.54	0.14, 2.08
No	1454	99.25	ref		ref	
Drug use						
Yes	28	1.91	3.15	2.17, 4.59	0.67	0.29, 1.54
No	1437	98.09	ref		ref	
Source of prenatal care						
No Care	174	12.01	19.35	16.37, 22.86	2.09	0.86, 5.12
Private physician	764	52.73	ref		ref	
Health department	110	7.59	1.42	1.16, 1.73	0.99	0.64, 1.52
Other	401	27.67	3.07	2.72, 3.46	1.13	0.90, 1.43
Method of payment						
Medicaid	445	30.84	1.56	1.39, 1.76	0.79	0.61, 1.02
Self-pay	170	11.78	2.45	2.07, 2.88	1.04	0.70, 1.54
Private Insurance	828	57.38	ref		ref	

Trimester of Prenatal Care Initiation						
First trimester	1098	75.26	ref		ref	
Second trimester	144	9.87	4.39	3.80, 5.08	0.79	0.57, 1.11
Third trimester	217	14.87	0.97	0.82, 1.15	0.73	0.32, 1.65
Previous Preterm Birth						
Yes	25	2.56	2.42	1.62, 3.60	0.45	0.23, 0.87
No	953	97.44	ref		ref	

Table 3. Comparisons of Determinants for Singleton Fetal and Early Neonatal Deaths

	Fetal Death		Early Neonatal Death		Chi-square	p-value
	N	%	N	%		
Sex					1.71	0.191
Male	1438	53.94	819	56.06		
Female	1228	46.06	642	43.94		
Race/Ethnicity					50.04	**<0.0001**
White, NH	1522	49.27	567	39.10		
Black, NH	1139	36.87	686	47.31		
Hispanic, any race	284	9.19	139	9.59		
Other, NH	144	4.66	58	4.00		
Mother's Age					14.90	**0.0049**
< 19 years	223	7.07	136	9.30		
19-24 years	963	30.54	480	32.81		
25-34 years	1355	42.97	613	41.90		
35-44 years	604	19.16	232	15.86		
45+ years	8	0.25	2	0.14		
Mother's Education					2.58	0.2753
<12 years	365	18.76	270	20.32		
12 years	798	41.01	559	42.06		
>12 years	783	40.24	500	37.62		
Live births, now living					0.53	0.7662
None	1460	50.96	757	51.67		
One	755	26.35	371	25.32		
2 or more	650	22.69	337	23.00		
Live births, now dead					234.22	**<0.0001**
None	1978	75.18	1382	94.33		
1 or more	653	24.82	83	5.67		
Marital Status					17.28	**<0.0001**
Married	1687	55.68	719	49.08		
Not Married	1343	44.32	746	50.92		

Method of Delivery					22.56	**<0.0001**
Vaginal	2546	89.27	1234	84.23		
C-Section	306	10.73	231	15.77		
Adverse Events of Labor/Delivery					28.96	**<0.0001**
Yes	1387	43.02	754	51.47		
No	1837	56.98	711	48.53		
Congenital anomalies of child					9.02	**0.0027**
Yes	392	12.16	225	15.36		
No	2832	87.84	1240	84.64		
Tobacco use					3.86	**0.0495**
Yes	195	6.05	111	7.58		
No	3029	93.95	1354	92.42		
Alcohol use					0.85	0.3571
Yes	17	0.53	11	0.75		
No	3207	99.47	1454	99.25		
Drug use					11.63	**0.0006**
Yes	25	0.78	28	1.91		
No	3199	99.22	1437	98.09		
Source of prenatal care					200.61	**<0.0001**
No Care	91	4.23	174	12.01		
Private physician	1576	73.34	764	52.73		
Health department	166	7.72	110	7.59		
Other	316	14.70	401	27.67		
Method of payment					3.88	0.1435
Medicaid	550	27.99	445	30.84		
Self-pay	224	11.40	170	11.78		
Private Insurance	1191	60.61	828	57.38		
Previous Preterm Birth					6.26	**0.0124**
Yes	28	1.31	25	2.56		
No	2112	98.69	953	97.44		