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Exploring prenatal care in a rural Appalachian state: A Project WATCH study of barriers and facilitators in all births from May 2018 to March 2022

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ABSTRACT

Exploring prenatal care in a rural Appalachian state: A Project WATCH study of barriers and facilitators in all births from May 2018 to March 2022

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Introduction: PNC is essential in protecting the health of birthing person and infant. Teenage and advanced maternal age (AMA) birthing persons are known risk factors for poor birth outcomes. However, less is known about whether these age groups are associated with inadequate PNC. Births to teenagers continue to be of concern in rural areas however, little is known about the association between inadequate PNC and poor infant outcomes in teenage populations. Previous studies have determined that greater risk of inadequate PNC has been linked to more rural areas compared to more urban areas. WV is the third most rural state with the majority of people living in rural areas. While PNC inadequacy has been examined in other rural settings this type of analysis has not been performed in West Virginia. The goal of this dissertation was to fill the gaps in the literature in a series of three studies: 1) The aim of study 1 was to determine which maternal age group was at increased odds of inadequate PNC, 2) The goal of study 2 was to determine if infants of teenagers who received inadequate PNC were at increased odds of poor infant outcomes (longer infant length of stay (LOS), infant being admitted to the NICU, infant being small for gestational age (SGA),and the infant having a low 5-minute APGAR score) compared to infants of teens who received adequate PNC, and 3) The 3rd study aimed to determine the geographic distribution of inadequate PNC in WV using spatial epidemiology.

Methods: Study 1 analysis used logistic regression analysis using the maternal age group of 25-29 years old as the referenced group. Study 2 analysis included logistic regression analysis to analyze the NICU, SGA, APGAR variables and Kaplan-Meier curves to determine if the probabilities of LOS differed between inadequate and adequate PNC groups and a Weibull model was used to perform a survival analysis to determine the bivariate relationship between PNC groups LOS. Study 3 analysis used 2 separate Bayesian Spatial Hierarchical regression models for private and public (WV Medicaid) health insurance groups.

Results: The results of study 1 examining PNC inadequacy across maternal age groups found the adjusted odds of receiving inadequate PNC was significantly higher in birthing persons aged 19 and younger (aOR: 1.3, CI:(1.14,1.43), $p < 0.0001$), 35-39 (aOR: 1.1, CI:(1.00,1.21), $p = 0.05$), 40 and older (aOR: 1.3, CI:(1.06,1.52), $p = 0.01$) compared to persons 25-29 years old. The results of study 2 analyzing PNC inadequacy in teen and their infant outcomes found significantly increased odds of poor infant outcomes such as infant being admitted to the NICU (aOR: 1.84, CI:(1.41, 2.42), $p <0.0001$), having a low 5-minute APGAR score (aOR: 3.26, CI:(2.03,5.22), $p <0.0001$), and a longer length of stay (Est. = -0.33, HR: 0.72, CI:(0.65,0.81), $p <0.0001$) in infants of teens who received inadequate PNC compared to infants of teens who received adequate PNC. The results of study 3 which aimed to examine geographic differences in PNC inadequacy showed the only covariate with a statistically significant association with risk of inadequate PNC for both private and public insurance groups of pregnant women was 30-minute drive time barrier (public IRR:3.83, CI:(2.85,5.18)) (private IRR:4.31, CI:(3.17,5.88)). The study found increased areas of hotspots of inadequate PNC in the eastern and southern parts of the state. The study also determined that most hotspots in the private insurance group were

located outside of the 30-minute drive time buffer. For the public insurance group hotspots were located inside and outside of the 30-minute drive time barrier.

Discussion: It was found that both teenage and AMA birthing person age groups were at significantly increased risk of inadequate PNC in WV when compared to 25-29-year-olds. Since it is already known these groups are at increased risk of poor infant and birthing persons outcomes, provision of adequate PNC is more important than ever for the health of the birthing person and the infant. Infant outcomes in teenage births were further explored to determine if receiving inadequate PNC had an effect on infant outcomes. The results showed significant effects on infant LOS, NICU status, and APGAR score. These results not only outline the importance of receiving adequate PNC but the importance of reaching the teenage population and giving extra support to help them receive PNC. The third study really highlights the geographic barriers to PNC that exist in WV. The study showed disparities in PNC in the eastern and southern regions of the state which are more rural and mountainous. The study also concluded that having to drive more than 30 minutes is a significant barrier to PNC. This points to transportation and location of birthing facilities being an issue to address for provision of PNC. The study also finds differences in hot spot locations of inadequate care between private and public insurance groups, this leads us to believe that these groups experience barriers to PNC differently. Results of all three studies show the overwhelming importance of receiving adequate PNC and the need to increase support to at risk groups and to help mitigate barriers to PNC across the state.

Dedication

This dissertation is dedicated to my parents, sister, fiancé, and mentor who provided unwavering support throughout my entire dissertation and educational process.

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CHAPTER 1

Prenatal Care (PNC) is one of the most important forms of preventative medicine because it is essential for ensuring the wellness of mother and baby and reducing risk for expecting mothers and their infants (1). PNC typically involves a wide variety of interactions between clinicians and expecting mothers, including exchanging pregnancy and birth information, facilitation of education, screening measures for abnormalities and complications for mother and baby, monitoring/continuous care, and preparation for childbirth and motherhood (2, 3). PNC additionally provides opportunities for the detection and treatment of disease, at providing interventions in a timely fashion, promoting overall wellness, and facilitating informed birth choice (1-7).

The National Center for Health Statistics states that in the years 2016- 2020 approximately 15% of women in the US, including women in the rural Appalachian state of West Virginia, received inadequate PNC based on the APNCU index (1, 8). The current pattern of PNC visits in place in the USA was introduced in the 1920s by Dame Janet Campbell (2). This fixed pattern of visits requires women to been seen once every 4 weeks until the 28th week of pregnancy, every two weeks between the 28th and 36th week of pregnancy, and weekly after the 36th week of pregnancy (2, 9). The American College of Obstetrics and Gynecology (ACOG) updates guidelines yearly; the 2022 guidelines state that the initial evaluation should be within the first 12 weeks of pregnancy. This evaluation should include a complete physical exam, family medical history of the mother and father, lifestyle, medical, and sexual history, current medication and drug use, a depression and domestic violence screening, evaluation of due date, a lab workup, and discussions about diet and smoking status. It may also include screening tests for fetal abnormalities. Up to 28 weeks of gestation, the PNC visits should include a physical exam of blood pressure, weight, fundal height, and fetal heart rate and lab tests including testing for gestational diabetes and a urine dipstick for glucose and protein. During the period of 28-36 weeks of gestation, PNC visits consist of a physical exam of blood pressure, weight, fundal height, fetal heart rate, and assessment for edema. It may include more lab tests, and a discussion with the expecting mother about choosing a pediatrician, breast feeding support, immunizations, baby safety at home, baby sleeping arrangements, car seats, and support at home. At 36 weeks gestation and after, PNC appointments include a physical exam of blood pressure, weight, fundal height, fetal heart rate, assessment of edema, and fetal presentation. It should also include lab tests including a urine dipstick for glucose and protein, a Group B Strep screen, an STD screening if indicated, and a discussion about long travel and the birth plan (10).

Maternal Age and Pregnancy

Over the course of pregnancy, women face many health risks and concerns. Women of advanced maternal age (AMA; age 35 and older) (11, 12) are at increased risk of many adverse maternal and child health outcomes, including: maternal mortality, miscarriage, preterm labor, gestational diabetes, pre-eclampsia, gestational hypertension, stillborn infant, chromosomal abnormalities, infant that is small for gestational age, intrauterine growth restriction, infant needing transferred to the neonatal intensive care unit (NICU), low APGAR score, and increased probability of requiring a C-section (11). Over the past three decades there has been an increase of births to women of AMA in the US (11). As maternal age increases, the risk of ectopic pregnancy increases as well; some studies demonstrate an 8 times increased risk of ectopic pregnancy for women of AMA than those 15-19 years old (11, 13). This may be due to accumulated exposure to risk factors, increased number of sexual partners, pelvic infections, and tubal pathologies (11, 13).

Women older than 35 are not the only ones at increased risk; teenage mothers are also at increased risk of poor pregnancy outcomes. Pregnancy and birth complications are the number one cause of death of girls ages 15-19 globally (14, 15). The Youth Risk Behavior Study found that nearly half of high school students in the US had sex in their lifetime and approximately 7% had sex before the age of 13 (16, 17). Many researchers equate these higher rates of poor outcomes to lower socioeconomic status and to the hypothesis of biological immaturity (18, 19). Teenage mothers are more likely to be poverty-stricken, minority racial or ethnic status, have less education, and be unmarried compared to their older peers (16, 18-20). Research studies have also shown that teenagers are more likely to smoke cigarettes and gain less weight during pregnancy (16). Infants of teenage mothers are at increased risk of pre-term delivery and being of low birth weight (16, 21). Some studies have found increased risk for neonatal mortality (22-24); however, others have found no increased risk (16, 25-27). Studies have also shown that teenage pregnancy decreases educational and economic opportunities; (21) however, the consensus shows that while teen pregnancy is associated with decreased educational and economic opportunities it is not necessarily causal (21).

Defining Inadequate PNC

Inadequate PNC has multiple definitions across literature. Many studies define inadequate PNC as initiation of care after 12 weeks of gestation or receiving less than 12 visits in total (1-4, 6, 7, 9, 28-30), while others depend on indexes, including the Kessner Index, the Graduated Index of Prenatal Care Utilization, the Adequacy of Prenatal Care Utilization, and the Missouri Index.

The Kessner Index classifies PNC into three categories: adequate, intermediate, and inadequate. For PNC to be considered adequate, initiation must begin in the first trimester and there must be 9 or more visits total for a pregnancy of 36 weeks or more (31). While widely accepted, the Kessner Index is not without flaws: the Kessner Index is mainly a measure of the timing of initiation to PNC and does not distinguish between inadequacy of care from late initiation and inadequacy due to insufficient number of PNC visits. The Kessner Index only requires nine total visits for a full-term infant for adequate PNC, and there is no differentiation for late-term births (31).

Another index for the measurement of PNC adequacy is the Graduated Index of Prenatal Care Utilization (GINDEX) and the revised version of GINDEX (R-GINDEX). Both GINDEX and R-GINDEX have three parameters measured to determine the adequacy of PNC care: trimester of initiation of care, gestational age, and the total number of PNC visits. This index is most popularly used in examining preterm births (32). Due to the three parameters, the GINDEX index is commonly viewed as an improvement over the Kessner Index (33).

The Adequacy of Prenatal Care Utilization (APNCU) index (or Kotelchuck Index) is a less frequently used index developed in response to the flaws of the Kessner Index. It uses two parameters, including time of initiation and number of visits (34). The APNCU index bases the number of visits off of the ACOG standards for uncomplicated healthy pregnancies that is used by practicing physicians as PNC standard of medical care (34). This index categorizes care into four categories: inadequate, intermediate, adequate, and adequate plus. Inadequate PNC is considered less than 50% of expected PNC visits, or 6 or less visits by ACOG standards. Intermediate PNC is considered 50-79% of expected PNC visits, which by ACOG standards would be 7 to 8 visits. Adequate PNC is 80-109% of expected PNC visits, or 9 to 13 total visits. Adequate plus PNC care is 14 or more total PNC visits resulting in 110+%. (34-36).

The Missouri Index is similar to the APNCU index because it also used the ACOG guidelines; however, it only classifies care into two categories: adequate and inadequate. The Missouri Index classifies inadequate care as less than 5 visits for pregnancies less than 37 weeks of gestation, less than 8 visits for pregnancies 37 weeks of gestation or greater, and any initiation to care beginning after the first four months of gestation (34).

The Project WATCH/WV Birth Score Program dataset classifies inadequate PNC as < 10 PNC visits total. This classification is based off the ACOG guidelines recommending a PNC visit every four weeks until 28 weeks, then every two or three weeks until 36 weeks, and weekly thereafter for uncomplicated pregnancies (10). Based on these guidelines 10 or 11 PNC visits is optimal. A previous study using this dataset by Umer et al. determined by way of ROC analysis that 10 PNC visits optimized the sensitivity and specificity for PNC visits and infant mortality, and also determined that the strength of the bivariate associations were stronger with < 10 PNC visits being the cut off for adequate PNC (37). Since the Project WATCH/WV Birth Score Program dataset is being used, inadequate PNC will be defined by a mother receiving < 10 PNC visits total for the purpose of this study.

Barriers to PNC

Prior research has identified many barriers to PNC, including among young mothers (2, 3, 7, 28, 29), those living in an area with below average family income (9), those living in an area with few office-based primary care physicians (7), and Medicaid insurance holders (6). When mothers with Medicaid were directly compared with mothers with private insurance it was found that mothers with Medicaid were at increased risk of inadequate PNC (6, 7). Studies have found increased risk of inadequate PNC in expecting mothers who lack insurance when compared to expecting mothers with private insurance or Medicaid (38-40). Consistent with

Medicaid insurance, lower socioeconomic status more generally is found to be associated with PNC inadequacy, as well as lower health care adequacy in general (41). A study by Perloff and Jaffee determined that if 30% of a zip code lived below the poverty line or if 60% of the population or if the majority of the population was nonwhite the initiation for late PNC was increased (7). Similar economic findings were found by Heaman et al., who determined that more inadequate rates of PNC were found in neighborhoods that had medium to high rates of unemployment, with high rates of single parent households, and where the residents had lower education levels (9). The lack of availability of childcare and social and family support can be a barrier to PNC that is difficult to measure and quantify but needs to be considered as possible confounders (42).

Geographic Barriers to PNC

There are other links between geographic regions where the expecting mother lives and barriers to PNC above and beyond SES indicators. Research from 2000 to 2012 shows that women in rural areas had increased rates of inadequate PNC in comparison to women in more urban areas (43, 44). There are many reasons for this; mothers may not have easy access or transportation to medical care and access to childcare may not be as readily available (38, 42) Additionally, in recent years, there has been a reduction of PNC services in rural areas due to workforce challenges, regionalization of healthcare, low birth volume, and cost of malpractice insurance (43). The barriers may not be equal across rural regions: some rural areas may be more proximal to urban areas, which can play a role in overall PNC care. A study of US pregnant women living in rural areas found an increase of births with no PNC care in women living in rural areas not adjacent to urban areas compared to women living in urban-adjacent areas (44).

Summary

In summary, PNC is important to the health of both the expecting mother and fetus. Several factors are known risk factors for poor PNC and/or birth outcomes. For example, we know maternal age is typically association with poorer birth outcomes for teens (18, 19) and AMA (11, 13). However, less is known about maternal age and what age groups other than expecting teenage mothers, (2, 3, 7, 28, 29) if any, are associated with receiving inadequate PNC. We also know teenage pregnancies in general result in higher risk of poor birth outcomes (18, 19) and maternal mortality (14, 15); however, we don't fully understand how this relates to inadequate PNC. Finally, we know geographic may impact PNC (38, 42); however, we don't know how geographic location affects PNC in a majority rural Appalachian state like West Virginia. In the conclusion of this chapter, we will propose three pertinent aims that will fill the outlined gaps in the literature.

Specific Aims

Specific Aim 1

Investigate the association between maternal age and inadequacy of PNC.

Objective 1.1

To determine the association between maternal age (<19 years, 20-24 years, 25-29 years, 30-34 years, 35-39 years, and >40 years) and inadequacy of PNC (<10 PNC visits).

Hypothesis 1.1.

Mothers aged 19 and under will have increased rates of inadequate PNC on average in WV compared to the reference group of mothers aged 25-29 after controlling for pertinent covariates.

Hypothesis 1.2.

Mothers aged 35 and over will have increased rates of inadequate PNC on average in WV compared to the reference group of mothers aged 25-29 after controlling for pertinent covariates.

Specific Aim 2

Guided in part by Aim 1 outcomes, investigate differences in infant outcomes of teenage pregnancies in teenagers who receive adequate PNC (≥ 10 visits) compared to teenagers who receive inadequate PNC (< 10 PNC visits).

Objective 2.1.

To determine if infants of teenage mothers who received inadequate PNC (< 10 PNC visits) have poorer infant outcomes (longer length of stay in the hospital, lower infant weight, and lower APGAR score) than infants of teenage mothers who received adequate PNC (≥ 10 visits).

Hypothesis 2.1.

Infants of teenage mothers who received inadequate PNC (< 10 PNC visits) will have poorer infant outcomes (longer length of stay in the hospital, lower infant weight, neonatal, and lower APGAR score) than infants of teenage mothers who received adequate PNC (≥ 10 visits).

Specific Aim 3

Using spatial epidemiology methodology, investigate the geographic distribution of inadequacy of PNC (adequate ≤10 PNC visits) in WV.

Objective 3.1

To determine what zip codes have increased rates of inadequate PNC (< 10 PNC visits).

Hypothesis 3.1.

Zip codes that reside further from birthing centers will have increased rates of inadequate PNC (< 10 PNC visits) when compared zip codes closer to birthing centers.

Significance

To our knowledge very few studies have researched associations with receiving inadequate PNC, particularly in the rural state of WV. This proposed research can have a significant impact in determining whether or not maternal age is associated with inadequate PNC and if inadequate PNC is associated with particular infant outcomes within teenage pregnancies in WV. This proposed research can also have a significant impact on evaluating areas within the state that receive higher rates of inadequate PNC on average and can aid in determining what these barriers are and why they exist.

Potential Public Health Implications

This proposed research has many implications to public health, particularly within the state of WV. Determining factors and barriers to receiving adequate PNC can aid in directing more targeted research or prevention measures into improving education and access to PNC for expecting mothers in WV and nationally. It is expected that the results of this study will contribute to the planning and implementation of preventative measures and promoting the importance of PNC. This proposed research additionally could aid in providing more targeted education to mothers who are at increased risk of inadequate PNC due to age or socioeconomic factors, as well as targeted education and increased access to areas within the state that are more at risk to receiving inadequate PNC due to geographic barriers that may exist.

CHAPTER 2

Abstract

Introduction: Adequate prenatal care (PNC) is essential to the overall health of mother and infant. Teenage and advanced maternal age (AMA) are known risk factors for poor birth outcomes. However, less is known about whether these age groups are associated with inadequate PNC.
Purpose: To determine the association between maternal age (<19 years, 20-24 years, 25-29 years, 30-34 years, 35-39 years, and >40 years) and inadequate PNC (<10 visits)
Methods: The study used West Virginia (WV) Project WATCH population level data (May 2018-March 2022). Multiple logistic regressions were performed on inadequate PNC (<10 PNC visits) with maternal age categories (<20, 20-24, 25-29 (referent), 30-34, 35-39, and ≥40 years old), adjusting for covariates including maternal race, smoking status, substance use status, parity, education, geographic location, and insurance status.
Results:11.04% of pregnant people who gave birth in WV received inadequate PNC. Participants aged <20 years (aOR:1.3, CI:(1.16,1.37)), 35-39 years (aOR:1.10, CI:(1.01,1.20)), and ≥ 40 years (aOR:1.24, CI:(1.05,1.45)) were at increased odds of inadequate PNC relative to 25–29-year-olds.
Discussion: Results demonstrated that both young and AMA pregnant people are more likely to receive inadequate PNC. PNC is particularly important for these groups as they are at increased risk of poor birth outcomes.
Implications: Results indicate easily obtained demographics, such as a pregnant person's age, can be utilized by policy makers and clinical interventionists to improve birth outcomes by increasing PNC outreach for these groups.

IntroductionThe National Center for Health Statistics states that in the years 2016- 2020 approximately 15% of women in the United State (US) each year received inadequate PNC based on the Adequacy of Prenatal Care Utilization (APNCU) index (1, 2). Receiving adequate PNC is essential to the health of mother and infant (2-8). Typical PNC involves a wide variety of interactions between clinicians and pregnant mothers, including exchanging pregnancy and birth information, facilitation of education, screening measures for abnormalities and complications for mother and baby monitoring/continuous care, and preparation for childbirth and motherhood (3, 4). PNC additionally provides opportunities for the detection and treatment of diseases, at providing interventions in a timely fashion, promoting overall wellness, and facilitating informed birth choice (2-8).

Over the last 50 years, more women in developed countries are postponing pregnancy (9). The average age of first delivery increased from 23-25 years of age in the 1970s to 27-29 years of age in 2017 to 28-30 in 2022 (9, 10). Although some of the increase in maternal age is due to decreases in teenage pregnancies, most of the increase is attributed to social changes such as effective oral contraceptives, the development of assisted reproductive technology and women prioritizing their education and careers (9, 11). Women of advanced maternal age (AMA; age 35 and older) (12, 13) are at increased risk of many adverse maternal and child health outcomes, including: maternal mortality, miscarriage, preterm labor, gestational diabetes, pre-eclampsia, increased probability of requiring a C-section, gestational hypertension, stillborn infant, chromosomal abnormalities, infant that is small for gestational age, infant needing transferred to the neonatal intensive care unit, and low APGAR score (12). This makes adequate PNC even more essential in ensuring the health of mother and infant in mothers of AMA.

Pregnancy and birth complications are the number one cause of maternal mortality in teenage women (14, 15). While teenage pregnancy (≤19 years old) on a global level has been decreasing since the 1970's, rates are still high (16). Teenage mothers are more likely to be poverty-stricken, minority racial or ethnic status, have less education, and be unmarried compared to their older peers (17-20). Previous research has observed increased risk of inadequate PNC and poor infant outcomes in teenage pregnant women (14, 15, 21, 22).

Relative to the US, West Virginia (WV) has some of the poorest health and socioeconomic statistics, ranking 2nd highest in terms of poor population health according to WV Behavioral Risk Factor Surveillance System (BRFSS) (23). Although the overall population health is below the US average, the 15% of expecting mothers in WV receiving inadequate PNC is consistent with US averages across the years 2016-2020 (1). WV has a high rate of teenage pregnancies with 22.5 per 1,000 births being from a teenager aged 15-19 compared to the national statistic of 15.4 per 1,000 (24). These poor health indices indicate this population may provide valuable insight to PNC improvement. Determining what age groups are most at risk of PNC inadequacy can aid in targeting education and interventions directly to these at-risk groups to improve rates of PNC across the state of WV.

In summary, PNC is vital for the health of mothers and their infants (3, 4). AMA and teenage mothers have increased risk to their health and to their infants (12). WV is a particularly important place to examine this intersection between maternal age and PNC because of the poorer health and SES statistics in this rural Appalachian state. The main objective of this study was to determine the association between maternal age (<19 years, 20-24 years, 25-29 years, 30-34 years, 35-39 years, and ≥40 years) and inadequate PNC (<10 visits).

Methods and Materials

Subjects

This study used de-identified data from a state mandated surveillance tool called Project WATCH. This tool collects data on all infants and their mothers born in West Virginia with the goal of identifying infants who are at greatest risk for health and care (25). The aim of Project WATCH is to identify newborns who are at a higher risk of infant mortality and health problems (26, 27). This study used data from the years May 2018– March 2022 resulting in a de-identified data sample of 70,724 birthing persons. Gender was not asked of participants; thus, although we may occasionally refer to these individuals with female descriptive characteristics such as "mothers", we understand that not all of our individuals may identify with those terms. This study was deemed exempt by the West Virginia University Institutional Review Board.

Measurements

The main outcome variable for this study is inadequate PNC. Project WATCH collects PNC visits as a binary variable and categorizes < 10 PNC visits as inadequate care and ≥ 10 PNC visits as adequate care. While there are many ways to define inadequate PNC, this method was chosen due to previous research based off the ACOG guidelines stating that 10 or 11 PNC visits is optimal. The cut-off established by Project WATCH data was previously determined by ROC analysis that 10 PNC visits optimized the sensitivity and specificity for PNC visits and infant mortality, and also determined that the strength of the bivariate associations were stronger with < 10 PNC visits being the cut-off for inadequate PNC (28).

The main exposure variable of interest for this study is maternal age. Maternal age is a continuous variable in years in the dataset but was categorized into five categories based off previous research: teenage (19 or younger), 20-24, 25-29, 30-34, 35-39, and 40 years and older

(29-32). The 25-29 year-old age category was selected as the referent group, consistent with previous research (29-32) and because the average age of first birth is 28-30 years old (9, 10).

Socio-demographic variables and other confounder variables were guided by prior research (2-8, 15, 18, 19, 22, 33, 34) and include maternal race (white, black, Asian, Hispanic, multiracial, and other), maternal education (≤ 8^{th} grade, 9^{th} grade, 10^{th} grade, 11^{th} grade, 12^{th} grade, and some college or greater), payment method (private insurance, WV Medicaid, self-pay, other, and unknown), smoking status during pregnancy (yes/no), substance use status during pregnancy (yes/no), geographic region (Right from the Start program regions 1-8 and out of state (35)), and parity (0, 1, 2, and 3 or more). Project WATCH collects data on substance use in pregnancy as a binary response (yes/no), which is assessed using self-report, medical records, and/or positive drug test. Possible substances considered are but not limited to opioids, stimulants, sedatives-hypnotics, phencyclidine (PCP), cannabinoids, gabapentin and antidepressants) to consider as substance use (36). For geographic region, we selected the most rural region with the fewest birthing hospitals as the referent group. This was region 4, which contains 6 counties but only 1 birthing hospital in the central eastern part of the state, geographic regions shown in the supplementary material Figure 1 (35).

Data Analysis

All statistical analyses were conducted in SAS version 9.4 (SAS Institute, Cary NC). Basic descriptive statistics were performed on all variables. Frequencies and valid percentages were calculated for categorical demographic characteristics and covariates for first the full sample, and then stratified by adequate/inadequate PNC. Chi-square with accompanying p-values were calculated to determine significance of categorical associations to inadequate PNC. Logistic regression analysis was used to examine the bivariate relationship between maternal age and adequacy of PNC, and multiple logistic regression analysis was used to examine the relationships between maternal age and adequacy of PNC with covariates. Adjusted and unadjusted odds ratios (OR) were calculated for having inadequate PNC by maternal age category using maternal age group 25-29 as the reference group. Accompanying 95% confidence intervals (CI) are also presented. Any confounding variables found to be related to PNC at a conservative alpha ≤ 0.20 were adjusted for in the final model.

Results

This study used data from a population-based cohort of all births in WV from May 2018 – March 2022. 92.6% of the population was White, 50% had some college education, 46.9% had private insurance and 44.2% had WV Medicaid. Among all the births in WV during that time-period, 11.04% of expecting mothers received inadequate PNC. Of the persons giving birth, 6.3% were 19 years of age or less, of which 13.9% received inadequate PNC. 28.9% were 20-24 years old, of which 11.2% received inadequate PNC. 32.8% were aged 25-29, of which 11.3% received inadequate PNC. 22.5% of persons giving birth were aged 30-34, of which 11.1% received inadequate PNC. Persons aged 35-39 made up 9.6% of this population, of which 12.2% received inadequate PNC. Finally, 1.9% of the population were persons 40 and older, of which 13.7% received inadequate PNC.

For all births in the state of WV, the unadjusted odds of receiving inadequate PNC is significantly higher for the maternal age groups of 19 and younger (aOR:1.3, CI:(1.16,1.37)), $p < 0.0001$), 35-39 (OR:1.10, CI:(1.01,1.20), $p = 0.02$), and 40 and older (OR:1.24, CI:(1.05,1.45) $p = 0.01$) when compared to the reference group of 25-29 years of age. When adjusting for significant covariates the adjusted odds of receiving inadequate PNC slightly attenuated but remained higher for expecting mothers aged 19 and younger (aOR: 1.3, CI:(1.14,1.43), p <

0.0001), 35-39 (aOR: 1.1, CI:(1.00,1.21), p = 0.05), 40 and older (aOR: 1.3, CI:(1.06,1.52), p = 0.01) compared to persons 25-29 years old.

While not the primary focus of this study, an exploration of significant confounders also provides interesting information for this rural Appalachian state. Although only representing a small minority of the rural Appalachian state (<1%), those who identified as Hispanic were 1.5 times (CI:(1.21,1.89), p = 0.0003) as likely to receive inadequate PNC compared to those who identified as white. Birthing persons receiving an 8th grade education or less (aOR:3.3, CI:(2.71,4.04), p <0.0001), 9th grade education (aOR:2.1, CI:(1.78,2.44), p <0.0001) 10th grade (aOR:1.7, CI: (1.54,1.98), p <0.0001) 11th grade (aOR:1.7, CI:(1.54,1.90), p <0.0001) and 12th grade (aOR:1.3, CI:(1.22,1.39), p <0.0001) had increased odds of receiving inadequate PNC when compared to those who had at least some college education. Increased parity was also a risk factor for increased odds of receiving inadequate PNC for 1 child (OR:1.2, CI:(1.13,1.32), p <0.0001), 2 children (OR:1.4, CI:(1.26,1.49), p <0.0001), and 3 or more (OR:1.7, CI:(1.54,1.81), p <0.0001) when compared to birthing persons with no previous children. Payment method also proves to be a significant risk factor; when compared to individuals with private insurance, birthing persons who self-pay for their care are at almost 6 times the risk of receiving inadequate PNC (OR:5.9, CI:(4.89,7.11), p <0.0001). Birthing persons with WV Medicaid (OR:1.9, CI:(1.76,2.02), p <0.0001), birthing persons with a payment method classified as other (OR:1.6, CI:(1.45,1.84), p <0.0001), and those whose payment method is unknown (OR:1.9, CI:(1.50,2.29), p <0.0001) are also at significantly increased odds when compared to those with private insurance. Birthing persons who use substances were at 3.6 times increases risk of inadequate care (OR:3.6, CI:(3.367,3.806), p <0.0001) and birthing persons who smoke were at almost 2 times increases risk (OR:1.9, CI:(1.80,2.03), p <0.0001). When compared to region 4 (i.e., the 6 most rural central and east counties with only a single birthing hospital), we were not surprised to find that birthing persons who live in region 1 or southeast counties (OR:0.66, CI:(0.58,0.75), p <0.0001), region 2 or southwest counties (OR:0.62, CI:(0.55,0.70), p <0.0001), region 3 or capital urban region and surrounding counties (OR:0.59, CI:(0.52,0.67), p <0.0001), and region 5 or central northwest counties (OR:0.85, CI:(0.74,0.97), p = 0.0127) were all at a significantly decreased risk of inadequate PNC. Surprisingly, birthing persons who live in region 6 or the northern panhandle counties (OR:1.2, CI:(1.05,1.37), p = 0.0078) and region 7 or the north central counties (OR:1.3, CI:(1.13,1.41), p <0.0001) are at significantly increased risk of receiving inadequate PNC when compared to those who live in region 4.

Discussion

Our study adds to the limited literature on maternal age and inadequate PNC use in a rural Appalachian state of WV. The results show that 12% of expecting mothers in West Virginia receive inadequate PNC per the dataset definition of inadequate care determined by Umer et al. (28). This number is slightly less than the US average of inadequate prenatal care (~15% in 2020 (2)), although differences may also be related to a less conservative measure of inadequate PNC in our study.

The results also demonstrate that teenage pregnant persons (19 years and younger) and pregnant persons of AMA are at increased risk of receiving inadequate PNC over the course of their pregnancies. Literature states that teenagers and mothers of AMA are at increased risk of poor maternal and infant outcomes (12-15, 20, 37). While some literature exists showing teenage mothers have poorer inadequate prenatal care (3, 4, 8, 34, 38-40), this study adds to the literature showing increased risk of inadequate PNC in birthing persons aged 19 and younger, age 35-39, and 40 and over relative to the referent group of 25-29. While the literature on PNC inadequacy across maternal age groups is scarce, there is literature showing that pregnant teens (41) and women with increased parity (42) are more likely to receive inadequate PNC. Increased parity could possibly explain why it was found women AMA were at increased odds of inadequate care. The next step is to identify barriers to inadequate PNC utilization faced by these demographics in WV.

Next, this analysis showed some interesting trends for covariates in terms of inadequate PNC. Consistent with the literature, high school education and less were associated with inadequate PNC relative to having at least some college (39). Also consistent with previous literature, increased parity is associated with increased inadequacy of PNC (42). Pregnant people identifying as Hispanic (<1% of our population) had increased odds of inadequate PNC which is in line with other publications suggesting an area of policy improvement for the state of WV and on a national scale (43-45).

Insurance status proved to have interesting results, consistent with previous literature individuals with Medicaid have increased odds of inadequate PNC as well as those who self-pay, have other insurance types, and who's insurance type is unknown when compared to those who have private insurance (7, 8, 39, 40, 46-49). The analysis also showed results consistent with previous literature (2) that individuals who smoke and who use substances during pregnancy have increased odds of inadequate PNC compared to those who do not.

Last, high rates of inadequate PNC were observed in the northern regions after accounting for covariates. While several counties in these regions do not have birthing hospitals and are fairly rural (e.g., Barbour, Doddridge, Harrison, Preston, Taylor, Tucker Tyler, Wetzel) this was a surprise as the selected comparison region (region 4, including Braxton, Fayette, Greenbrier, Nicholas, Pocahontas, and Webster counties) had only a single birthing hospital for 6 of the most rural counties in the state. When looking at unadjusted rates, region 4 had the highest inadequate PNC in the state (14.6%); however, the other northern regions of 6 and 7 also had high inadequate PNC (14%).

Limitations

Although the study appropriately models population-level data to demonstrate a relationship between PNC and maternal age, there are some limitations to the study. One of the limitations of this study is the lack of information regarding other potential confounders such as household income, marital status, support within the household, and access to affordable childcare. Not being able to control for these potential confounders may introduce information bias into the study. Secondly, our results may not be generalizable outside of the state. Although this is data specific to WV, the study could potentially lead further research on a wider scale to determine association between maternal age and PNC in other states or on a national level. Finally, the definition of PNC was previously defined in the Project WATCH dataset and cannot be adjusted to fit other indexes of PNC; this limits inferences to other definitions of inadequate PNC. Despite these limitations, this study aids in our understanding of the relationship between multiple maternal age categories and inadequate PNC in the state of WV.

Implications and Next Steps

This study has many implications for public health, particularly within the state of WV. Determining what age category group (19 or younger, 20-24 years old, 25-29 years old, 30-34 years old, 35-39 years old, and 40+ years old) of pregnant persons are at risk for receiving inadequate PNC in WV can aid in directing more targeted research or prevention measures into improving education and access to PNC for pregnant persons of that age group. This research can also aid in improved education in the importance of PNC to teen mothers in the state. This information contributes to the broader literature as well; specifically, to literature on maternal age and how that affects their adequacy of PNC.

Summary

PNC is vital for the health of mothers and their infants (3, 4). AMA and teenage mothers have increased risk to their health and to their infants (12). WV is a particularly important place to examine this intersection between maternal age and PNC because of the poorer health and SES statistics in this rural Appalachian state. This report adds vital information on what age groups are at increased odds of receiving inadequate PNC. Future implications of this report could be aiding in more targeted research and prevention measures to certain at-risk groups. This research could help improve PNC education overall in the state and in Appalachian regions.

Tables

Table 1. Study characteristics of all women who gave birth to all infants born in the state of West Virginia May 2018-March 2022 (n = 70,724)

Variables	Total Frequency(Percent)	Inadequate PNC Frequency(Percent)	Adequate PNC Frequency(Percent)	Chi-square P-value
Maternal Age				<0.0001
19 or Less	4347(6.3%)	603(13.9%)	3744(86.1%)	
20-24	19969(28.9%)	2244(11.2%)	17725(88.8%)	
25-29	22677(32.8%)	2554(11.3%)	20123(88.7%)	
30-34	15534(22.5%)	1728(11.1%)	13806(88.9%)	
35-39	6638(9.6%)	815(12.3%)	5823(87.7%)	
40+	1349(1.9%)	183(13.6%)	1166(86.4%)	
Race				<0.0001
White	64516(92.6%)	7403(11.5%)	57113(88.5%)	
Black	1798(2.6%)	235(13.1%)	1563(86.9%)	
Asian	416(0.6%)	33(7.9%)	383(92.1%)	
Hispanic	679(1.0%)	117(17.2%)	562(82.8%)	
Multiracial	783(1.1%)	128(16.4%)	655(83.7%)	
Other	1476(2.1%)	228(15.5%)	1248(84.6%)	
Maternal Education				<0.0001
8th Grade or Less	556(0.8%)	206(37.0%)	350(63.0%)	
9th Grade	1088(1.5%)	300(27.6%)	788(72.4%)	
10th Grade	2095(3.0%)	514(24.5%)	1581(75.5%)	
11th Grade	3607(5.1%)	795(22.0%)	2812(78.0%)	
12th Grade	27839(39.5%)	3795(13.6%)	24044(86.4%)	
Some College	35244(50.0%)	2478(7.0%)	32766(93.0%)	
Parity				<0.0001
0	21325(30.2%)	1772(8.3%)	19553(91.7%)	
1	20291(28.7%)	2022(10.0%)	18269(90.0%)	
2	13345(18.9%)	1641(12.3%)	11704(87.7%)	
3 or more	15713(22.2%)	2852(18.2%)	12861(81.9%)	
Payment Method				<0.0001
WV Medicaid	31206(44.2%)	5409(17.3%)	25797(82.7%)	
Private	33167(46.9%)	1843(5.6%)	31324(94.4%)	
Self Pay	680(1.0%)	239(35.2%)	441(64.9.%)	
Other	4537(6.4%)	666(14.7%)	3871(85.3%)	
Unknown	1075(1.5%)	126(11.7%)	949(88.3%)	
Smoking Status				<0.0001
Yes	15252(21.6%)	3992(26.2%)	11260(73.8%)	
No	55394(78.4%)	4264(7.7%)	51130(92.3%)	

Substance Use				<0.0001
Yes	9574(13.5%)	3341(34.9%)	6233(65.1%)	
No	61149(86.5%)	4992(8.2%)	56157(91.8%)	
Region				<0.0001
1	1628(8.9%)	694(11.0%)	5620(89.0%)	
2	1952(10.7%)	721(8.9%)	7402(91.1%)	
3	2415(13.2%)	782(8.7%)	8212(91.3%)	
4	1093(6.0%)	631(14.8%)	3644(85.2%)	
5	1324(7.2%)	602(11.6%)	4568(88.4%)	
6	1173(6.4%)	663(14.0%)	4058(86.0%)	
7	3563(19.5%)	1938(14.0%)	11921(86.0%)	
8	1608(8.8%)	889(14.6%)	5195(85.4%)	
Out of State	3562(19.5%)	1251(10.6%)	10599(89.4%)	

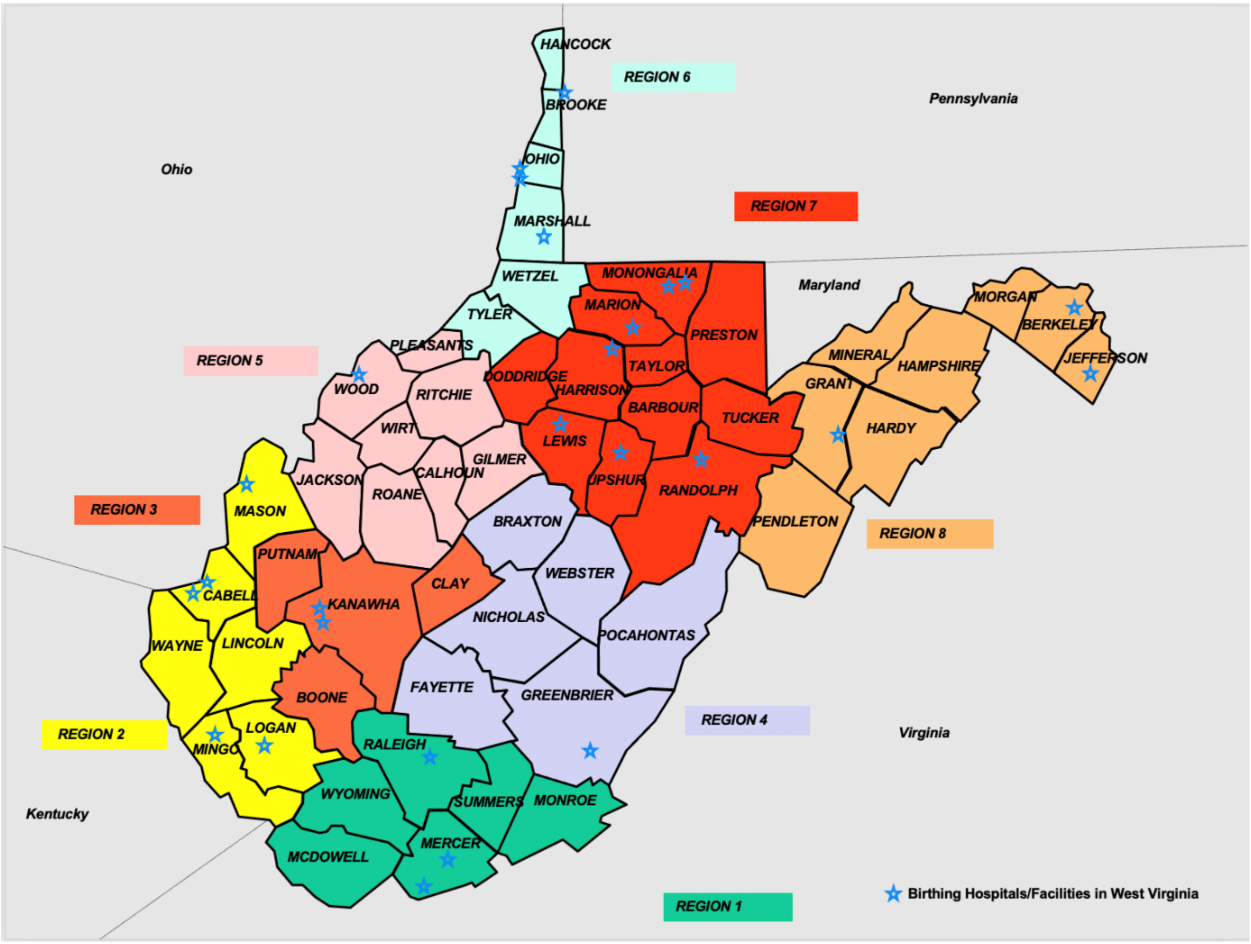
Table 2. Unadjusted and adjusted odds ratios of maternal age category by prenatal care (PNC) inadequacy in the state of West Virginia May 2018-March 2022 (n = 70,724)

Model	Predictor	Odds Ratio (95% CI)	Chi-Square	P-Value
Unadjusted Model	**Maternal Age Category**			
	19 and Younger	1.269(1.155,1.369)	24	<0.0001
	20-24 years old	0.997(0.939,1.059)	0.0067	0.9348
	25-29 years old	1		
	30-34 years old	0.986(0.924,1.052)	0.2	0.6733
	35-39 years old	1.103(1.014,1.199)	5.2	0.0226
	40 and Older	1.237(1.052,1.453)	6.7	0.0098
Adjusted Model	**Maternal Age Category**			
	19 and Younger	1.279(1.140,1.434)	17.7	<0.0001
	20-24 years old	1.00(0.934,1.071)	0	0.9977
	25-29 years old	1		
	30-34 years old	1.047(0.973,1,126)	1.5	0.2178
	35-39 years old	1.098(0.998,1.208)	3.7	0.0545
	40 and Older	1.271(1.061,1.523)	6.8	0.0093
Covariates	**Race**			
	White	1		
	Black	1.022(0.877,1.191)	0.08	0.7792
	Asian	1.275(0.880,1.848)	1.6	0.1992
	Hispanic	1.509(1.208,1.886)	13.1	0.0003
	Multiracial	1.225(0.993,1.511)	3.6	0.0578
	Other	1.143(0.969,1.348)	2.5	0.112
	Maternal Education			
	8th Grade or Less	3.309(2.708,4.044)	137	<0.0001
	9th Grade	2.084(1.782,2.438)	84.2	<0.0001
	10th Grade	1.748(1.544,1.978)	78.1	<0.0001
	11th Grade	1.709(1.541,1.895)	103	<0.0001
	12th Grade	1.302(1.224,1.385)	69.5	<0.0001
	Some College	1		
	Payment Method			
	Private Insurance	1		
	WV Medicaid	1.884(1.760,2.018)	24	<0.0001
	Self Pay	5.895(4.890,7.106)	346	<0.0001
	Other	1.635(1.452,1.841)	66	<0.0001
	Unknown	1.856(1.504,2.290)	33.2	<0.0001
	Smoking Status			
	No	1		

Yes	1.907(1.796,2.026)	440.1	<0.0001
Substance Use			
No	1		
Yes	3.580(3.367,3.806)	1669	<0.0001
Region			
Region 1	0.661(0.580,0.753)	38.4	<0.0001
Region 2	0.621(0.548,0.704)	55.2	<0.0001
Region 3	0.593(0.524,0.672)	68.0	<0.0001
Region 4	1		
Region 5	0.845(0.740,0.965)	6.2	0.0127
Region 6	1.197(1.048,1.366)	7.1	0.0078
Region 7	1.262(1.132,1.408)	17.5	<0.0001
Region 8	1.018(0.899,1.153)	0.1	0.7792
Out of State	0.917(0.810,1.040)	1.8	0.1766
Parity			
0	1		
1	1.221(1.132,1.317)	26.8	<0.0001
2	1.367(1.258,1.486)	54.6	<0.0001
3 or more	1.672(1.542,1.812)	155.3	<0.0001

Supplementary Material

Supplemental Material Figure 1: Regions of West Virginia



CHAPTER 3

Abstract

Introduction: Infants of teenage pregnancies are known to have increased risk of poor infant outcomes. Adequate prenatal care (PNC) is essential to the overall health of infants and their mothers. While teenage pregnancies continue to be of concern in rural areas, little is known about the association between inadequate PNC and poor infant outcomes in teenage populations.
Purpose: To determine the association between inadequate PNC (<10 visits) and poor infant outcomes neonatal intensive care unit (NICU) stay, low APGAR score, small for gestational age (SGA) and length of stay (LOS).
Methods: The study used West Virginia (WV) Project WATCH population level data (May 2018-March 2022). Multiple logistic regressions and survival analysis were performed on infant outcomes; NICU stay, APGAR score, infant size, and infant length of stay (LOS) with PNC categories inadequate (<10 PNC visits) vs adequate (10 or more) adjusting for covariates including maternal race, insurance status, parity, smoking status, substance use status, and diabetes status.
Results: Of births to teenage mothers, 14% received inadequate PNC. Teens who received inadequate PNC had increased odds of infant admitted to NICU (aOR: 1.84, CI:(1.41, 2.42), p <0.0001), low 5- minute APGAR score (aOR: 3.26, CI:(2.03,5.22), p <0.0001), and increased LOS (Est. = -0.33, HR: 0.72, CI:(0.65,0.81), p <0.0001).
Conclusions: Results demonstrated that infants of teenagers who received inadequate PNC are at increased risk of requiring a NICU stay, having a low APGAR score and requiring an increased LOS. PNC is particularly important for these groups as they are at increased risk of poor birth outcomes.

Keywords: Prenatal Care, Teen Pregnancy, APGAR, NICU

Introduction

Pregnancy and birth complications are the number one cause of death of girls ages 15-19 globally (1, 2). Approximately 21 million teenagers give birth each year (1, 2). While global rates of teenage pregnancy have been decreasing since the 1970's, in developed nations, such as the US, Canada, and Western Europe, teenage pregnancy rates remain high (3). In developing countries, these adolescent pregnancies are more likely to be planned and within the union of marriage (4). In developed counties however, adolescent pregnancies are typically unplanned and occur in unmarried women (4). In addition to maternal mortality, teenage pregnancy increases the risk of infant mortality, preterm birth, low birth weight, placental abruption, and eclampsia (1, 2, 5, 6). Teenage births are also associated with decreased education or educational prospects, decreased work prospects, menarche at early age, lack of sexual education, and family history of teenage births (7). Teenage birthing persons are at increased risk of living in poverty, being excluded by their peers and community, and have increased barriers to education post-birth (7). For this study teenage births is defined as a live infant born to an individual less than 20 years of age.

Prenatal Care (PNC)

One medical necessity that may mitigate some of these poor health profiles includes patient-physician interactions during prenatal care (PNC) visits. PNC is essential to the health of mother and baby (8-14), as it gives clinicians the opportunity to advise young mothers and to prepare them for birth and motherhood. These interactions with health care providers can include exchanging pregnancy and birth information, facilitation of education, screening measures for abnormalities and complications for mother and baby, monitoring/continuous care, and preparation for childbirth and motherhood (12, 13). PNC also provides the possibility of early detection and possible treatment of diseases, initiate timely intervention, promote overall wellness, and aid in facilitating informed birth choices (8-14).

The most common and publicly well-validated indices for adequate PNC are the Kessner Index and the Adequacy of Prenatal Care Utilization (APNCU) index (or Kotelchuck Index). The Kessner Index classifies PNC into three categories: adequate, intermediate, and inadequate. For PNC to be considered adequate, initiation must begin in the first trimester and there must be 9 or more visits total for a pregnancy of 36 weeks or more (15). The Adequacy of Prenatal Care Utilization (APNCU) index (or Kotelchuck Index) uses two parameters, including time of initiation and number of visits (16). The APNCU index bases the number of visits off of the ACOG standards for uncomplicated healthy pregnancies that is used by practicing physicians as PNC standard of medical care (16). This index categorizes care into four categories: inadequate, intermediate, adequate, and adequate plus. Adequate PNC is 80-109% of expected PNC visits, or 9 to 13 total visits (16-18). Both indices require initiation of care in the first trimester.

Infant Outcomes of Teenage Births

There are many adverse infant outcomes related to teenage births already known in the literature. Teen pregnancy has been linked with preterm birth and low birthweight babies (2, 6, 19). While much literature has observed the association between poor infant outcomes and teenage births, the relationship is confounded by social and economic conditions (2). Pregnant teenagers are more likely to be poverty-stricken, of minority racial or ethnic status, have less education, and be unmarried compared to their older peers (7, 20-22).

Teenage Births and PNC

While little is known about the relationship between PNC inadequacy and adverse infant outcomes of teenage births, one recent study showed that teenage mothers who received inadequate PNC (RR: 1.82 (95% CI: 1.39, 2.37)) and intermediate PNC (RR: 1.58 (95% CI:

1.83, 2.57)) were at increased risk of maternal morbidity when compared to teenage mothers who received adequate PNC (5). The study also found that teenage mothers with maternal comorbidities who received inadequate PNC had 5 times increased risk of maternal mortality than those without maternal comorbidities and adequate PNC (5).

West Virginia

West Virginia (WV) is one of the poorest states economically and in terms of population health. According to the WV Behavioral Risk Factor Surveillance System (BRFSS), WV is ranked number 2 nationally for the highest prevalence of adults who report being in fair or poor health (23). The prevalence of no healthcare coverage in the state is 14.9%, compared to only 10.1% nationally, and one fifth of adults do not have a personal healthcare provider (PCP) (23). WV also has a very high rate of teenage births with 22.5 per 1,000 births being from a teenager aged 15-19 in 2020 (24) compared to the national average for 2020 of 15.3 per 1,000 (24).

In summary, there is a strong relationship between teen births and poor infant outcomes. Additionally, there is strong relationship between inadequate PNC and poor infant outcomes, while little is known about the relationships between teen births and inadequate PNC. To our knowledge no other study has examined infant outcomes of teen births directly in a statewide analysis. Our study aims to fill these gaps and examine the association of inadequate PNC and infant outcomes among teenage population giving birth in WV. We hypothesize that teenage mothers who do not receive inadequate PNC will have infants who are smaller for gestational age, lower APGAR scores, more likely to go to NICU, and are more likely to have longer hospital stays than infants of teenage mothers who receive adequate PNC. This is hypothesized because PNC is designed to monitor mother and fetus for possible complications that could arise over the course of the pregnancy. Without appropriate monitoring and evaluation complications that arise could go untreated leading to poorer infant outcomes.

Methods

This study used data from the Project WATCH/WV Birth Score Program. This dataset collects surveillance data on all infants and their pregnant persons born in WV. This is a unique dataset to WV fully funded by WV Division of Health and Human Resources. This dataset provides additional information not found on birth certificate data that allows the state to identify infants who are at greatest risk for poor health and care, and has made significant contributions in the reduction of mortality in infants from 1 month to 1 year of age (25). The dataset has a 98-99% match to available birth certificate data, and relative to this study, additional variables such as substance use and APGAR score. The proposed study used data from the years May 2018 – March 2022 resulting in a total sample of 70,724 individuals; the data was subset to include all live hospital births to teenagers (< 20 years old) (n = 4,347) 6.2% of total sample. The datasets generated and/or analyzed during this study are not publicly available due to funding agreements, but aggerate datasets are available from the corresponding author on reasonable request.

Independent Variable

The exposure variable for this study is inadequacy of PNC. Inadequacy of PNC is measured as a binary variable defined as inadequate care as < 10 PNC visits and adequate care a as ≥ 10 PNC visits. While there are many ways to define inadequate PNC, this method was chosen due to a previous study using this dataset by Umer et al. which determined by way of Receiver Operating Curve (ROC) analysis that 10 or 11 PNC visits optimized the sensitivity and specificity for increased risk of infant mortality, and also determined that the strength of the bivariate associations were stronger with < 10 PNC visits being the cut off for inadequate PNC (26). This definition of inadequate PNC is consistent with both the Kessner and APNCU indices.

Dependent Variables

The main outcome variables of interest were length of infant hospital stay (LOS), small for gestational age (SGA), infant stay in the Neonatal Intensive Care Unit (NICU) and APGAR score. APGAR score is a method for assessing an infant after birth. Elements in the APGAR score assessment include color of infant, heart rate, reflexes, muscle tone, and respiration rate (27). These variables of interest are based on previous literature (2, 6, 19) and information that is collected and available within the dataset. Infant stay in NICU, APGAR score and SGA were analyzed as binary variables. Infant stay in NICU was binary (yes vs no) and captures if the infant was admitted to the NICU, including those transferred to a NICU at a different hospital. For this study 5-minute APGAR score that ranges from 0 – 10 was recoded into low APGAR score being less than 7 and normal being 7 or greater this cutoff value is based on literature (27) Using data on birthweight (grams) and gestational age (weeks), gestational age categories were computed. Small for gestational age (SGA) was defined as infants born with a birth weight below the 10th percentile, appropriate for gestational age (AGA) defined as infants born with a birth weight between the 10th percentile and the 90th percentile, and large for gestational age (LGA) was defined as infants born with a birth weight above the 90th percentile. These cut-off values were based on recommendations by the World Health Organization's (WHO) (28). AGA and LGA were combined in this study due to both groups having very similar PNC rates. LOS was analyzed as a continuous count variable of days in the hospital, where infant discharge date was subtracted for date of birth. In this dataset the discharge date is captured on final hospital discharge so even if an infant was transferred to a different unit or hospital, the discharge date captured is the final discharge date.

Covariates

Socio-demographic and confounding variables were controlled for in this analysis, including maternal race, education, parity, insurance payment method, smoking status, diabetes, substance use, and maternal age. Project WATCH collects data on race as a categorical variable with categories white, Black, Asian, Hispanic, Multiracial, and other. For this study, race was dichotomized into white vs not white. Maternal age was gathered as a continuous data ranging from 11 to 51 years old. Data was subset to only include teen births aged 19 and under. Maternal education was collected as a continuous variable and was recategorized for the purpose of demographics into 8^{th} grade or less, 9^{th} grade, 10^{th} grade, 11the grade 12^{th} grade, and some college. Parity included number of previous pregnancies and was collected as a continuous variable. Parity was then categorized as 0, 1, 2, and 3 or more for demographic purpose but was then recoded into 0 and 1 or more for simplicity in the model. For this study, insurance status was originally collected as private insurance, WV Medicaid, self-pay, other, and unknown was reclassified into private insurance vs other. Smoking was collected as nicotine use during pregnancies and was based on self-report data. Smoking status was categorized as yes vs no. Substance use data includes opioids, sedatives/hypnotics, cannabinoids , alcohol, stimulants, phencyclidine- PCP, gabapentin, and antidepressants and was based on either self-report, prenatal records, and drug test of birthing person, data categorized as yes vs no. Diabetes was collected as type I, type II, gestational diabetes, or none and was recategorized to any diabetes and no diabetes. Maternal age and education were highly correlated ($r = 0.60$, <0.0001), so only maternal age was included in the models.

Statistical Analysis

All statistical analysis was conducted in SAS version 9.4 (SAS Institute, Cary NC). Missing data was treated using pairwise deletion. Basic descriptive statistics were performed on all variables. Frequencies and percentages were calculated for adequacy of PNC groups in teen births categorical demographic characteristics, and covariates for the full sample, and then stratified by adequate/inadequate PNC. Chi-square tests were performed with accompanying p-values presented to determine the significance of the associations between covariates and PNC. Means and standard deviations were calculated for continuous variables. Bivariate associations for continuous variables included t-tests or Mann-Whitney tests to evaluate their relationship with PNC. Logistic regression analysis was used to examine the bivariate relationship between PNC and each categorical health outcome, small for gestational age (SGA), NICU, and low APGAR score, with covariates. Covariates were binary coded for the logistic regression analysis, including payment method (WV Medicaid vs other), Race (white vs not white), Parity (0 vs 1 or more), smoking (no vs yes), substance use (no vs yes), diabetes (no vs yes), while maternal age was kept continuous. Results are presented as odds ratio (OR) and adjusted OR (aOR) along with 95% confidence intervals (CI). Kaplan-Meier curves were used to determine if the probabilities of LOS differed between PNC groups, and a Weibull model was used to perform a survival analysis to determine the bivariate relationship between PNC groups and the continuous count outcome, infant length of stay (LOS). A Weibull model was selected due to ties, appropriate model shape, and having the lowest AIC value (29). Adjusted and unadjusted hazard ratios (HR) and 95% confidence intervals (CI) along with p-values and regression coefficients were calculated for having inadequate PNC; this type of model was selected due to high number of ties (e.g., 2-day stays) among a large proportion of the sample. All covariates were adjusted for in the final model. Since prematurity is in the causal pathway to LOS, a post hoc sensitivity analysis was conducted to determine that appropriateness of the model by stratifying by term and pre-term births and comparing the resulting HRs.

Results

The study population (n = 4,347) was predominately white (i.e., 92.1%), 62% had at least a 12th grade education, 75% of the population had no previous pregnancies, 69% had WV

Medicaid insurance, 79% were non-smokers, and 87% did not use substance during pregnancy (need to define this variable in the method section). Of the total population, 7% of the infants born were of small for gestational age, 2% had an APGAR score of less than 7, and 9% of infants required a stay in the NICU. Of all births to teenagers, 14% received inadequate PNC. Other descriptive statistics and differences by adequate v. inadequate PNC are provided in Table 1.

Infant outcomes: NICU, APGAR, and SGA

For all births to teens in WV during the study period, compared to teenagers who received adequate PNC, the odds of an infant admitted to NICU was significantly increased when inadequate PNC was received during the pregnancy (Table 2; aOR: 1.84, CI:(1.41, 2.42), p <0.0001). The odds of infants having a low 5- minute APGAR score when teenagers received inadequate PNC were significantly increased (Table 2; aOR: 3.26, CI:(2.03,5.22), p <0.0001). Increased odds were found for infants being SGA when born to teens who received inadequate PNC compared to those who received adequate PNC, those results were not statistically significant (Table 2; aOR: 1.08, CI:(0.78, 1.50), p = 0.6302).

An exploration of significant confounders also revealed interesting information about teenage births and PNC. Individuals who had diabetes (Type I, II or gestational) were almost 2.5 times greater odds (aOR: 2.46, CI:(1.57,3.85), p <0.0001) to have an infant admitted to the NICU. It was also found that teenagers who smoke were at twice the odds (aOR: 1.98, CI:(1.52,2.58), p <0.0001) and teenagers that used substances were 1.5 times greater odds (aOR: 1.55, CI:(1.14,2.11), p = 0.0048) to have an infant classified as SGA.

Infant outcome: LOS

Results of the Kaplan-Meier analysis show statistically different probabilities for LOS between teens who received inadequate and adequate PNC -2log(LR) test ($\chi 2$ = 58.72, p=

<0.0001) LOS being longer for infants of teens who received inadequate PNC (mean stay: 4.37 days (SD=14.74) compared to 2.95 days (SD=7.15) Shown in Figure 1.

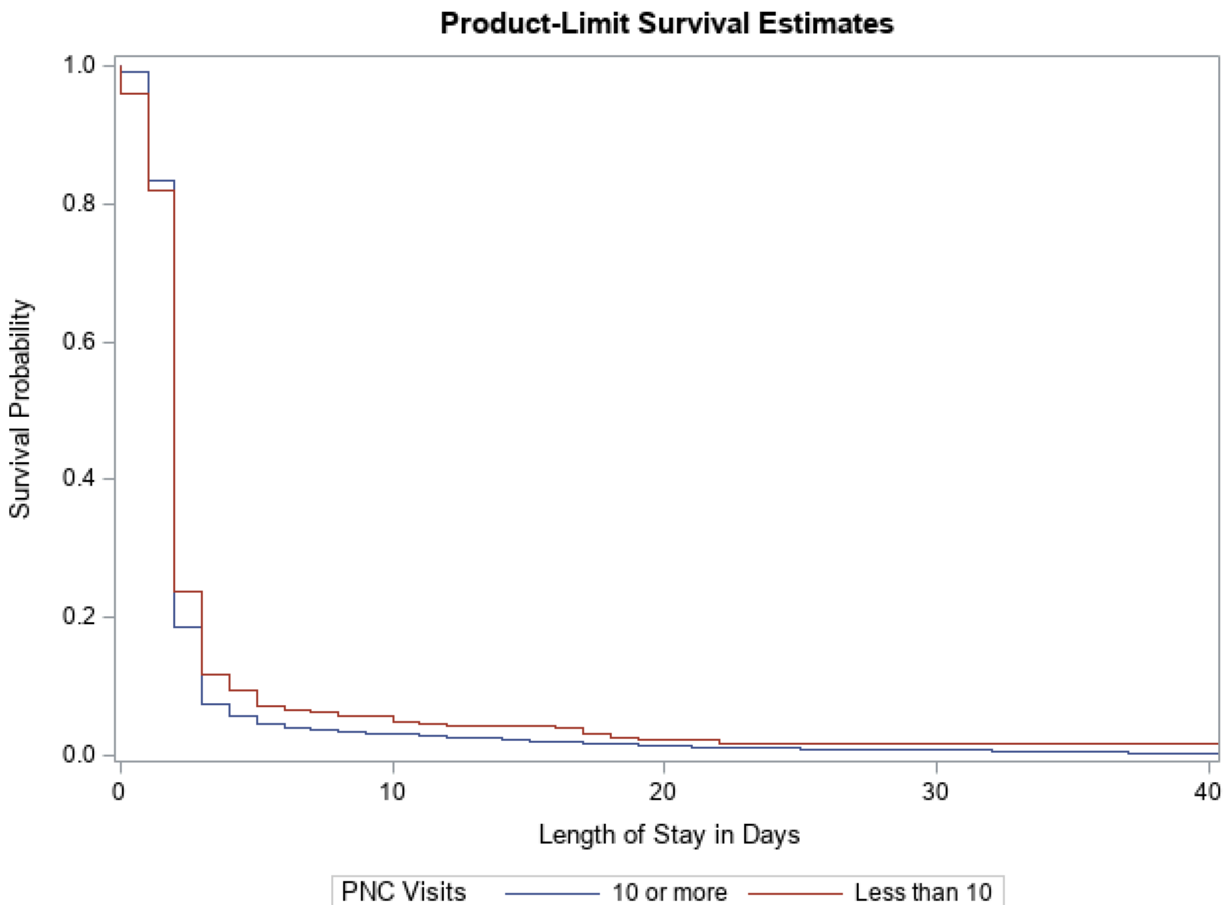


Figure 1. Survival analysis for infant LOS in hospital stratified by teenagers who received inadequate vs. adequate PNC

The Weibull estimates, HRs, and their corresponding 95% CI and p-values are presented in Table 3. The results of the survival analysis show that infants of teenagers that received inadequate PNC had longer LOS compared to infants of teenagers that received adequate PNC (Est. = -0.33, HR: 0.72, CI:(0.65,0.81), p <0.0001). The analysis also found that infants of non-white teenagers (Est. = -0.4, HR: 0.67, CI:(0.58,0.77), p <0.0001) and infants of younger teenagers (Est. = -0, HR: 0.91, CI:(0.88,0.91), p <0.0001) also had longer median LOS compared to their counterparts.

The results of the post hoc sensitivity analysis stratifying by term and pre-term birth showed a slightly attenuated but similar hazard ratio estimate for term birth infants (HR:0.76, CI:(0.70,0.83). For pre-term infants, the hazard ratio was slightly more attenuated but still in the correct direction (HR:0.70, CI:(0.48,1.03) and a drop in significance (p=0.06); suggesting this model may be best suited for term infants.

Discussion

This study adds to the limited extant literature on infant outcomes of teenage births and inadequate PNC use in a rural Appalachian state of WV. WV has a very high rate of teenage births , with 22.5 per 1,000 births being from a teenager in 2020 (24) compared to the national average for 2020 of 15.3 per 1,000 (30). The results show that 14% of teenage births in WV received inadequate PNC based off the definition of inadequate PNC determined by Umer et al. (26). This statistic is in line with the national average of inadequate PNC across all age groups of approximately 15% in 2020 (14); small differences could be attributed to differences in the measuring of inadequate PNC.

Prior literature concluded that infants of teenagers are at increased risk of poor infant outcomes (31, 32). The results of this study conclude that infants of teenagers who receive inadequate PNC are at subsequent increased risk of certain poor infant outcomes, including SGA, NICU stay, longer LOS, and lower APGAR scores.

More specifically, the results of this study determined that a relationship exists between teenagers who receive inadequate PNC and their infants being born with low 5-minute APGAR score (< 7). This is of particular concern, as the literature demonstrates that infants born with low APGAR scores have poor long-term cognitive outcomes including lower IQ scores and lower test scores at ages 15-16 (33).

Similarly, studies have found that having an infant requiring a NICU stay can have a negative impact on the overall mental health of the parents; these studies note elevated levels of anxiety and depression found in parents of NICU babies when compared to parents whose babies did not require a NICU admission (31, 32, 34). This anxiety and depression can cause discomfort in the parent-infant interactions (34). Substance use was also found to have a significant association with infants requiring admission to the NICU. This is in line with previous literature that has linked maternal substance use to premature births, smaller infant weight and length, and smaller head circumference (35). Literature also reports that infants of substance-using birthing persons require longer hospital stays and NICU admission due to neonatal abstinence syndrome (NAS) and family dysfunction (35, 36).

While infant size was not found to be associated with inadequate PNC, covariates found to be significant were consistent with previous literature. For example, this study also noted a relationship between smoking and having an infant born SGA (37-39). Infants SGA have been found to have significantly lower academic achievement later in life when compared to infants who were not SGA (40, 41).

Increased infant LOS was also found to be associated with inadequate PNC; while this relationship could be highly confounded with other factors such as medical conditions, the health of the mother, and characteristics of the mother-infant dyad, it is still worth noting. Longer infant LOS has been associated with mental distress on the parents of the infant, as well as strain on parent-infant bonding (34).

This study analyzes the risks of receiving inadequate PNC for infants of teenage pregnancies in the rural state of WV. Many poor infant outcomes can be attributed to inadequate PNC and other factors over the course of the pregnancy. PNC and other factors such as smoking, substance use, having diabetes, and being non-white have an impact on infant outcomes. Improving use of PNC on a state level could be a primary prevention measure in improving mother and infant health. While there is minimal research on interventions to improve PNC, there have been a few studies that have determined that incentives such as cash or baby items (i.e. car seats, baby blankets, etc.) have shown to improve overall PNC (42). This, however, is not a feasible intervention due to costs within this population. This study concludes that inadequate PNC in teenagers is a risk factor for poor infant outcomes at time of delivery with long-term implications. Some additional barriers to PNC in rural populations include distance to the nearest clinic and available transportation (43). These barriers could be addressed by increased access to public transportation and increased presence of clinicians within rural communities. We recommend that the strong association of poor infant outcomes, with teens that do not receive proper PNC in WV should be addressed by directing more targeted research and/or prevention measures aimed at improving education and access to PNC.

Teenagers experience additional barriers to PNC such as cost, fear, and lack of education. A secondary prevention measure to address the poor infant outcomes in teenagers would be to provide proper sex education and birth control methods to teenagers. Sexual education is more scrutinized and less common in rural school systems due to greater religious and community influence (44). While most sexually active teens use some form of birth control (~90%), the most common forms used are condoms or birth control pills which are not the most effective and require consistent and correct use to prevent pregnancy (45). Long-acting reversible contraception (LARC) methods such as intrauterine devices and implants are the most effective and could be a better option for teens (45) .

Limitations

There are limitations to this analysis, one of the most pertinent is the lack of information on a potential confounder of financial support within the household. There is a known association of poverty and teen pregnancy, and poverty and inadequate PNC (7, 20-22); not including this known confounder might mean the implications of the study are indirectly due to SES rather than directly inadequate PNC. However, the inclusion of medical insurance status in the model may help to mitigate some of this potential bias. Similarly, there are many unknown health conditions of both the infant and mother that could have an association with infant outcomes in which this dataset does not account for, one in particular being maternal hypertension, while maternal hypertension is known to be a common morbidity in pregnancy and childbirth it is not collected in this dataset in the future we hope to be able to explore the association of inadequate PNC and infant outcomes while including maternal hypertension as a covariate. We were limited to de-identified data, because of this we are unable to account for births to multiples (twins, triplets, etc.) in this analysis. The lack of an ethnicity variable creates a limitation, Hispanic is considered a race in the race variable which doesn't permit us to analysis ethnicity directly. While the state is largely non-Hispanic future work should include analyzing a state with more ethnic diversity. This is also a cross-sectional analysis; therefore, causal inferences cannot be drawn as temporality could not be assessed. The results of this study may not be generalizable to populations outside of WV. While not generalizable, the results of the study could potentially lead further research on a wider scale to determine association between LOS, infant size, and low APGAR score and PNC among teenage pregnancies other states or on a national level. Finally, the definition of PNC was previously defined in the Project WATCH dataset and could not be adjusted to fit other indexes of PNC (15, 46) . Despite these limitations, this study demonstrates the potential harm inadequate PNC can have on infant outcomes such as LOS, SGA, and low APGAR scores among teenage pregnancies in the state of WV.

Conclusions

This analysis concludes the strong association of poor infant outcomes, including longer LOS, SGA, NICU stays, and low APGAR scores with teen births that do not receive proper PNC in WV. This association should be addressed by directing more targeted research and/or prevention measures aimed at improving education and access to PNC. While this study analyzed teenage births in WV, we believe that the same barrier to PNC exist nationally and more research needs to be done to determine the most effective interventions to mitigate these barriers and improve the adequacy of PNC. This information contributes to the broader literature base as well; specifically, to literature on teenagers and their likelihood to receive PNC and the impact on infant outcomes.

List of Abbreviations

Abbreviation	Definition
AGA	Average for gestational age
BRFSS	Behavior
CI	Confidence intervals
LARC	Long-acting reversible contraception
LGA	large for gestational age
LOS	Length of stay
NAS	Neonatal abstinence syndrome
NICU	Neonatal intensive care unit
PCP	Personal healthcare provider
PNC	Prenatal care
SGA	Small for gestational age
WHO	World Health Organization
WV	West Virginia

Declarations

- Ethics approval and consent to participate – study was approved by West Virginia University's Institutional Review Board
- Consent for publication – not applicable
- The datasets generated and/or analyzed during the current study are not publicly available due to funding agreements, but aggerate datasets are available from the corresponding author on reasonable request.
- Competing interests – The authors declare that they have no competing interests
- Funding – The authors declare that no funding was required
- Authors' contributions –
    - M.G. - Wrote main manuscript text and prepared tables and figure.
    - A.U. - Wrote main manuscript text and prepared tables and figure.
    - B.H. - Wrote main manuscript text and prepared tables and figure.
    - T.R. - Wrote main manuscript text and prepared tables and figure.
    - C.L - Wrote main manuscript text and prepared tables and figure.
    - C.J. - Wrote main manuscript text and prepared tables and figure.
    - C.L. - Wrote main manuscript text and prepared tables and figure.
    - All authors reviewed the manuscript

- Acknowledgements – not applicable

Tables

Table 1. Study characteristics of all teenagers who gave birth to infants in WV (n = 4,347)

Variables	Total Frequency(Percent)	Inadequate PNC Frequency(Percent)	Adequate PNC Frequency(Percent)	P-value
Race				0.3033
White	3950(92.1%)	534(13.5%)	3416(86.5%)	
Black	131(3.1%)	18(13.7%)	113(86.3%)	
Hispanic	36(0.8%)	7(19.4%)	29(86.6%)	
Multiracial	106(2.5%)	19(17.9%)	87(82.1%)	
Other	65(1.5%	13(20.0%)	52(80.0%)	
Maternal Education				<0.0001
8th Grade or Less	99(2.3%)	22(22.2%)	77(77.8%)	
9th Grade	258(5.9%)	54(20.9%)	204(79.1%)	
10th Grade	450(10.4%)	85(18.9%)	365(81.1%)	
11th Grade	845(19.5%)	133(15.7%)	712(84.3%)	
12th Grade	2245(51.7%)	271(12.1%)	1974(87.9%)	
Some College	445(10.3%)	37(8.3%)	408(91.7%)	
Parity				0.0443
0	3273(75.3%)	427(13.0%)	2846(87.0%)	
1	820(18.9%)	131(16.0%)	689(84.0%)	
2	195(4.5%)	35(17.9%)	160(82.1%)	
3 or more	59(1.4%)	10(16.9%)	49(83.1%)	
Payment Method				0.0726
WV Medicaid	2988(68.7%)	431(14.4%)	2557(85.6%)	
Private	847(19.5%)	95(11.2%)	752(88.8%)	
Self-Pay	34(0.8%)	8(25.5%)	26(76.5%)	
Other	412(9.5%)	59(14.3%)	353(85.7%)	
Unknown	66(1.5%)	10(15.2%)	56(84.9%)	
Smoking Status				<0.0001
Yes	919(21.1%)	175(19.0%)	744(81.0%)	
No	3427(78.9%)	427(12.5%)	3000(87.5%)	
Substance Use				<0.0001
Yes	582(13.4%)	139(23.9%)	443(76.1%)	
No	3765(86.6%)	464(12.3%)	3301(87.7%)	
Conditions				0.0265
No diabetes	4162(96.6%)	584(14.0%)	3578(86.0%)	
Type I Diabetes	12(0.3%)	2(16.7%)	10(83.3%)	
Type II Diabetes	7(0.2%)	1(14.3%)	6(85.7%)	
Gestational Diabetes	128(3.0%)	6(4.7%)	122(95.3%)	
Infant Size				0.3924
Small for Gestational Age	311(7.2%)	51(16.4%)	260(83.6%)	

Average for Gestational Age	1953(44.9%)	264(13.5%)	1689(86.5%)	
Large for Gestational Age	2083(47.9%)	288(13.8%)	1795(86.2%)	
APGAR Score				<0.0001
Less than 7	85(2.0%)	29(34.1%)	56(65.9%)	
7 or Greater	4262(98%)	574(13.5%)	3688(86.5%)	
Infant Stay in NICU				<0.0001
Yes	378(8.7%)	86(22.8%)	292(77.2%)	
No	3969(91.3%)	517(13.0%)	3452(87.0%)	
	Mean(SD)	**Mean(SD)**	**Mean(SD)**	
Length of Stay	3.15(8.70)	4.37(14.74)	2.94(7.15)	
Maternal Age	18.15(1.14)	18.0(1.34)	18.18(1.10)	
***Column percentages used for total frequency and row percentages used for PNC group**				

Table 2. Unadjusted and adjusted odds ratios of infant outcomes NICU admission, APGAR score, and SGA by PNC (n = 4,347)

Dependent Variable			**Odds Ratio (95% CI)**	**Chi-Square**	**P-Value**
NICU Admission	**Unadjusted Model**	**Prenatal Care**			
		Less than 10	1.967(1.520,2.544)	1642.5	<0.0001
		10 or more	1		
	Adjusted Model	**Prenatal Care**			
		Less than 10			
		10 or more	1.84(1.41,2.42)	19.5	<0.0001
	Covariates	**Payment Method**			
		WV Medicaid	1		
		Other	0.95(0.750,1.21)	0.16	0.6932
		Race			
		White	1		
		Non-White	1.10(0.75,1.61)	0.19	0.6635
		Parity			
		0	1		
		1 or more	0.98(0.76,1.27)	0.03	0.8716
		Smoking			
		No	1		
		Yes	0.91(0.69,1.20)	0.49	0.4842
		Substance Use			
		No	1		
		Yes	1.42(1.05,1.91)	5.15	0.0232
		Diabetes			
		No	1		

		Yes	2.46(1.57,3.85)	15.42	<0.0001
5- minute APGAR score less than 7	**Unadjusted Model**	**Prenatal Care**			0.2469
		Less than 10	3.33(2.107,5.255)	967.3	<0.0001
		10 or more	1		
	Adjusted Model	**Prenatal Care**			
		Less than 10	3.26(2.03,5.22)	23.98	<0.0001
		10 or more	1		
		Payment Method			
		WV Medicaid	1		
		Other	0.87(0.53, 1.42)	0.32	0.5696
		Race			
		White	1		
		Non-White	1.35(0.66,2.76)	0.68	0.4088
		Parity			
		0	1		
		1 or more	1.12(0.66,1.84)	0.18	0.6677
		Smoking			
		No	1		
		Yes	0.90(0.52,1.58)	0.12	0.724
		Substance Use			
		No	1		
		Yes	1.09(0.59,2.03)	0.08	0.7754
		Diabetes			
		No	1		
		Yes	2.13(0.84,5.39)	2.54	0.1107
Infant Small for Gestational Age	**Unadjusted Model**	**Prenatal Care**			0.5415
		Less than 10	1.24(0.91,1.70)	1.79	0.1814
		10 or more	1		
	Adjusted Model	**Prenatal Care**			
		Less than 10	1.08(0.78,0.150)	0.23	0.6302
		10 or more	1		
	Covariates	**Payment Method**			
		WV Medicaid	1		
		Other	1.20(0.94,1.55)	2.05	0.1521
		Race			
		White	1		
		Non-White	1.39(0.93,2.06)	2.6	0.1069
		Parity			

	0	1		
	1 or more	0.93(0.70,1.22)	0.31	0.5785
	Smoking			
	No	1		
	Yes	1.98(1.52,2.58)	25.5	<0.0001
	Substance Use			
	No	1		
	Yes	1.55(1.14,2.11)	7.97	0.0048
	Diabetes			
	No	1		
	Yes	0.45(0.18,1.11)	3.03	0.0816
	Age of Mother	1.04(0.93,1.17)	0.55	0.4591

Table 3. Results of Weibull Survival Analysis for infant LOS by PNC for infants born to teenagers (n = 4,347)

Dependent Variable			**Regression Coefficient**	**Hazard Ratio (95% CI)**	**Chi-Square**	**P-Value**
Length of Stay	Unadjusted Model	**Prenatal Care**				
		Less than 10	-0.41	0.66(0.59,0.74)	52	<0.0001
		10 or more				
	Adjusted Model	**Prenatal Care**				
		Less than 10	-0.33	0.72(0.65,0.81)	32.62	<0.0001
		10 or more				
	Covariates	**Payment Method**				
		WV Medicaid				
		Other	-0.01	0.99(0.91,1.07)	0.1	0.7521
		Race				
		White				
		Non-White	-0.4	0.67(0.58,0.77)	29.93	<0.0001
		Parity				
		0				
		1 or more	-0.07	0.93(0.85,1.02)	2.36	0.1248
		Smoking				
		No				
		Yes	0.01	1.01(0.92,1.11	0.04	0.8448
		Substance Use				
		No				
		Yes	0.04	1.04(0.93,1.17)	0.44	0.5094
		Diabetes				
		No				
		Yes	-0.14	0.87(0.70,1.07)	1.73	0.1878

	Age of Mother	-0.09	0.91(0.88,0.94)	25.3	<0.0001

CHAPTER 4

Abstract

Introduction: Adequate prenatal care (PNC) is essential to the overall health of mother and infant. Studies have determined that greater risk of inadequate PNC has been linked to more rural areas compared to more urban areas. West Virginia (WV) is the third most rural state, with the majority of people living in rural areas. While PNC inadequacy has been examined in other rural settings this type of analysis has not been performed in WV.

Purpose: To examine the rate of inadequate PNC in each zip code in a rural Appalachian state.

Methods: Data were obtained from Project WATCH/Birth Score Program for WV zip codes from May 2018 to March 2022. Zip code level distribution for all variables were visualized in thematic maps with graduated colors. Separate Bayesian Spatial Hierarchical regression models were used to investigate risk of inadequate PNC associated with model independent variables for those with public and private insurance.

Results: Findings indicated that only 30-minute drive time had a statistically significant association with risk of inadequate PNC for both private and public insurance groups (public IRR:3.83, CI:(2.85,5.18)) (private IRR:4.31, CI:(3.17,5.88). Most hot spots of inadequate PNC were clustered in the mid-eastern and southern parts of the state. Most of these zip codes are located outside of a 30-minute drive time to a birthing center. Differences were found between groups more hot spots for public insurance groups were located within the 30-minute drive time of a birthing facility.

Discussion: A strong geographic disparity exists between areas within the state. The similarities of hotspots locations being outside of 30-minute drive times suggest transportation as a major barrier to PNC in the state. The differences in hotspot locations between public and private insurance groups suggest these groups experience some different barriers to PNC.

Introduction

Prenatal Care (PNC) is essential to the overall wellness of mother and infant (1). PNC typically involves a wide variety of interactions between clinicians and expecting mothers, including exchanging pregnancy and birth information, facilitation of education, screening measures for abnormalities and complications for mother and baby, monitoring/continuous care, and preparation for childbirth and motherhood (2, 3). PNC visits also provide opportunities for the detection and treatment of disease, at providing interventions in a timely fashion, promoting overall wellness, and facilitating informed birth choice (1-7). Unfortunately, as many as 15% of women in the US each year receive inadequate PNC (1, 8).

Geographic Factors to PNC

Many studies suggest inadequate PNC is the result of a complex intersection of many socioeconomic, sociodemographic, and personal factors (9). While there are many obvious barriers to PNC, such as insurance and financial status, there are many geographic barriers that exist and may be overlooked. Access to PNC in the US has been improving since the 1990's (9); however, many inequalities to access still exist. Geographic barriers to PNC are complex and multi-factorial, and may include location of services, travel distance, travel time, and access to transportation (9, 10).

Most studies that have evaluated the relationship between residence type and PNC have determined that greater risk of inadequate PNC has been linked to more rural areas compared to more urban areas (11-13). Research from 2000 to 2012 shows that women in rural areas had increased rates of inadequate PNC in comparison to women in more urban areas (14, 15). There are many reasons for this; mothers may not have easy access or transportation to medical care and access to childcare may not be as readily available (9, 16). Additionally, in recent years, there has been a reduction of PNC services in rural areas due to workforce challenges, regionalization of healthcare, low birth volume, and cost of malpractice insurance (14). However, a study of women in Oregon that aimed to determine how rural residence affected late initiation to PNC found that while there were significant associations between rurality and teenage pregnancies and unintended pregnancies, they did not find a significant association between rural residence county and late initiation to PNC (11). The barriers may not be equal across rural regions: some rural areas may be more proximal to urban areas, which can play a role in overall PNC care. To this end, a recent 2018 study found a higher number of pregnant women receiving no PNC in rural areas not adjacent to urban centers, compared to those living in urban-adjacent areas (15). This disparity may be rooted in distance to a medical center for these rural pregnant women. A study of rural Michigan counties determined that women who needed to travel greater than 30 miles for PNC were at higher risk of not receiving adequate PNC (17).

While PNC inadequacy has been examined in other rural settings this type of analysis has not been performed in West Virginia (WV). WV is the third most rural state in the US. Is it estimated that 51.3% of the population live in rural areas and that 98.3% of its land area is considered rural (18). WV is also one of the poorest states economically and in terms of population health. According to the Behavioral Risk Factor Surveillance System (BRFSS), WV is ranked second nationally for the highest prevalence of adults who report being in fair or poor health (19). The prevalence of state residents without healthcare coverage is 14.9% compared to only 10.1% nationally, and one-fifth of adults do not have a primary care provider (PCP) (19). WV is particularly unique in the US, as 98.3% of the land area is considered rural (18); thus, a county level analysis would not be sufficient for studying rurality and PNC adequacy in this region. While individuals may live in a county that is classified as urban, their place of residence may not accurately reflect that. Fortunately, WV is home to a state-wide screening project, called Project WATCH. This dataset includes the zip code of residence of all individuals giving birth in the state along with the number of PNC visits. Due to the detailed information that is available via this population-level dataset, we hypothesize that a zip code level analysis will result in an accurate examination of inadequate PNC and geographic risk factors across the state.

In summary, PNC is important for maternal and child health (1-7) and teasing out the complexities of why some women receive inadequate care is multi-faceted (9). Geographic locations and distance to a birthing facility may play an important role in inadequacy of PNC (9, 10). The goal of this study is to examine the rate of inadequate PNC in each zip code in a rural Appalachian state. We hypothesize that zip codes outside of the 30-minute drive time area will have increased rates of inadequate PNC compared to zip codes inside of the 30-minute drive time area.

Methods and Materials

Study Area

Data were obtained from Project WATCH/Birth Score Program for WV zip codes from May 2018 to March 2022. Project WATCH/Birth Score is a WV Department of Health and Human Resources (WV DHHR) funded program which collects birth, behavioral, clinical, and demographic data on infants and their mothers in WV. Importantly, all live births statewide are captured in this database. Data contained fields for a unique patient identifier, patient address of residence, prenatal care adequacy, parity, age, and insurance status. Missing data were removed to perform a complete case analysis. The raw data was imported into R (20). Data was then aggregated from unique patient data to zip code of residence. Zip code level data was then visualized in R as points. These zip code points were then spatially joined to a 2020 West Virginia zip code shapefile (22, 23) in ArcMap 10.5 (ESRI Redlands, CA), where 100% of the available zip codes for WV contained data within the dataset. Since not all individuals within a zip code are at risk of inadequate PNC, the population at risk was limited to the contents of the dataset and not the census population of the zip code. This study was reviewed and approved by the West Virginia Institutional Review Board (protocol #2208638419).

Dependent Variable

The dependent variable was inadequacy of PNC. Adequacy of PNC was measured as a binary variable defined in the Project Watch dataset as ≤ 10 PNC visits is inadequate care and > 10 PNC visits is adequate care. While there are many ways to define adequate PNC, this method was chosen due to previous research based off of the American College of Obstetricians and Gynecologists (ACOG) guidelines stating that 10 or 11 PNC visits is optimal (21). A previous study using this dataset by Umer et al. determined by way of Receiver Operating Curve (ROC) analysis that 10 PNC visits optimized the sensitivity and specificity for PNC visits and infant mortality, and also determined that the strength of the bivariate associations were stronger with < 10 PNC visits being the cut off for adequate PNC (22).

Independent Variables

Independent variables included maternal age category (19 and younger and 20 and older), insurance type (Medicaid v. private/other), parity (1 v. more than 1) and smoking status all categorized as binary variables. Drive time in minutes was also included and estimated from the 21 statewide birthing centers using ArcGIS Online Rural Drive Time analysis in the Proximity tools (23). Rural drive time was optimal here, as it enables the analyses to account for rural routes and other roadways observed in geographically isolated communities (23). Zip code centroids were computed and were coded as a binary variable for 30-minute drive time if their centroid was within the drive time shapefile, and as outside 30-minute drive time if their centroid was outside the buffer.

Statistical Analysis

Zip code level distribution for all variables were visualized in thematic maps with graduated colors. Separate Bayesian Spatial Hierarchical regression models were used to investigate risk of inadequate PNC associated with model independent variables for those with public and private insurance. Our stratified approach provided an opportunity to compare risk ratios and examine relative difference between pregnant women receiving public insurance and those not receiving public assistance. Regression models were distributed Poisson and incorporated a log-normal approximation as has been done in previous public health literature (24, 25). Effects were assessed using 95% credible intervals (CI) and incident rate ratio (IRR) estimates. Statistically significant associations were identified if a CI did not contain 1 (H0: IRR ≠ 1). Local Getis Ord (G*) was conducted to identify clustering in the adjusted rate of inadequate PNC for those with public insurance and private insurance separately. 30-minute drive time shapefiles were layered on top of spatial regression results to better understand how clustering of low PNC relates to the travel efforts for these pregnant women. Local Getis Ord (G*) values can be interpreted as Z-scores, where a zip code with a G* value lower than -1.96 or greater than 1.96 indicates clustering of high (hotspot) or low (cold spot) inadequate PNC respectively (26, 27).

Results

Thematic maps for the independent variables are displayed in Figure 1. These choropleth maps are classified according to quantile for each of the independent variables, with the exception of 30-minute drive time. As such, zip codes shaded in red are in the top 75th percentile and those in green are in the bottom 25th percentile for a given independent variable. Overall, these maps suggest different dispersion in high rates of increased parity between public and private insurance groups. In the public insurance group higher rates of increased parity are observed in the mid-eastern part of WV, while in the private insurance group the southern part of WV has higher parity. High rates of teen pregnancy appear sporadically throughout the state, but high rates also appear centrally located in the mid-eastern and southern parts of the state. The distribution of smoking while pregnant is consistent throughout the state, with the exception of higher rates in the pregnant women receiving public insurance group. Zip codes within a 30-minute driving time from birthing facilities in the state are shaded in black, while those outside a 30-minute drive time are shaded in grey. Of particular note, the majority of zip codes in the state of WV are outside a 30-minute drive time from a birthing facility.

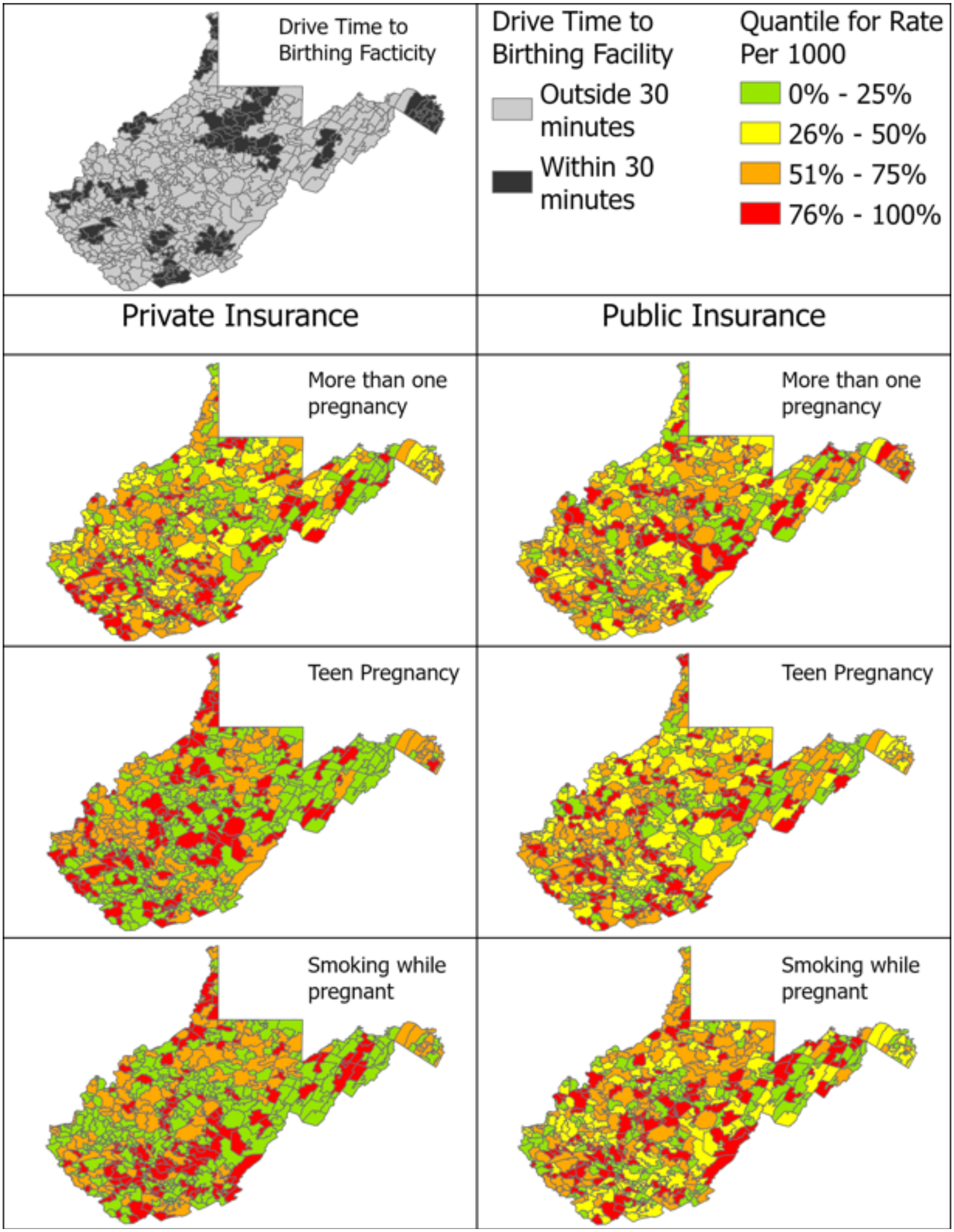


Figure 1. Zip code level distributions of model covariates.

Results from the Bayesian spatial hierarchical regression models are displayed in Table 1. Overall, findings indicated that only 30-minute drive time had a statistically significant association with risk of inadequate PNC for both private and public insurance groups of pregnant women (public IRR:3.83, CI:(2.85,5.18)) (private IRR:4.31, CI:(3.17,5.88). Of particular interest, the risk of inadequate PNC for women outside a 30-minute drive time buffer was higher for pregnant women receiving private insurance. While not statistically influential, inclusion of the other independent variables in statistical models provided a means to estimate an adjusted risk ratio for inadequate PNC.

Model adjusted risk of inadequate PNC was the dependent variable for the cluster analyses. Results of Local Getis Ord (G*) are displayed with zip codes within a 30-minute drive time from a birthing facility outlined in green in Figure 2. Hotspot detection between pregnant women with public versus private insurance were strikingly different. For those with public insurance, hot spots with inadequate PNC were scattered sporadically throughout the state. Several of these zip codes are located within the 30-minute drive time of a birthing facility, while some require a longer drive time. For those with private insurance, hot spots with inadequate PNC were clustered in the mid-eastern and southern parts of the state. Most of these zip codes are located outside of a 30-minute drive time to a birthing center.

Table 1. Results of Spatial Poisson Model.

Insurance Type	Variable	IRR	95% CI
Public Insurance	Teen Pregnancy Rate	1.00	(1.00,1.00)
	Smoking Rate	1.00	(1.00,1.00)
	More Than 1 Pregnancy Rate	1.00	(1.00,1.00)
	More than 30 Min Drive Time	3.83	(2.85,5.18)
Private Insurance	Teen Pregnancy Rate	1.00	(1.00,1.00)
	Smoking Rate	1.00	(1.00,1.00)

	More Than 1 Pregnancy Rate	1.00	(1.00,1.00)
	More than 30 Min Drive Time	4.31	(3.17,5.88)

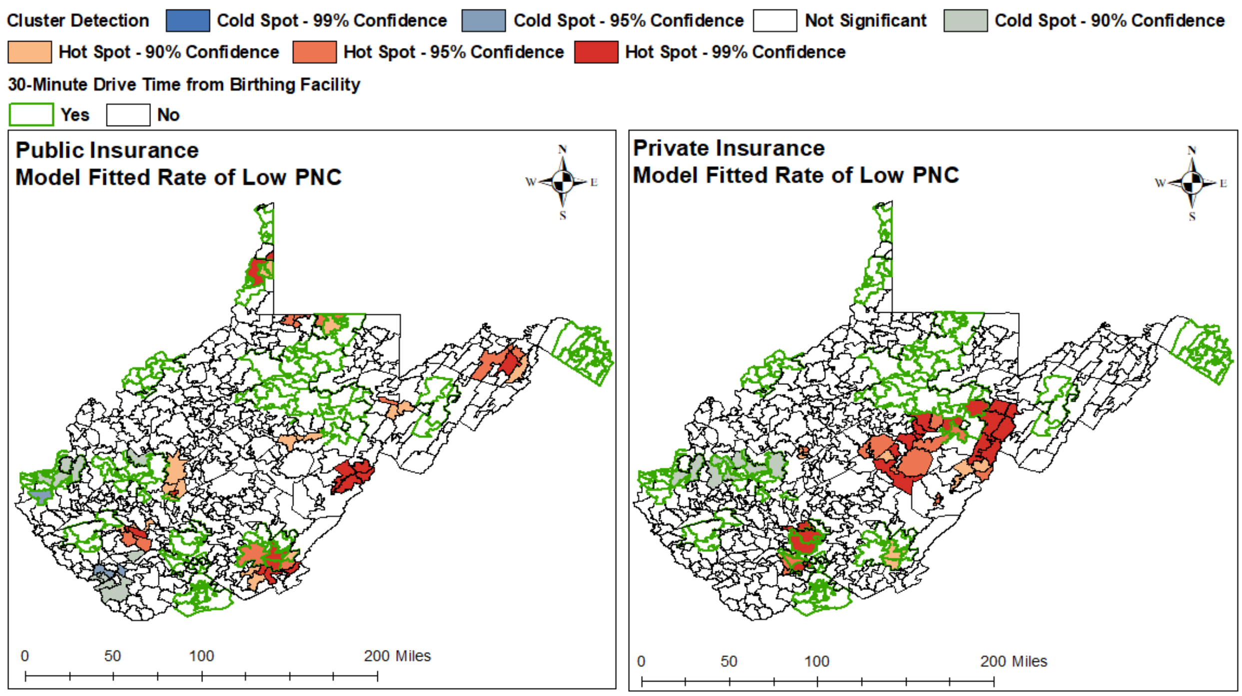


Figure 2. Results of cluster analysis with 30-minute drive time boundaries.

Discussion

This study identified variation in prenatal care inadequacy across the state. The mid-eastern and southeastern areas of WV were identified as having higher rates of inadequate PNC while the south and southwestern part of the state have lower rates of inadequate PNC. A strong geographic disparity exists between locations with high rates of inadequate PNC between public and private insurance groups. This study identified that within the private insurance group, hot spots of inadequate PNC are most likely to be found in areas that lie outside of a 30-minute driving distance to a birthing facility in some of the most rural areas of the state. This shows that drive time is likely a barrier to care in WV for areas with higher rates of private insurance, and thus, likely requires better access to a private vehicle for transportation. Within the public insurance group, however, several hot spots of inadequate care are located within the 30-minute drive time boundaries and are in some of the most urban areas of the state. For this group, transportation may be a barrier to care. WV is part of the Appalachian region of the United States; Appalachia lags behind the national average in high school graduation rates, rate of population with bachelor's degrees, overall population health, infrastructure, public services, poverty, unemployment, substance use, and economic disruption (28). This study attempts to address why these disparities exist. Figure 3 shows a topographic map of WV (29); the map shows the Appalachian Mountains run through the mid-eastern part of the state. Drive times are likely prolonged in these areas because the terrain makes it harder to traverse local roadways enroute to the interstate. The part of the state is more mountainous and has more challenges in access to healthcare.

Moreover, even the most urban areas of the state showed hot spots of increased inadequate PNC in the public insurance group. This may be surprising considering these urbans areas include a birthing facility within a 30-minute drive time, but unfortunately these urban areas also lack reliable public transportation. According to US News and World Report WV is ranked 49th in the US for transportation overall, while being ranked 50th in terms of infrastructure and 37th for public transit usage (30). This means that even though most people live in these urban areas of the state, a car is still required to access healthcare.

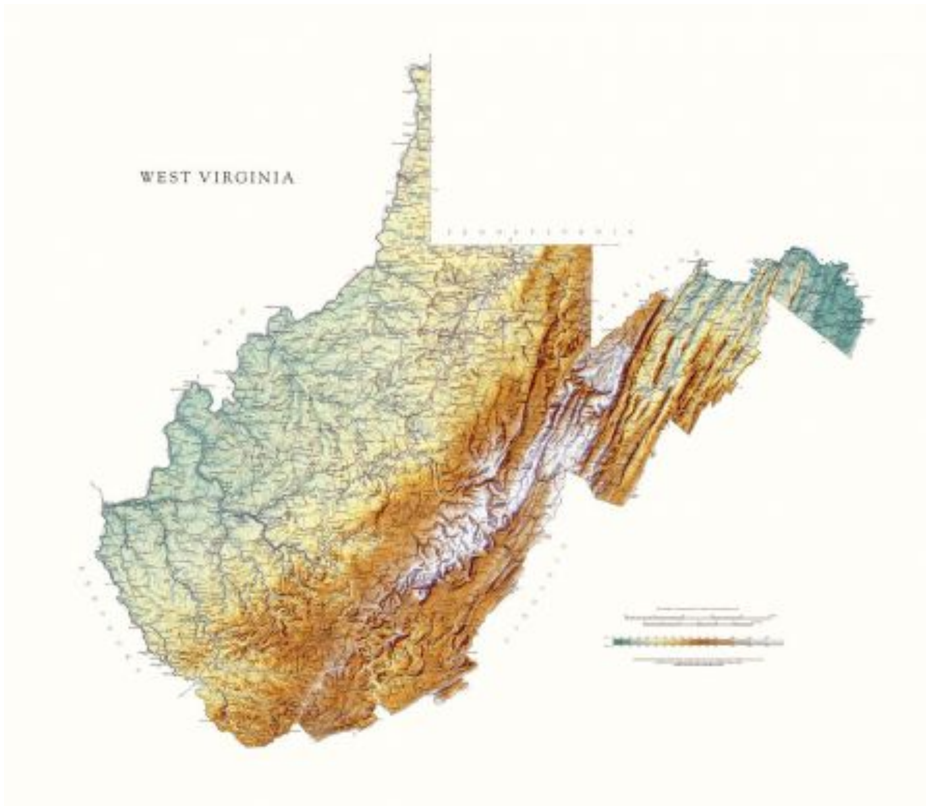


Figure 3. Lithographic map of WV showing the difference in elevation and outlining the Appalachian Mountains running through the eastern part of the state (29).

Limitations and Future Work

This study is an innovative and granular representation of the geographic distribution and driving distance from a birthing facility affect the inadequacy of PNC in the state of WV, despite these strengths like any study limitations exist; one of the main limitations is that due to the cross-sectional/ecological nature of the pooled data causal inferences cannot be drawn. Further studies are needed to demonstrate a causal link between geographic location in relation to inadequate PNC rates. A second limitation is that only one driving distance buffer was assessed, in the future different driving distance buffers (60 minutes or 90 minutes) should be assessed to determine if longer drive times have an effect on PNC inadequacy in WV, in the future HRSA maps could also be used to help analyze PNC care shortages. Another limitation to the study is the lack of data on other possible confounders such as household income, marital status, support at home, and accessibility to childcare, which may also influence the relationship between zip codes and PNC. While we know where an individual gave birth, it is unknown how far an individual must travel to access PNC care because many individuals would receive regular PNC care outside of the hospital where they gave birth. In future studies it would be important to pull all addresses from all facilities that provide PNC in the state and map to better assess PNC in place of just birthing facilities. Home births are not included in this dataset, which is a possible limitation, however home births are a minority of births. In the future it would be interesting to examine doula and midwife usage compared to "typical" PNC care, as this might be impacted by minority status and rurality, traditional PNC availability, this could also aid in accounting for home births. Associations and conclusions drawn from this study cannot be generalized to states other than WV. While the results of the study may not be generalizable, the study could potentially lead to further research on a wider scale to determine association between rurality of zip code of residence and PNC among expecting mothers in other states or nationally. Finally, the definition of PNC was previously defined in the Project WATCH dataset and cannot be adjusted to fit other indices of PNC; this may limit inferences to other definitions of inadequate PNC. Despite these limitations, this study demonstrates how distance to birthing facility from zip code of residence affects the adequacy of PNC of expecting mothers in the state of WV.

Public Health Implications

There are many public health implications to this analysis; first, gaining knowledge on existing geographic barriers can aid in future research and interventions to improve PNC in WV. Areas including the mid-eastern and southeastern regions of WV should be targeted for improving rates of PNC, particularly for private insurance groups. To our knowledge, this research is one of the first to examine barriers and factors influencing geographic rates of PNC for the entire state; 30-minute drive time was a particular barrier to expecting mothers with private insurance while those with public insurance appeared to be suffering from lack of transportation, even in urban centers. This information contributes to the broader literature as well; specifically, to literature on how geographic barriers affect PNC. It may not be sufficient for researchers to individually examine drive-time; these factors are likely moderated by the economic wealth, insurance types, and public transportation options within those regions.

CHAPTER 5

Overview

This set of studies aimed to analyze PNC and the factors associated with PNC in the state of WV. Over the course of pregnancy, women face many health risks and concerns. Women of advanced maternal age (AMA; age 35 and older) (1, 2) are at increased risk of many adverse maternal and child health outcomes. Over the past three decades there has been an increase of births to women of AMA in the US (1). Teens are also at increased risk of maternal and infant complications, pregnancy and birth complications are the number one cause of death of girls ages 15-19 globally (3, 4). While this risks to these groups are known there are no studies looking at PNC inadequacy directly at these groups in a rural state like WV. The geography and overall rurality of WV create a unique set of barriers to healthcare. Most studies that have evaluated the relationship between residence type and PNC have determined that greater risk of inadequate PNC has been linked to more rural areas compared to more urban areas (5-7). Most studies that have evaluated the relationship between residence type and PNC have determined that greater risk of inadequate PNC has been linked to more rural areas compared to more urban areas (5-7). Additionally, in recent years, there has been a reduction of PNC services in rural areas due to workforce challenges, regionalization of healthcare, low birth volume, and cost of malpractice insurance (8). While PNC inadequacy has been examined in other rural settings this type of analysis has not been performed in West Virginia (WV). WV is the third most rural state in the US. Is it estimated that 51.3% of the population live in rural areas and that 98.3% of its land area is considered rural (9).

To fill these gaps in the literature, we conducted three studies, two of which analyzed factors on an individual level, while the third study analyzed factors on a zip code level. The first study analyzed the effect of maternal age on PNC inadequacy in the state of WV and the second study used one of the most at-risk groups identified in the first study and analyzed teenage births and how inadequate PNC affects their infant outcomes. The third study analyzed the zip code level geographic distribution of inadequate PNC in the state along with determining if a drive time of 30-minutes to a birthing facility had a significant effect on PNC inadequacy.

Maternal Age and PNC

The aim of the first study was to evaluate the association between maternal age and PNC inadequacy in WV. This study used data from the years May 2018– March 2022 resulting in a de-identified data sample of 70,724. In this study sample, 6.3% were 19 years of age or less, of which 13.9% received inadequate PNC. 28.9% were 20-24 years old, of which 11.2% received inadequate PNC. 32.8% were aged 25-29, of which 11.3% received inadequate PNC. 22.5% of persons giving birth were aged 30-34, of which 11.1% received inadequate PNC. Persons aged 35-39 made up 9.6% of this population, of which 12.2% received inadequate PNC. Finally, 1.9% of the population were persons 40 and older, of which 13.7% received inadequate PNC.

Logistic regression analysis using the maternal age group of 25-29 years old as the referenced group was used to complete the analysis. The reference group was based off this data in being the largest groups and prior literature that says that this is the most common age for pregnancies in the US. The unadjusted odds of receiving inadequate PNC were significantly higher for the maternal age groups of 19 and younger (aOR:1.3, CI:(1.16,1.37)), $p < 0.0001$), 35-39 (OR:1.10, CI:(1.01,1.20), $p = 0.02$), and 40 and older (OR:1.24, CI:(1.05,1.45) $p = 0.01$) when compared to the reference group of 25-29 years of age. When adjusting for significant covariates the adjusted odds of receiving inadequate PNC slightly attenuated but remained higher for expecting birthing persons aged 19 and younger (aOR: 1.3, CI:(1.14,1.43), $p < 0.0001$), 35-

39 (aOR: 1.1, CI:(1.00,1.21), p = 0.05), 40 and older (aOR: 1.3, CI:(1.06,1.52), p = 0.01) compared to persons 25-29 years old.

While the literature on PNC inadequacy across maternal age groups is limited, there is research concluding that teenagers are less likely to receive adequate PNC, and the results of this study strengthen the previous literature (2, 3, 10, 11, 12). It is also known from previous literature that birthing person AMA and teenagers are at increased risk for poor pregnancy/birth and infant outcomes (1-4). We also found that both these age groups were at significantly increased risk of inadequate PNC in WV when compared to 25-29-year-olds. Due to the already known increase in risks for these groups, provision of adequate PNC is more important than ever for the health of the birthing person and the infant. Further research needs to be completed to determine what barriers and factors deter individuals in these groups from accessing and receiving adequate PNC and how they can be mitigated. Targeted measures need to be taken to improve access and usage of PNC services in the state especially in these particularly at-risk groups.

PNC and Infant Outcomes

The second study aimed to determine if inadequate PNC was associated with adverse infant outcomes of infants born of teenage pregnancies in WV. Restricting the population to just include infants born of teenage pregnancies was important due to the very high rate of teenage pregnancies in WV with 22.5 per 1,000 compared to the national average of 15.3 per 1,000 of births being of a teenager (21, 52, 73). The infant outcomes analyzed were LOS, APGAR score, SGA, and if the infant required a NICU stay.

LOS was measured in two different analyses, first using a Kaplan-Meier analysis which found significant differences in probabilities between infants of teens who received inadequate and adequate PNC -2log(LR) test ($\chi2 = 58.72$, p= <0.0001) LOS being longer for infants of teens who received inadequate PNC (mean stay: 4.37 days (SD=14.74) compared to 2.95 days (SD=7.15). The second analysis performed was a Weibull model, the results of this model found that infants of teenagers who received inadequate PNC at significantly longer LOS compared to those of teenagers who received adequate PNC (Est. = -0.33, HR: 0.72, CI:(0.65,0.81), p <0.0001). The results of these analyses show agreeance in increased risk of longer LOS in infants born to teens who receive inadequate PNC.

Logistic regression models were used to examine the bivariate associations for the APGAR score, SGA, and the NICU variables. The results of the analysis for APGAR score found significantly increased odds of infants of teens who received inadequate PNC compared to those of teens who received adequate PNC of having lower 5-minute APGAR scores (aOR: 3.26, CI:(2.03,5.22), p <0.0001). The results of the analysis for SGA found increased odds of infants born to teenagers who received inadequate PNC born SGA when compared to infants of teens who received adequate PNC (aOR: 1.08, CI:(0.78, 1.50), p = 0.6302) however these results were not significant. The analysis for infant stay in NICU found statistically significant increased odds of infants of teens who received inadequate PNC requiring a NICU stay compared to infants of teens who received adequate PNC aOR: 1.84, CI:(1.41, 2.42), p <0.0001). Further exploration into significant covariates found that infants of teens who had diabetes (Type I, II, or gestational) were almost 2.5 times greater odds of being admitted to the NICU than infants of teens who do not have diabetes (aOR: 2.46, CI:(1.57,3.85), p <0.0001).

While previous literature has concluded that infants born to teens are at increased risk of poor infant outcomes, (3,4) this study adds to the literature in adding that infants of teens who receive inadequate PNC are at increased risk of certain poor infant outcomes (NICU stay, longer LOS, and lower APGAR score) when compared to infants of teens who received adequate PNC.

Additionally, this study identified the existence of a relationship between teenagers who received inadequate PNC and low 5-minute APGAR score, infants being admitted to the NICU, and longer infants LOS relative to those who receive adequate care. While SGA was not found to be associated with inadequate PNC in our study, it has been found in previous literature to be associated with other covariates consistent with what was found in this study, such as maternal smoking (13-15), and resulting in lower academic success (16-18). The analysis reveals that a strong association exists between poor infant outcomes, including longer LOS, SGA, NICU stays, and low 5-minute APGAR scores in infants of teenagers who received inadequate PNC relative to teenagers who received adequate PNC.

Geographic Distribution of Inadequate PNC

The goal of aim 3 was to determine the geographic distribution of inadequate PNC in WV using spatial epidemiology. Using separate Bayesian Spatial Hierarchical regression models for private and public (WV Medicaid) health insurance groups, we found that a 30-minute drive time or greater to a birthing facility was the only predictor with a significant association to inadequate PNC prevalence within zip codes (public IRR:3.83, CI:(2.85,5.18)) (private IRR:4.31, CI:(3.17,5.88). For the public insurance group, geographic hot spots with inadequate PNC were scattered sporadically throughout the state. Several of these zip codes were located within the 30-minute drive time of a birthing facility, while some required a longer drive time. For the private insurance group, hot spots with inadequate PNC were clustered in the mid-eastern and southern parts of the state. Most of these zip codes were located outside of a 30-minute drive time to a birthing center. These results show that for the most part, areas considered hotspots for inadequate PNC were usually located outside of a 30-minute driving distance of a birthing center.

The study identified significant variation in PNC inadequacy across the state of WV particularly between groups with public and private insurance and areas located outside of a 30-minute drive time of a birthing facility. Within the private insurance group, hot spots of inadequate PNC are more likely to be found in areas outside of a 30-minute drive time to a birthing facility. Within the public insurance group, however, several hot spots of inadequate care are located within the 30-minute drive time boundaries. This shows that drive time and transportation are likely barriers to care in WV. Geography is also a likely barrier to care from the results of this analysis. Several of the hotspots of inadequate PNC were in the eastern and southern parts of the state, likely because these areas are much more mountainous and rural in comparison to other parts of the state.

Limitations of the Dissertation

All studies have limitations and one of the primary limitations of this dissertation is that our results may not be generalizable outside of the state of WV. A second limitation is that the definition of PNC was previously defined in the Project WATCH dataset and could not be adjusted to fit other indexes of PNC; this limits inferences to other definitions of inadequate PNC. Another limitation of this study is the lack of information regarding other potential confounders such as household income, marital status, support within the household, and access to affordable childcare. A fourth and final limitation is that due to the nature of the analysis, causal inferences cannot be drawn.

Strengths of the Dissertation

One of the main strengths of this dissertation is the use of a large comprehensive and up to date dataset unique to the state of WV that has been checked against birth certificate data with 98-99% agreement. To our knowledge this is the first set of studies to analyze the inadequacy of PNC in WV. This dissertation strengthened the previous literature in concluding that teenagers and birthing persons of AMA are less likely to receive adequate PNC when compared to individuals 25-29 years of age. This dissertation also added to the existing literature on infant outcomes of teenagers.

One of the biggest strengths of this dissertation is the completeness of the analysis of PNC in the state of WV, as it utilized all births in the state for PNC in three different examinations. This dissertation highlights many of the serious barriers to PNC that exist in the state. Study 1 confirms that teenage and AMA birthing persons are at increased risk of inadequate PNC. Since teenage births are prevalent in the state study two focuses directly on the infant outcomes of teens who are already known to be at increased risk of inadequate PNC and poor infant outcomes. The results of study two further highlight the importance of receiving adequate PNC by concluding that receiving inadequate PNC puts the infants of teens at even more increased risk of poor infant outcomes. To further highlight the importance of PNC the third study focuses on the geographic barriers to PNC that exist in such a rural state. The study found that individuals who must drive more than 30 minutes for PNC are at increased odds as well as individuals who live in the more mountainous regions of the state. These results all point to transportation being a huge barrier to care in the state. This dissertation draws a comprehensive picture of concerns and barriers to PNC that exist in WV.

Potential Public Health Implications and Future Work

This dissertation has a multitude of potential public health implications. For the first aim, determining what age category group (19 or younger, 20-24 years old, 25-29 years old, 30-34 years old, 35-39 years old, and 40+ years old) of pregnant persons were at risk for receiving inadequate PNC in WV can aid in directing more targeted research or prevention measures into improving education and access to PNC for pregnant persons of that age group. This research can also suggest the importance of education in the importance of PNC to teen pregnant persons in the state. The inference of this research is a gateway into the importance of education and access to pregnancy prevention measures. Pregnancy prevention measures are a form of secondary prevention in addressing poor infant outcomes in teenagers. Providing proper sex education and birth control methods to teenagers is of the upmost importance. Finally, gaining knowledge on existing geographic barriers can aid in future research and interventions to improve PNC in WV. Areas including the mid-eastern and southeastern regions of WV should be targeted for improving rates of PNC. To our knowledge, this research is one of the first to examine barriers and factors influencing geographic rates of PNC for the entire state; 30-minute drive time to a birthing facility was a particular barrier to expecting mothers with private insurance while those with public insurance appeared to be suffering from lack of transportation, even in urban centers. This information contributes to the broader literature as well; specifically, to literature on how geographic barriers affect PNC. It may not be sufficient for researchers to individually examine drive-time; these factors are likely moderated by the economic wealth, insurance types, and public transportation options within those regions. This information contributes to the broader literature on PNC but specifically to the literature relating to PNC of teenage births and geographic distributions of PNC.

Conclusion

The findings of these studies demonstrate the risk of receiving inadequate PNC, and more specifically the increased risks that exist to the infants of teenagers who receive inadequate PNC. These increased odds of poor infant outcomes such as longer infant stays, being admitted to the NICU, and lower 5-minute APGAR scores have been linked to lower test scores and academic struggles later in life as well as strain on the mental health of the parents and difficulty in parent-infant bonding(citations?). Geographic disparities in PNC inadequacy were also found at the zip code level it was concluded that more mountainous and rural zip codes as well as zip codes outside of a 30-minute driving distance of a birthing facility were at increased risk of inadequate PNC. These results all point to the importance of PNC and the disparities that exist in access and usage of care. These studies combined conclude the importance of receiving adequate PNC and the overwhelming need to increase education and support to at risk groups and to mitigate the barriers to PNC that exist within the state. While the results of these studies drawn a comprehensive picture of need to improve PNC across the state more targeted research is needed to implement prevention measures to provide support and mitigate the barriers that exist.

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