SOCIAL DETERMINANTS OF PRENATAL CARE USE IN SUB-SAHARAN AFRICA: EXPLORING EQUITY IN CONTENT AND OUTCOMES OF CARE

by

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ABSTRACT

YHENNEKO JALLAH TAYLOR. Social determinants of prenatal care use in sub-Saharan Africa: exploring equity in content and outcomes of care. (Under the direction of DR. JAMES N. LADITKA and DR. SARAH B. LADITKA)

Objectives: This study examined prenatal care use among women in sub-Saharan Africa, focusing on the West African region. The primary analysis examined variations by individual and national measures of wealth and literacy. Secondary analyses examined whether adequate prenatal care is associated with lower risk of infant mortality for women in all income groups.

Methods: Analyses used data from Demographic and Health Surveys, completed between 2006 and 2010 in Benin, Burkina Faso, Ghana, Guinea, Liberia, Mali, Niger, Nigeria, Senegal and Sierra Leone, to examine prenatal care use among women with a recent live birth (58,512 respondents). Chi-square tests, multivariate logistic regression and proportional hazards regression were used to test study hypotheses. Adequate prenatal care was defined by the World Health Organization's recommendations of at least four prenatal care visits beginning in the first trimester, with at least one visit with a skilled health professional. Individuals were grouped into wealth quintiles based on household assets. Models were adjusted for the following predisposing, enabling and need characteristics, which were available for all countries: age, parity, marital status, religion, pregnancy wantedness, rural/urban residence, occupation, and involvement in decision-making at home.

Results: In multivariate analyses, women who could not read had lower odds of adequate prenatal care compared to literate women (odds ratio, OR 0.70; 95% confidence

interval, CI 0.66-0.74). Similarly, women in the poorest quintile were less likely to receive adequate prenatal care compared to women in the wealthiest quintile (OR 0.31; CI 0.28-0.34). Each one-point increase in the literacy rate among women was associated with 4% higher odds of having adequate prenatal care (OR 1.04; CI 1.01-1.08). The effect of prenatal care on infant mortality varied significantly by wealth quintile. In the wealthiest quintile, women with adequate prenatal care had 34% lower risk of infant death compared to women with inadequate or no care (hazard ratio, HR 0.66; CI 0.51-0.85). However, the effect of adequate prenatal care on infant death was not significant for women in other wealth quintiles.

Discussion: Findings from this study suggest that illiteracy and poverty may both increase the likelihood of inadequate prenatal care, even when use of prenatal care is high. Findings highlight effects of wealth disparities on the use of prenatal care and on infant mortality. These effects suggest that additional interventions focused on reducing poverty may be useful for improving maternal and child health in this region. Policymakers should consider mechanisms for increasing access to skilled care by addressing barriers faced by poor, less educated women.

DEDICATION

To women and children

who hope for freedom from poverty and its related ills.

To my family, especially my parents, for always believing in me.

And to my husband and friend,

John,

for his unconditional love and support throughout this journey.

To God be the glory.

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CHAPTER 1: INTRODUCTION

1.1 Statement of Problem

Substantial disparities exist in maternal and child health outcomes between developing countries and more industrialized nations. In the least developed countries, women die during pregnancy and childbirth at a rate of 240 per 100,000 live births, more than 15 times the rate in developed countries (Wall, 2012). Developing countries also account for nearly 99% of the estimated three million neonatal deaths in the world; 37% of all neonatal deaths occur in sub-Saharan Africa (You, Jones, & Wardlaw, 2011).

These global disparities in maternal and child health have led to calls for action. The Safe Motherhood Initiative was launched in 1987 in Nairobi, Kenya, to mobilize stakeholders to develop ways to address disparities in infant and maternal morbidity and mortality (Sai, 1987). In 2000, the United Nations adopted eight Millennium Development Goals (MDGs) to reduce poverty, hunger and disease by 2015 (U.N. General Assembly, 55th Session, 2000). The fifth MDG is to reduce the maternal mortality ratio by 75% and achieve universal access to reproductive health care. Some countries have progressed towards this goal, while others have made much less progress (Wall, 2012). In sub-Saharan Africa, the percentage of mothers who received prenatal care from a skilled professional increased from 69% in 1990 to 77% in 2010 (Wall, 2012). However, universal coverage for prenatal care and primary care remains elusive, especially in the poorer regions of West and Central Africa (Wall, 2012).

Adverse outcomes that persist in poorer countries, and among the most economically disadvantaged populations, underscore the role of social factors, such as education and wealth, in health disparities. Many studies have examined social factors associated with prenatal care use. Yet few studies have compared social and economic factors associated with the use of prenatal care across multiple countries in sub-Saharan Africa. Even fewer studies have explored contextual variations between sub-Saharan African countries that could account for differences in prenatal care use. A better understanding of recent trends in prenatal care use in this region and their associations with social and economic factors would be useful for policymakers and health professionals. Specifically, understanding how wealth, education, and contextual characteristics influence use of prenatal care in sub-Saharan Africa can help target interventions to improve access to needed care. Experts agree that prenatal care is beneficial for maternal health, and that prenatal care may influence infant outcomes through education and management of risk factors (Abou-Zahr & Wardlaw, 2003; Bhutta, Darmstadt, Hasan, & Haws, 2005; Lincetto, Mothebesoane-Anoh, Gomez, & Munjanja, 2006). Additional research can improve our understanding of how women in Africa use prenatal care and whether use of prenatal care is associated with improved outcomes.

1.2 Background

Prenatal care fits into a larger continuum of maternal and child health care. This care continuum includes timely access to primary health care for girls and adolescents, preconception care, family planning, prenatal care, skilled birth attendance, postnatal care and scheduled vaccinations for newborns (Kinney, Lawn, & Kerber, 2009; Lu & Halfon,

2003). Over 100 years, prenatal care evolved from a focus on hypertension during pregnancy to include multiple clinical interventions, substance abuse education and mental health evaluations (Alexander & Kotelchuck, 2001). More recently, there has been increased focus on screenings and services with well-established benefits, such as tetanus immunizations, blood pressure screenings and iron/folic acid supplementation (Bhutta et al., 2005; Villar et al., 2001). The goal of prenatal care is to identify risks and provide education and services to improve the health of mothers and their babies during the period between conception and delivery. Prenatal care also often provides anticipatory guidance intended to improve health after birth by encouraging healthy behaviors such as breastfeeding, and by helping mothers understand how to avoid health risks and how to access appropriate medical care for their infants. Interventions during this period can play an important role in preventing maternal, fetal, neonatal, and infant morbidity and mortality (Alexander & Kotelchuck, 2001). In sub-Saharan Africa, prenatal care may also be more cost-effective than interventions after delivery (Prata, Sreenivas, Greig, Walsh, & Potts, 2010).

Access to prenatal care varies within and between countries in sub-Saharan Africa. In 2010, the percentage of women receiving prenatal care was 67% in Western Africa; 82% in Central Africa and 94% in Southern Africa (Wall, 2012). Women who are wealthier and have higher education tend to seek prenatal care earlier and more often than less affluent women (De Allegri et al., 2011; Mbuagbaw & Gofin, 2011; Ochako, Fotso, Ikamari, & Khasakhala, 2011). Women with husbands who have more education also tend to have better use of prenatal care (Ali & Adam, 2011). Other research suggests that cultural factors, such as the role of women in making decisions in the home and beliefs

regarding pregnancy, influence use of prenatal care (Lori & Boyle, 2011; Stephenson & Elfstrom, 2012). Cost and transportation are additional factors that may reduce access to prenatal care (Magoma, Requejo, Campbell, Cousens, & Filippi, 2010; Mubyazi et al., 2010).

When women do receive prenatal care, levels of care may be inadequate. The World Health Organization recommends at least four prenatal care visits for women with normal pregnancies. Less than half of women in sub-Saharan Africa receive this level of care (Wall, 2012). In studies based on women in this region, having at least four prenatal care visits was associated with lower odds of home birth (Faye, Wone, Samb, & Tal-Dia, 2010), lower odds of perinatal mortality (Fawole et al., 2011) and higher rates of exclusive breastfeeding (Agho, Dibley, Odiase, & Ogbonmwan, 2011) compared to women with no prenatal care. Adequate prenatal care visits may also be associated with lower risk of low birth weight (Gajate Garrido, 2011; Vieira et al., 2012). Other components of care, such as education about pregnancy complications (Nikiema, Beninguisse, & Haggerty, 2009), and receiving care from a trained health professional (McCurdy, Kjerulff, & Zhu, 2011) may have specific benefits for women. It is therefore important to understand barriers to any prenatal care, as well as factors that prevent the adequate use of prenatal care.

1.3 Overview of the Demographic and Health Survey

Data for this study come from the Demographic and Health Survey (DHS), a national household survey funded by the United States Agency for International Development (USAID) in over 90 developing countries (www.measuredhs.com). The goal of the DHS is to help governments to collect data on health and nutrition, with a

specific focus on maternal and child health and diseases such as HIV/AIDS and malaria. The DHS program began in 1984 and is currently in its sixth phase; each phase is a five-year overlapping interval (Rutstein & Rojas, 2006). Chapters 3, 4, and 5 describe the DHS data collection and questionnaires. A brief overview follows, in the paragraph below.

The DHS uses a multistage cluster design to produce samples that are representative at the levels of region, rural and urban residence, and nation. Eligible participants include women and men aged 15 to 49. Local interviewers obtain informed consent prior to conducting face-to-face interviews. ICF International (previously Macro International), an organization based in Calverton, Maryland, partners with local government agencies to provide technical assistance, including standardized questionnaires and training manuals. The standard DHS survey includes separate questionnaires for households, women and men. This dissertation research uses data from the questionnaires for households and women.

1.4 Overview of Ten Sub-Saharan Countries Included in this Research

My dissertation research analyzed data from countries that participated in the DHS in the previous ten years, and were located in the western region of Africa. Included countries and survey year were Benin (2006), Burkina Faso (2010), Ghana (2008), Guinea (2006), Liberia (2007), Mali (2006), Nigeria (2008), Niger (2006), Senegal (2005), and Sierra Leone (2008). As shown in Table 1.1, these countries vary in size from a population of 5.87 million in Sierra Leone to 158.42 million in Nigeria. The countries are all low-income (less than $1,025) or lower-middle income ($1,026 to $4,035) based on the World Bank classification of per capita gross national income (GNI) (The World

Bank, 2013). Ghana has the highest GNI per capita ($1,230 USD) as well as the highest literacy rate among adults aged 15 and older (66.6%). All countries have large rural populations except Liberia where only 38.5% of the population is rural. Rates of maternal and infant mortality are high. Liberia has the highest maternal mortality rate (994 per 100,000 live births), while infant mortality is highest in Sierra Leone (113.7 per 1,000 live births).

The response rate for women ranged from 92.7% in Senegal to 99.0% in Burkina Faso (Table 1.2). Across the ten countries 135,096 women were surveyed; 62,093 women had given birth in the three years prior to the survey; 94% (n=58,512) of these women had data available about prenatal care use and literacy. Most women were multiparous (81.6%), married (89.4%), lacked formal education (69.6%), and lived in a rural area (72.2%).

1.5 Literacy, Wealth and Social Determinants of Health

Literacy and wealth are social determinants of health. These are conditions in which you live, work, and play (Marmot & Wilkinson, 2006), compared to genetic factors that may influence health. Literacy may influence health, social and economic status, and access to preventive health care (Berkman, Sheridan, Donahue, Halpern, & Crotty, 2011; LeVine, LeVine, Rowe, & Schnell-Anzola, 2004). Wealth may influence health in similar ways, by influencing social conditions, and health behaviors (Andersen & Davidson, 2007a; Brunner & Marmot, 2006). The DHS assessed literacy of participants who never attended school, or who only attended primary school (generally grades one through six). Women with at least secondary education were considered literate. The DHS computes an index of household wealth using principal components

analysis to weight indicators for various assets including appliances, vehicles, telephone, type of roofing and flooring materials, land ownership, electricity, water supply, and sanitation facilities (Rutstein & Johnson, 2004). The resulting scores are ranked at the national level to identify wealth quintiles. As shown in Figure 1.1, the percentage of women who could not read decreased with the wealth quintile. The largest differences were between women in the wealthiest quintile and those in the poorest quintile.

1.6 Adequate Prenatal Care

Previous research suggests a number of benefits of having recommended levels of prenatal care (Fawole et al., 2011; Gajate Garrido, 2011; Kotelchuck, 1994). The DHS collects data on prenatal care provider, number of visits, timing of the first visit, and whether women received blood pressure screening, or provided samples of blood and urine for analysis during their most recent pregnancy resulting in a live birth in the previous three or five years. Some countries also collect data on the location of prenatal care. In addition to whether the women received any prenatal care, this dissertation research examined whether women received adequate care as defined by at least four visits beginning in the first trimester and with at least one visit with a skilled provider (doctor, nurse, midwife, or auxiliary midwife). Figure 1.2 shows large differences in the receipt of adequate prenatal care for women in the bottom 20% and top 20% of wealth. About 43% of women in the wealthiest quintile received adequate care compared to 12.9% of women in the poorest quintile. As shown in Figure 1.3, the percentage of women with adequate care also varied notably by literacy. Women who cannot read tend to have lower rates of adequate care. The smallest differences by literacy were observed in Liberia and Sierra Leone; the largest differences were observed in Benin and Mali.

1.7 Objectives of My Dissertation Research

My research focuses on outcomes for women in the western region of sub-Saharan Africa, a region with high poverty and poor maternal health outcomes. Andersen's behavioral model of health service use (Andersen & Davidson, 2007a; Andersen, 1995) provides a theoretical framework to examine prenatal care use and outcomes for women in this region. Chapter 2 reviews the literature on prenatal care use and outcomes for women in sub-Saharan Africa. My dissertation research has three objectives. The first objective is to examine whether maternal education and wealth are associated with receiving any prenatal care and with adequacy of prenatal care, after adjusting for other individual characteristics (Chapter 3). The second objective is to explore whether national investments in health and female literacy rates are associated with the use of prenatal care (Chapter 4). The third objective is to investigate whether wealth modifies the association between receiving any prenatal care and infant mortality, or the corresponding association for adequate prenatal care (Chapter 5).

My research extends previous studies in several ways. First, I examine the adequacy of prenatal care using a measure that combines number of visits, timing of first visit, and type of provider. Most prior studies use only the quantity of prenatal care visits. My research also examines the influence of health expenditures, female literacy rates and density of health care professionals on prenatal care use. In Chapter 5, I examine how wealth may modify associations between prenatal care use and outcomes. That analysis extends the literature by exploring whether prenatal care provides equal benefits for women in different wealth quintiles. Findings from my research can help to inform policy

and discussions about potential strategies to address poor maternal health indicators in one of the poorest regions of the world.

Table 1.1 General descriptors for ten West African countries included in analysis

Country	Population (millions)	Official Language	Major Religion	GNI per capita (USD)	Rural Population (%)	Adult Literacy Rate	MMR	IMR
Benin	8.85	French	Christian (43%)	$780	58.0	41.7	397	73.2
Burkina Faso	16.47	French	Muslim (61%)	$550	79.6	28.7	307	92.6
Ghana	24.39	English	Christian (69%)	$1,230	48.5	66.6	451	50.0
Guinea	9.98	French	Muslim (85%)	$400	64.6	39.5	980	81.2
Liberia	3.99	English	Christian (86%)	$200	38.5	59.1	994	73.6
Mali	15.37	French	Muslim (90%)	$600	66.7	26.2	464	99.2
Niger	15.51	French	Muslim (80%)	$370	83.3	28.7	648	72.5
Nigeria	158.42	English	Muslim (50%)	$1,180	50.2	60.8	545	88.4
Senegal	12.43	French	Muslim (94%)	$1,090	57.1	49.7	401	49.8
Sierra Leone	5.87	English	Muslim (60%)	$340	61.6	40.9	857	113.7

Source: African Development Indicators (2010) and the World Factbook (Central Intelligence Agency, 2012).

GNI, gross national income; IMR Infant mortality rate per 1,000 live births; MMR, Maternal mortality rate per 100,000 live births

Table 1.2 Response rates for eligible women in the Demographic and Health Survey

Country	Survey Year	Response Rate	Country	Survey Year	Response Rate
Benin	2006	94.4%	Burkina Faso	2010	99.0%
Ghana	2008	96.5%	Guinea	2006	97.2%
Liberia	2007	95.2%	Mali	2006	96.6%
Niger	2006	95.6%	Nigeria	2008	96.5%
Senegal	2010	92.7%	Sierra Leone	2008	94.0%

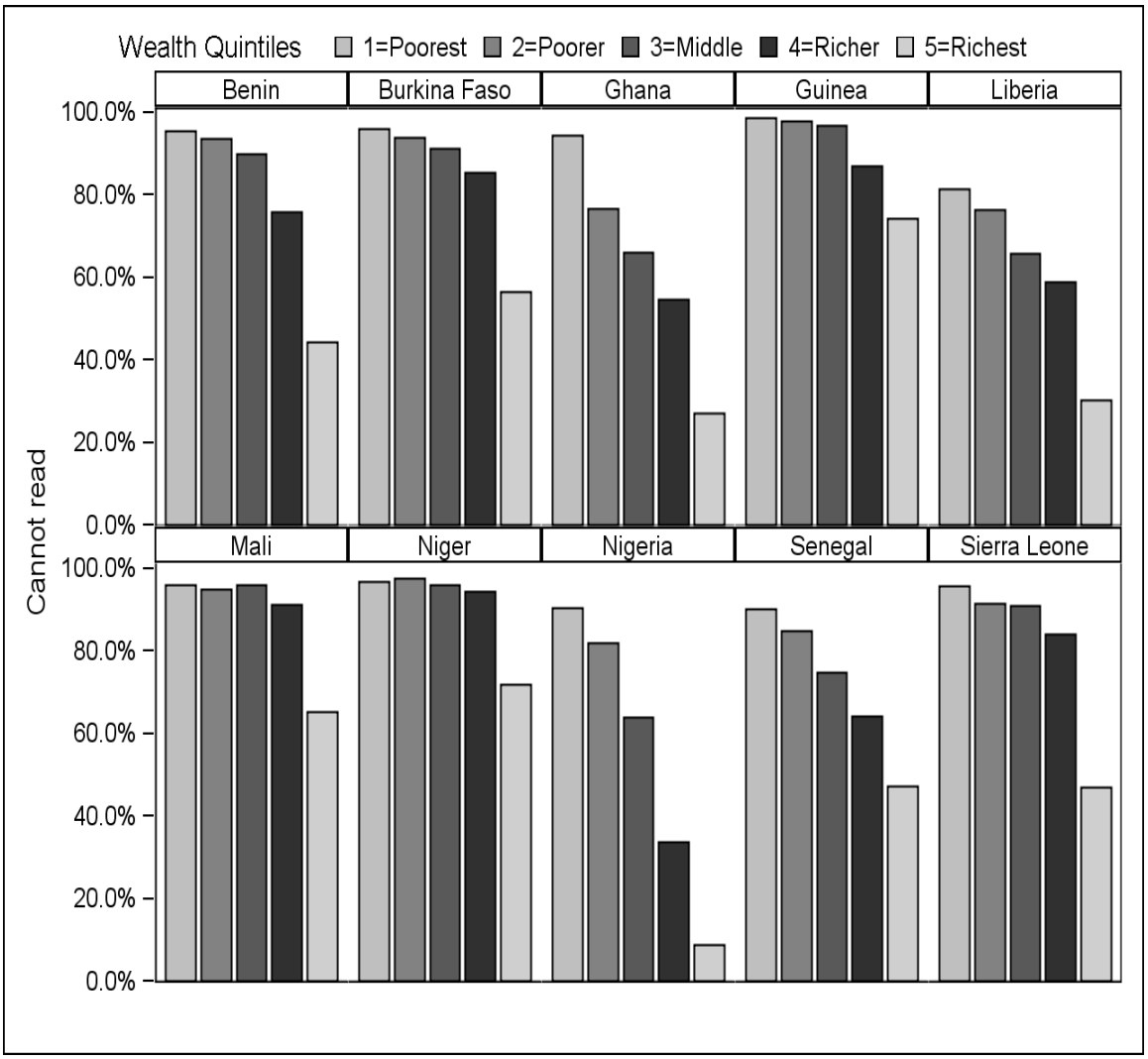

Figure 1.1 Association between literacy and wealth in West Africa, women with a recent birth reported in the Demographic and Health Surveys

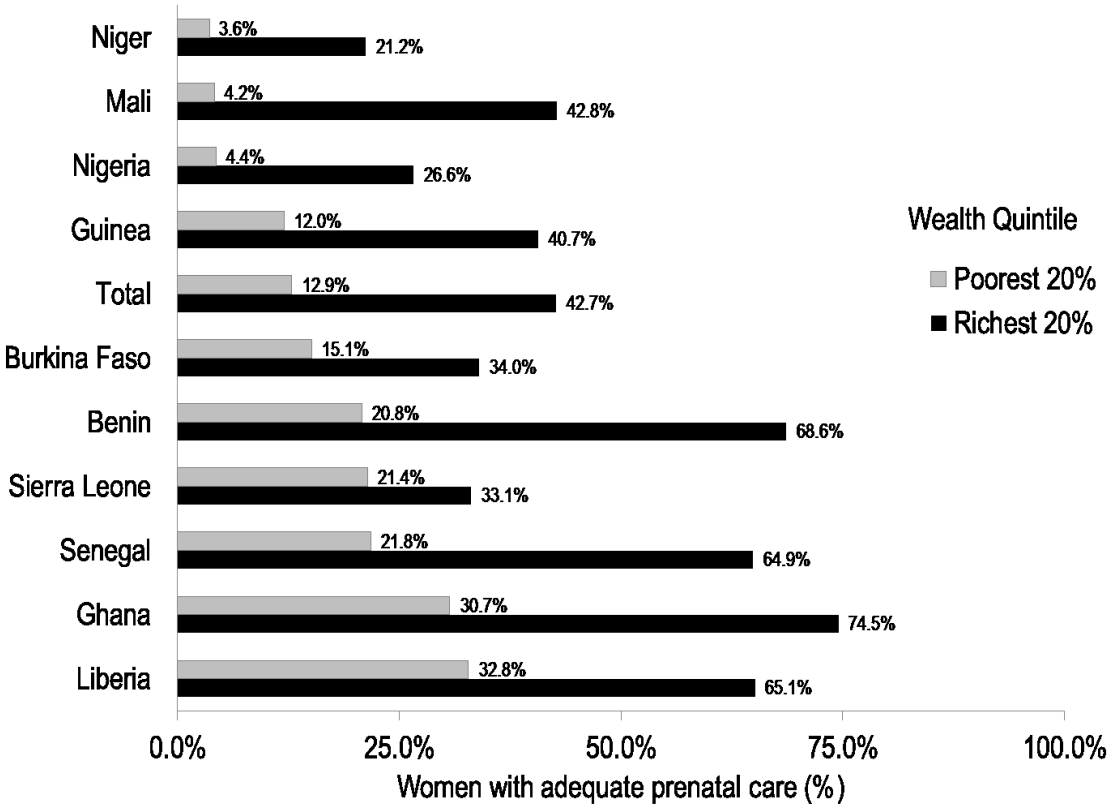

Figure 1.2 Adequate prenatal care use among women in the poorest and richest wealth quintiles, women with a recent birth reported in the Demographic and Health Surveys

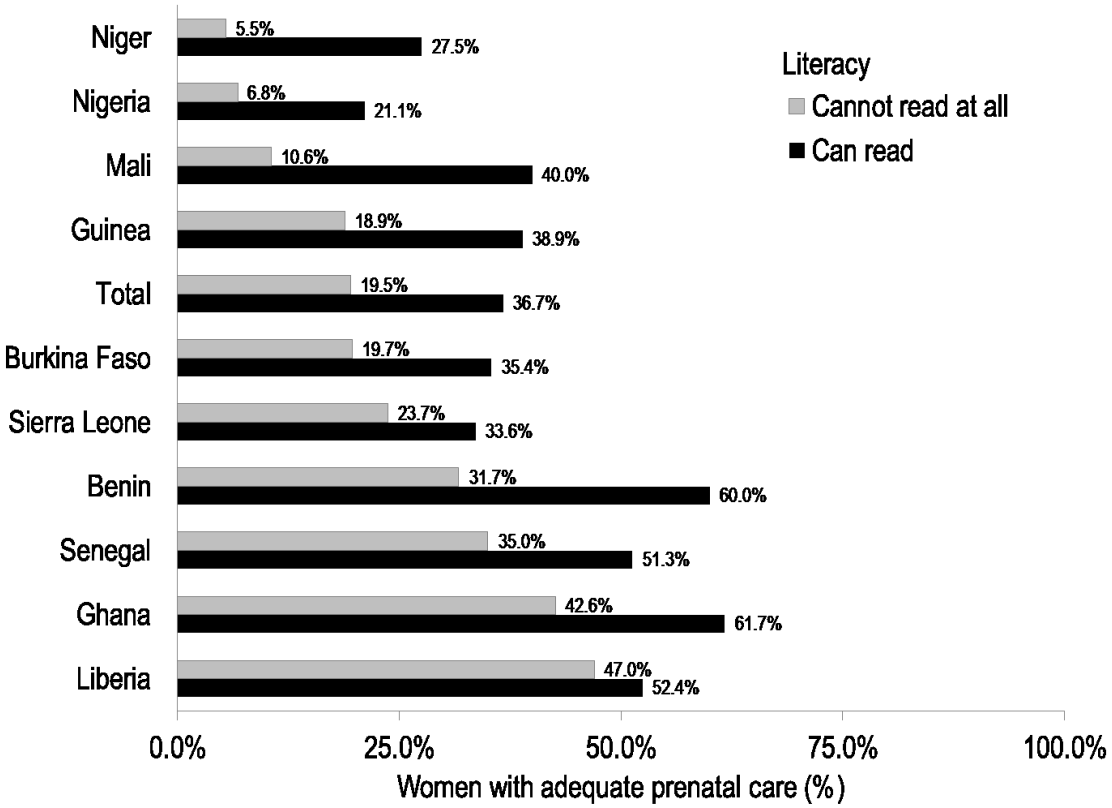

Figure 1.3 Adequate prenatal care use by ability to read, women with a recent birth reported in the Demographic and Health Surveys

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Social conditions have a direct impact on health. Where we live, our working conditions, and our social status— as determined by wealth, education, or ethnic origin— can influence risk for disease, ability to access care, and life expectancy, among other outcomes. Social determinants of health are expansive. They include poverty, unemployment, social exclusion, housing, neighborhood, food supply, economic position, and social support (Marmot & Wilkinson, 2006). In 2005, the World Health Organization (WHO) established the Commission on Social Determinants of Health (CSDH) in an effort to further highlight the role of social inequities on health outcomes (Irwin et al., 2006). Sub-Saharan Africa is one region affected by high rates of poverty, unemployment and illiteracy. Approximately 48% of residents of sub-Saharan Africa live in poverty, and 37% of adults aged 15 and older cannot read (The World Bank, 2012).

Implications of social inequities for the health of mothers and children are notable. In developing countries, 240 of every 100,000 live births result in maternal death compared to less than twenty maternal deaths for every 100,000 live births in developed countries (Wall, 2012). Similarly, life expectancy at birth is 56 in Liberia, one of the poorest countries in the world, compared to 73 in Seychelles, an upper middle-income country (The World Bank, 2012). When the United Nations accepted the challenge of reducing poverty in the world by 2015, goals for reducing poverty and illiteracy were

listed together with goals for reducing child mortality and improving maternal health. Literature on the subject supports the conclusion that poverty, war, and other adverse social conditions have a negative impact on children's physical and mental health; some adverse effects such as stunted growth may be irreversible (Wadsworth & Butterworth, 2006).

Relationships between education, socioeconomic status, and health are not unique to sub-Saharan Africa. However, the corresponding burden of disease and disability from preventable causes is much greater than in developed countries. Low-income developing countries face additional challenges of low literacy rates, poor sanitation, and lack of safe water sources. As a region, sub-Saharan Africa has the highest rate of poverty and undernourishment, and the lowest rates of primary education (Wall, 2012). These conditions coexist with high regional rates of under-five child mortality (121 per 1,000 live births in 2010) and the highest regional rates of maternal mortality (500 per 100,000 live births in 2010) (Wall, 2012). Over half of maternal, newborn, and child deaths occur in sub-Saharan Africa despite the fact that this region includes less than 15% of the world's population (Friberg et al., 2010). The greatest burden falls to the poorest families, as regional data suggests a marked socioeconomic gradient with regard to access to clean water, primary education, and child mortality (Wall, 2012).

Countries where primary education for girls and gender equality have improved have also seen progress in achieving goals for maternal and child health (United Nations Development Program, 2003). Still, wealth disparities persist. In a review of maternal and child health interventions in 54 low-income countries, Barros (2012) found great rich-poor disparities for facility based services such as skilled birth attendance and prenatal

care. Stakeholders such as the CSDH draw attention to social inequities in health, acknowledge the challenge of developing solutions, and highlight the need for additional research that results in feasible policy solutions (Irwin et al., 2006).

My review of the literature explores the impact of individual and contextual social determinants of health on use of prenatal care. In addition, I describe findings of studies that have examined the relationship between prenatal care and infant mortality. My goal is to improve our understanding of outcomes associated with inadequate prenatal care. I begin with an overview of prenatal care and its implementation in the African context. Next, I review studies examining individual and contextual factors associated with prenatal care use. This chapter concludes with a review of the association between prenatal care and infant mortality, and of its implications for women in sub-Saharan Africa.

2.2 Overview of Prenatal Care

Prenatal care includes preventive care and health education provided by a health care provider during the period between conception and delivery. The scope and content of prenatal care varies widely in developed and developing countries (Carroli, Rooney, & Villar, 2001), but generally focuses on screenings and education to identify and minimize risk factors for adverse outcomes. Guidelines for prenatal care proposed by U.S. organizations include assessments for blood pressure, weight, and fetal presentation; laboratory tests for genetic diseases, sexually transmitted infections, and blood typing; and education around safety and healthy behaviors (Hanson, VandeVusse, Roberts, & Forristal, 2009). The WHO recommends blood pressure screenings, tetanus immunizations, iron supplementation, and urine and blood tests, in addition to obstetric

and gynecological exams, and education about emergencies, delivery and breastfeeding (Villar & Bersgjø, 2002; WHO, 1999). Table 2.1 lists key components of prenatal care as recommended by major health organizations. For example, while the WHO does not recommend routine assessment of maternal weight during pregnancy (Villar & Bersgjø, 2002; WHO, 1999), the American College of Obstetrics and Gynecology (ACOG) does (American Academy of Pediatrics & ACOG, 2002). Unlike ACOG recommendations, the WHO recommendations do not include genetic testing or lab tests beyond syphilis, HIV and anemia, reflecting a broader audience consisting of rich and poor health systems. ACOG recommendations include screening for gestational diabetes, substance abuse, and postpartum depression, whereas the WHO recommendations do not. The WHO recommends counseling on hygiene, which is not included in recommendations by ACOG.

Recommendations for timing and frequency of prenatal visits also vary, as shown in Table 2.1. The 1989 Expert Panel on the Content of Prenatal Care, convened by the U.S. Public Health Service, concluded that low-risk nulliparous women should receive 9 visits (at 8, 12, 16, 24, 32, 36, 38, 40 and 41 weeks gestation), while low-risk parous women should receive 7 visits (at 8, 16, 24, 32, 36, 38 and 41 weeks gestation) (Rosen, Merkatz, & Hill, 1991). Recent prenatal care guidelines from the Institute for Clinical Systems Improvement (ICSI) recommend 11 visits at 6-8, 10-12, 16-18, 22, 28, 32, 36, 38, 39, 40, and 41 weeks gestation for normal low-risk pregnancies (Akkerman et al., 2012). However, ACOG recommends that women with uncomplicated pregnancies receive visits once every 4 weeks through 28 weeks, every 2 to 3 weeks through 36 weeks, and then weekly until delivery for a total of 14 visits for a 40-week pregnancy

(American Academy of Pediatrics & ACOG, 2002). In addition to prenatal visits, the Expert Panel, ICSI and ACOG recommend at least one preconception visit. For women with normal pregnancies, the WHO recommends at least four prenatal visits beginning in the first trimester and continuing at approximately 24, 32, and 36 weeks of gestation (Villar & Bersgjø, 2002).

Despite variations in recommendations, prenatal care is thought to be beneficial for improving maternal health (Abou-Zahr & Wardlaw, 2003; Villar & Bergsjø, 1997). The benefit of prenatal care for improving infant outcomes such as low birth weight and infant mortality, however, is widely debated (Abou-Zahr & Wardlaw, 2003; Alexander & Kotelchuck, 2001; Fiscella, 1995). Conway and Kutinova (Conway & Kutinova, 2006) have argued that the benefits of prenatal care for maternal health have a direct effect on infant health. Econometric models by Conway and Deb suggest further that prenatal care has a beneficial impact on birth weight for normal pregnancies, compared with complicated pregnancies that result in very preterm low birth weight infants (Conway & Deb, 2005). Others believe that primary prevention such as that delivered during prenatal care can have tremendous benefit (Zanconato, Msolomba, Guarenti, & Franchi, 2006). A review of available evidence from community-based interventions suggests that education on complication symptoms, birth preparedness, tetanus immunizations, and breastfeeding counseling are important components of care that should be provided in the prenatal period (Bhutta et al., 2005). Iron supplementation, malaria prophylaxis, and screenings for blood pressure and sexually transmitted infections are additional interventions with potential to reduce the development or severity of anemia, hemorrhage, hypertension, and other major causes of maternal morbidity and mortality

(Carroli, Rooney, et al., 2001). Therefore, women receiving prenatal care may benefit from adequate content of care that addresses their baseline risk profile.

2.3 Prenatal Care and the Global Agenda for Maternal Health

Two major global initiatives draw attention to the problem of maternal health in the developing world. In 1987, the Safe Motherhood Initiative (SMI) was launched in Nairobi, Kenya, to mobilize stakeholders to develop ways to address disparities in maternal and infant morbidity and mortality between rich and poor nations of the world (Sai, 1987). The SMI aimed to reduce maternal deaths by 50% by the year 2000, by addressing social and medical factors contributing to maternal deaths, and by promoting feasible and effective interventions (Starrs, 2006). While initial SMI targets have not been met, the initiative continues to garner support for its key interventions, which include family planning, prenatal care, obstetric care, postnatal care, post abortion care, equity for women and control of sexually transmitted infections (World Bank, 2012a). Focus on maternal health increased further in 2000, when the United Nations adopted eight Millennium Development Goals (MDGs) to reduce poverty, hunger and disease by 2015 (U.N. General Assembly, 55th Session, 2000). The fifth MDG (MDG5) seeks to reduce the maternal mortality ratio by 75% between 1990 and 2015 and achieve universal access to reproductive healthcare including prenatal care (United Nations, 2010). MDG5 is tracked alongside goals for reducing child mortality, improving gender equity in education, reducing hunger, and combatting HIV/AIDS. While many countries have made progress towards achieving MDG5, progress is slow in sub-Saharan Africa and other deprived regions (Wall, 2012).

Prenatal care may have greater benefit for women in developing countries where perinatal morbidity and mortality are high (Abou-Zahr & Wardlaw, 2003). Prenatal care provides an opportunity for delivering needed interventions and education to women who may otherwise have limited interactions with the health care system. Prenatal care visits are also a useful entry point into other interventions such as those designed to prevent malnutrition and mother to child transmission of HIV (Lincetto et al., 2006).

Single country and multinational studies in developing countries have found an inverse association between prenatal care use and adverse outcomes. In Burkina Faso, women who were informed about pregnancy complications during pregnancy were more likely to deliver in a health care facility versus at home (Nikiema et al., 2009). In Senegal, having at least four prenatal care visits was associated with lower odds of home birth (Faye et al., 2010), although this result could have occurred if those with notably high risks for maternal or infant complications received more follow-up visits and were also advised to use health care facilities for birth. Data from 17 of the poorest countries in sub-Saharan Africa found that prenatal care from a doctor, nurse or midwife was associated with lower risk of neonatal mortality when controlling for maternal and delivery characteristics (McCurdy et al., 2011). In a study of hospital-based deliveries in Nigeria, women with four or more prenatal care visits had 46% lower odds of perinatal mortality compared to women with no prenatal care (Fawole et al., 2011). Additional studies have found that having prenatal care is associated with higher rates of exclusive breastfeeding (Agho et al., 2011) and lower risk of low birth weight (Gajate Garrido, 2011; Vieira et al., 2012). While randomized controlled trials are lacking and most studies have used cross-sectional designs (Bhutta et al., 2005), the consistency of

evidence supports the suggestion that appropriate interventions during the prenatal period may improve outcomes.

2.4 Measuring Prenatal Care

Prenatal care utilization is measured in a variety of ways. MDG reports track two measures: percent of women receiving prenatal care by a skilled provider (i.e. doctor, nurse or midwife) and the percent of women receiving at least four prenatal care visits as recommended by the WHO for normal pregnancies in developing countries. In addition to evaluating early initiation of prenatal care in the first trimester, researchers examining outcomes for women in developed countries use one of many indices that combine timing of prenatal care, number of visits, and gestational age to assess whether prenatal care was adequate or inadequate. The most commonly used are the Adequacy of Prenatal Care Utilization index (APNCU) (Kotelchuck, 1994), the Graduated Index of Prenatal Care Utilization (GINDEX) (Alexander & Cornely, 1987), and the Kessner index (Institute of Medicine (U.S.), 1973), which use prenatal care timing and frequency guidelines recommended by ACOG. These measures are limited in that they do not address content of prenatal care. Beeckman (2012) attempted to address this limitation when defining adequate prenatal care for women in Belgium by expanding timing and frequency criteria to include a minimum care package of blood pressure screening, ultrasound, and blood screening. Results from a prospective cohort of 333 women with singleton pregnancies showed that while 91% of women received at least adequate care by the APNCU, only 78% received the minimum number of interventions, and only 44% of women received the minimum number and recommended timing of prenatal interventions (Beeckman et al., 2012).

Researchers examining outcomes in developing countries have used variations of the WHO recommendations when measuring adequacy of prenatal care. The majority of studies focus on the number of visits alone and use at least four visits to determine adequate utilization of prenatal care (Ali & Adam, 2011; Arthur, 2012; De Allegri et al., 2011; Overbosch, 2004). Additional studies have combined both the timing and number of visits (Gajate Garrido, 2011; Magadi, Agwanda, & Obare, 2007), or combined skill level of provider with timing and number of visits (Mbuagbaw & Gofin, 2011). Other researchers use national guidelines. For example, Tran et al. (2012) used early initiation of prenatal care, at least three visits, and receipt of core services (measurement of height and weight, urine test, blood pressure, tetanus vaccination, medical consultation and fetal exam) to indicate adequate prenatal care use in Vietnam. No studies have combined the full scope of the WHO recommendations (timing, frequency, and content) into a replicable index. As many developing countries lack modern data collection systems for collecting data representing prenatal care and delivery, population-level analyses most commonly use measures that can be collected easily through surveys.

2.5 Prevalence of Prenatal Care

Only 77% of women in sub-Saharan Africa receive care from a skilled health professional at least once during pregnancy (Wall, 2012). In contrast, approximately 98% of women in the U.S. receive prenatal care and 73% of women initiate prenatal care in the first trimester (Centers for Disease Control and Prevention (CDC), 2010). Prenatal care use in sub-Saharan Africa ranges from 26% in Somalia to 99% in Burundi, with a median value of 88%, based on country-level means (United Nations Statistics Division, 2012). The proportion of women with at least four prenatal care visits ranges from 6.3%

in Somalia to 87% in South Africa with a median value of 50%, also based on country-level means (United Nations Statistics Division, 2012). Most women in sub-Saharan Africa initiate prenatal care later than recommended. In Kenya, only 11% of young women initiated prenatal care in the first trimester (Ochako et al., 2011). A qualitative study that interviewed key informants, health care providers, and 74 women with recent births in eight rural Tanzanian villages found that the majority of women did not seek care until 18 or 19 weeks of pregnancy (Mrisho et al., 2009). These statistics suggest less than optimal use of prenatal care, with regard to frequency and timing of prenatal care visits, and missed opportunities for education and interventions that could reduce adverse pregnancy outcomes.

2.5.1 Delivery of Prenatal Care

The WHO defines skilled health professionals to include doctors, nurses, and midwives (WHO, 2004). Other persons involved in providing health care during pregnancy may include traditional birth attendants who are relatives or local women with childbirth experience (Lefèber & Voorhoever, 1997). Traditional birth attendants often have no formal medical training. However, women living in rural areas of South Africa preferred receiving care from traditional birth attendants rather than trained professionals in health centers because of their knowledge of cultural practices and easier accessibility (Ngomane & Mulaudzi, 2012).

Skilled health providers in sub-Saharan Africa generally receive training in western models of prenatal care that involve 7 to 14 visits throughout pregnancy. When trials of a reduced schedule of prenatal care visits were conducted in Zimbabwe during 1995 to 1997, standard care involved at least 9 visits for term pregnancies when

commenced in the first trimester (Majoko, Munjanja, Nyström, Mason, & Lindmark, 2007). Apart from recommendations to initiate prenatal care early, which can identify risks earlier, recommendations regarding the frequency of prenatal care visits have not undergone rigorous scientific evaluation (Carroli, Rooney, et al., 2001). There is some consensus in the literature regarding specific screenings such as weight, blood pressure, urinalysis, and fetal heartbeat (Kirkham, Harris, & Grzybowski, 2005). Current evaluations support revised prenatal care guidelines with fewer visits as recommended by the WHO (Akkerman et al., 2012; Arthur, 2012).

Randomized trials evaluating models of prenatal care with five or fewer visits lend support to the WHO recommendations of at least four prenatal care visits for women with normal pregnancies (Carroli, Villar, et al., 2001; Villar et al., 2001). Some trials involved goal-oriented visits, where providers delivered specific evidence-based interventions at each encounter, while others involved only a reduced visit schedule. The WHO model of care supports goal-oriented visits with a checklist that includes medical history, physical examination, screening tests, and consultation (Villar & Bersgjø, 2002). However, a meta-analysis has suggested that four visits with or without specific goals may provide similar benefits (Carroli, Villar, et al., 2001).

One multicenter randomized study led by the WHO in urban areas of Argentina, Cuba, and Saudi Arabia, and rural areas of Thailand, compared 12,568 women receiving standard care to 11,958 women receiving the WHO model of at least four goal-oriented visits (Villar et al., 2001). Results showed similar outcomes for low birth weight and length of hospital stay, but some evidence of higher rates of preeclampsia for women receiving the WHO model of care. Prior to the study less than half of women in

Argentina, Saudi Arabia, and Thailand initiated care in the first trimester, and the average number of prenatal care visits for term pregnancies ranged from six to eight visits (Piaggio et al., 1998). Only in Cuba did women have 12 to 17 visits on average with 78% of women initiating care in the first trimester (Piaggio et al., 1998). Obstetricians were the primary provider in Argentina, general practitioners most often provided care in Cuba and Saudi Arabia, while nurses or midwives most often provided care in Thailand (Piaggio et al., 1998). Women in the standard care arm attained a median of eight visits, compared to a median of five visits for women in the WHO model of care (Villar et al., 2001).

A cluster randomized trial in rural Zimbabwe compared the standard prenatal care schedule to a reduced-visit model with five goal-oriented visits at <20, 24 32, 36, and 40 weeks (Majoko et al., 2007). There was a median of four visits in both groups; however, women in the new model were more likely to receive five or fewer visits. When women in the five-visit model were compared to women in the standard model, there were no significant differences in syphilis testing, place of delivery, or postpartum referrals for complications. Preterm birth, birth weight, and fetal and neonatal mortality also did not differ between groups. Fewer women in the five-visit model required surgery or referral during delivery.

A meta-analysis, evaluating data from seven randomized trials involving 26,619 women in standard care and 30,799 women in a model with reduced visits, further confirms that outcomes associated with a lower number of prenatal care visits are similar to standard care (Carroli, Villar, et al., 2001). Authors of the meta-analysis found no significant differences for the outcomes of pre-eclampsia, low birth weight, and maternal

mortality. Therefore, recommendations issued by WHO in 2001 recognize potential barriers to access and aim to reduce burden for women while providing interventions known to benefit health outcomes (Carroli, Villar, et al., 2001). In an updated meta-analysis comparing a reduced schedule of prenatal care to a standard schedule, Dowswell et al. (2010) found that the reduced visit schedule was associated with a 15% higher rate of perinatal mortality for women in low and middle income countries with fewer visits. The authors reviewed four randomized trials in high-income countries and three cluster-randomized trials in low and middle-income countries. Maternal death, pre-eclampsia, preterm birth, and other clinical outcomes did not differ significantly between groups.

The WHO recommendations of at least four prenatal care visits are lower than what other major organizations recommend; however, these recommendations represent a more realistic schedule for women in developing countries given resource constraints. Randomized trials in the U.S and the U.K. have found that as few as nine (McDuffie, Beck, Bischoff, Cross, & Orleans, 1996), eight (Binstock & Wolde-Tsadik, 1995; Walker & Koniak-Griffin, 1997), and seven (Sikorski, Wilson, Clement, Das, & Smeeton, 1996) prenatal care visits offer low-risk women similar perinatal outcomes as do traditional models with 13 visits. Three U.S. studies reported greater satisfaction with a reduced visit schedule (Binstock & Wolde-Tsadik, 1995; McDuffie et al., 1996; Walker & Koniak-Griffin, 1997). A U.K. study examining seven visits found less satisfaction with the reduced visit schedule although women reported that they would chose a reduced schedule of prenatal care for future pregnancies (Sikorski et al., 1996). In low-income countries, benefits of a reduced visit schedule and focused prenatal care interventions include less demand on scarce resources and potentially longer patient-provider

consultations (Munjanja, Lindmark, & Nyström, 1996). Altogether, these studies suggest that while health care context may influence delivery of prenatal care, there is a general trend towards fewer visits than the standard 13 visits for women at low risk for adverse pregnancy outcomes.

2.5.2 Coverage for Prenatal Care

Prenatal care coverage varies widely across sub-Saharan Africa. In Burkina Faso, policies implemented between 2002 and 2007 reduced costs for maternal health care and ended fees associated with prenatal care (De Allegri et al., 2011). In Ghana, user fees for delivery were removed in 2003 for women in the poorest regions of the country (S. Mills, Williams, Adjuik, & Hodgson, 2008). In 2004, Ghana implemented a national health insurance scheme, which covered health services for workers in the formal sector with voluntary and less consistent enrollment for workers in the informal sector (A. Mills et al., 2012). Other countries with national insurance schemes include Tanzania and South Africa (A. Mills et al., 2012). A comparative analysis of Tanzania, Ethiopia, Kenya, Malawi, Rwanda and Uganda, found that donor contributions made up 20% to 80% of funding for reproductive health services; percentages of out-of-pocket spending by households were smallest in countries with high levels of monetary contributions from international donors (Nguyen, Snider, Ravishankar, & Magvanjav, 2011).

Where policies do not provide universal coverage for prenatal care, it is generally expected that women pay out of pocket for these services (A. Mills et al., 2012). An analysis by Leive and Xu (2008), using cross-sectional data from 15 sub-Saharan countries, found that many countries lack risk-pooling mechanisms and that families cope with out-of-pocket expenses by borrowing or selling assets to pay for care. Families were

more likely to borrow money if they were poor, uneducated or lived in a rural area. Families were also more likely to borrow money to pay for inpatient services than for outpatient services (Leive & Xu, 2008). Since prenatal care is preventive and does not involve inpatient care in most cases, these findings suggest that poor families would be less likely to seek prenatal care if a cost is involved.

2.5.3 Quality of Prenatal Care

Several studies have examined the quality of prenatal care provided in sub-Saharan African countries with a focus on length and content of consultations. Findings of the studies reviewed in the following paragraphs suggest that counseling and health promotion activities may be insufficient to ensure healthy birth outcomes.

Chaibva, Ehlers and Roos (2011) conducted a retrospective review of patient charts to assess the accuracy of prenatal care records for adolescent patients aged 19 and younger in Bulawayo, Zimbabwe. Results from a random sample of 80 charts showed gaps in documentation of social history and limited indications of health promotion activities such as providing information about contraception, nutrition, malaria, and prepartum hemorrhage. In contrast, more than 80% of charts included information on vertical transmission of HIV, tetanus, and obstetric and general health details such as gestation, history of abortion, parity, fetal presentation, blood pressure, and number of prenatal care visits. While the study did not determine whether documentation varied by type of provider, findings suggest that providers did not document or perform some aspects of prenatal care as recommended.

Pembe et al. (2010) examined the extent to which providers in rural Tanzania counseled women on pregnancy complications by surveying 438 pregnant women at 18

randomly selected health facilities. Data collected by observation and exit interviews showed that 42% of women did not receive counseling on warning signs of pregnancy complications. Only half of the women were given the opportunity to ask questions during visits, which averaged 17 minutes for new patients and 10 minutes for returning patients. When told about pregnancy complications, patient recall was less than 50% for all items except vaginal bleeding and headaches. Results suggested that women had low health literacy, or that providers did not communicate information in way that would facilitate recall. An interesting finding was that nurse auxiliaries, who receive limited on the job nursing training, spent more time with patients and had three times greater odds of reviewing signs of pregnancy complications than midwives and nurses, who receive three to four years of nursing training. Regression models included maternal age, marital status, education, occupation, gravidity, gestational age, and need for referral as predictors. A limitation was that the study did not describe variation between types of patients seen by different providers. However, findings suggest that all providers could do a better job at educating patients about warning signs.

In Southwest Nigeria, a descriptive analysis by Ijadunola et al. (2010) demonstrated that health providers also did not provide information about pregnancy warning signs. The authors surveyed all health workers (n=152) at 22 facilities in Osun and Ekiti states. Although 75% of providers indicated that they provided counseling on pregnancy warning signs and complication readiness, observation showed that less than 25% actually did so. Eighty-nine percent of nurses reported providing counseling, compared to 62% of community health workers.

A study by Okoli et al. (2012) suggests that health care facilities may lack the capacity to provide clinical components of prenatal care. The authors surveyed managers at 652 primary health care facilities in rural areas of Nigeria to assess the availability of prenatal and obstetric services. The majority of facilities (97%) provided prenatal care. However, only 35% of facilities provided tetanus immunizations and only 47% provided iron supplements. Regarding laboratory screenings, only 61% of facilities did blood tests, and only 60% tested urine for protein.

2.6 Individual Determinants of Prenatal Care Use

Individual determinants of prenatal care use among sub-Saharan African women include wealth, education, cultural beliefs, and autonomy. Women who are wealthier and have more education tend to seek prenatal care early and more often (De Allegri et al., 2011; Mbuagbaw & Gofin, 2011; Ochako et al., 2011). Women with educated husbands also tend to have better use of prenatal care than women with uneducated husbands (Ali, Osman, Abbaker, & Adam, 2010). Other factors influencing use of prenatal care include place of residence, maternal age, religion, and media exposure. The following section reviews studies of these factors.

2.6.1 Wealth, Cost, and Use of Prenatal Care

Arthur (2012) used data from the 2008 Ghana Demographic and Health Survey (DHS) to examine the association between wealth and the number prenatal care visits received by Ghanaian women after implementation of policies to support free maternal health services. All 2,118 women with births in the five years prior to the survey were represented in ordered logistic regression analysis, which showed a wealth gradient in the number of prenatal care visits (0,1, 2, 3, or ≥4) in models adjusted for age, education,

parity, transportation, health insurance, employment status, urban/rural residence and region of residence. Women in wealthier quintiles had greater odds of a higher number of visits than women in the poorest quintile did. A limitation of this analysis was the lack of control for socio-cultural factors that may influence prenatal care use, such as religion and autonomy.

Mbuagbaw and Gofin (2011) examined determinants of a measure of optimal prenatal care defined as a minimum of four visits, with at least one visit in the first and third trimesters, and at least one visit with a skilled provider. Using data representing 2,540 women who reported timing of prenatal care in the 2004 Cameroon DHS, the authors found a wealth gradient in use of optimal prenatal care. Women in the middle quintile had 33% higher odds of having optimal prenatal care (odds ratio, OR 1.33; 95% confidence interval, CI 1.01-1.69), while women in the two wealthiest quintiles had over twice the odds of having optimal prenatal care (OR 2.31; CI 1.73-3.10) compared with women in the two poorest quintiles. Control variables in the model included age, education, place of residence, marital status, health care autonomy, religion, parity, age at first birth, and history of terminated pregnancy. A limitation of this study was that 66% of women with recent births were excluded because they lacked sufficient information on prenatal care utilization to be classified as having optimal or suboptimal prenatal care.

A stark wealth gradient was seen in analysis of adequate prenatal care visits among married young women giving birth at age 15 to 19 in the 2008 Nigeria DHS (Rai, Singh, & Singh, 2012). Logistic regression analysis on a sample of 2,434 respondents indicated that women in the wealthiest quintile had five times greater odds of receiving at least four prenatal care visits compared to women in the poorest quintile (OR 5.56; CI

2.45–9.66). In models adjusted for parity, religion, and employment status, additional factors associated with prenatal care use were maternal education, husband's education, and media exposure as defined by reading the newspaper, watching television, or listening to the radio.

Qualitative analysis by Mubyazi et al. (2010) sought to determine the impact of cost on women's use of prenatal care in rural Tanzania. Data were obtained from 24 focus groups and interviews involving a random sample of 232 pregnant and postpartum women. Despite policies that supported reduced or no fees for some aspects of prenatal care, costs related to transportation, access to referral centers, access to pharmacies, variations in facilities' adherence to the no user fee policy, and opportunity costs related to clinic wait times continued to impede women's use of prenatal care.

2.6.2 Education and Use of Prenatal Care

Education may influence use of prenatal care by increasing exposure to health guidelines and by increasing women's ability to apply that knowledge to their personal circumstances. Ewbank (1994) argues that maternal education influences child outcomes through interaction with the social environment, including social expectations and level of autonomy, and not through knowledge and perceptions alone. For women in sub-Saharan Africa, where use of untrained birth attendants may be common, education may increase their ability to make decisions regarding their health and provide the knowledge needed to obtain safe and timely care.

Ali et al. (2010) examined determinants of inadequate prenatal care use in a region of eastern Sudan with 28 health centers and three hospitals providing free prenatal care to a population of 260,000. The authors defined inadequate prenatal care use as less

than two visits. Logistic regression models applied to survey responses from a random sample of 900 women with a recent or current pregnancy greater than 14 weeks gestation showed that maternal education was not a significant predictor of inadequate prenatal care, but that husband's education was. Additional factors included in regression models were age, parity and rural residence, of which only parity ≥3 was significant. Results suggest that in a region with high access to care, husband's education is a more important predictor of access to care or its use. However, findings may be an artifact of the very limited set of determinants used in this analysis.

Overbosch et al. (2004) applied a discrete choice model to data from the 1998 Ghana Living Standard Survey to assess determinants of prenatal care use. The authors evaluated seven combinations of number of antenatal care visits (0, 1 to 3, or ≥4) and type of provider (doctor, nurse, and midwife). Covariates in the model included cost, age, parity, years of schooling, religion, and distance to prenatal care. Simulation models suggested that the greatest increase in demand for adequate prenatal care would be achieved by providing at least 9 years of education for all residents.

Simkhada et al. (2008) reviewed 28 papers examining determinants of prenatal care use in developing countries in Africa, Asia, the Middle East, South America, and the Caribbean. Sixteen studies identified maternal education as a significant predictor of prenatal care. Studies reviewed found that higher maternal and husband education were associated with earlier initiation of prenatal care and with receipt of the recommended number of prenatal care visits. These findings align with those of Rai et al. (2012) and Arthur (2012) who also found that maternal education was associated with use of prenatal care in studies of Nigeria and Ghana, respectively.

2.6.3 Place of Residence and Use of Prenatal Care

Magadi, Zulu and Brockerhoff (2003) compared prenatal and delivery care between urban poor, urban non-poor, and rural residents using 1990 to 1998 DHS data for 23 sub-Saharan African countries. Urban poor included respondents who lacked piped water, flush toilet, and electricity in their homes. They ranged from 5% of urban dwellers in Ghana to 72% of urban dwellers in Chad. Random-effect models including age, education, and birth order as covariates found that women classified as urban non-poor were less likely to initiate prenatal care late than women classified as urban poor. In comparison, rural residents were more likely to initiate prenatal care late compared to poor urban residents. Results for adequate prenatal care visits (≥4) were similar. However, the impact of residence varied by country. Disparities between the urban poor and the urban non-poor were greater in countries where rates of late and inadequate prenatal care were low. Rural residents had a higher probability of both late and inadequate prenatal care in countries with high rates for these outcomes.

Additional challenges for rural women were identified in a study of 435 women in rural Burkina Faso where policies had been implemented to reduce user fees for maternal health services (De Allegri et al., 2011). Results of multivariate models applied to survey data suggested that women living more than 3 miles from a health facility were less likely to have at least three prenatal care visits. Lack of public or private transportation to the site of care and poor road conditions created barriers despite a positive view of prenatal care.

2.6.4 Age, Religion, and Other Individual Determinants of Prenatal Care Use

Magadi, Agwanda and Obare (2007) examined the influence of maternal age on prenatal care using data from the DHS for 21 sub-Saharan African countries. Multivariate models including individual factors (birth order, urban/rural residence, education, premarital birth) and contextual factors (gross national income, health expenditure per capita, female literacy rate) showed that women aged 15-19 were more likely to initiate prenatal care late and more likely to have less than four prenatal care visits, compared to women 20-34 and 35-49 years old. The impact of maternal age did not vary significantly between countries in pooled analysis. These results correspond with findings of Kurth et al. (2010) who surveyed 356 women giving birth at hospitals in Gabon and found that adolescent women aged 16 and younger (n=24) received 1.2 fewer prenatal visits than women aged 17 to 45 (n=332).

Religion was an important predictor of prenatal care use in a study by De Allegri et al. (2011) who examined factors associated with at least three prenatal care visits. The authors surveyed 435 women who lived in a rural district of Burkina Faso and had completed a pregnancy in the previous 12 months. Women practicing traditional African religions were 69% less likely to receive at least three prenatal visits than Christian women (OR 0.31;CI <0.01-0.62); there was no difference in utilization between Christian and Muslim women in multivariate models including age, ethnicity, literacy, marital status, parity, history of miscarriage, household wealth, and distance to health facility as covariates (De Allegri et al., 2011). While wealth, distance to a health facility, and ethnicity were significant factors; literacy and parity were not.

Religion was also a significant predictor of prenatal care use and skilled delivery in an analysis using the 2003 Ghana DHS (Gyimah, Takyi, & Addai, 2006). Regression models applied to data for 2,084 women with births in the three years prior to the survey showed that women practicing traditional African religions had 62% lower odds of receiving prenatal care from a skilled provider ($p<0.01$), 49% lower odds of skilled delivery ($p<0.01$) and a 29% lower rate of prenatal care visits than Catholic women ($p<0.001$). Models were adjusted for age, education, parity, urban/rural residence, region of residence, ethnicity, and marital status. Notably, women practicing traditional African religions were older, less educated, poorer, and more likely to live in a rural area compared to women with other religions. Adding these socioeconomic factors to regression models diminished the effect of traditional African religion but did not remove it altogether. Therefore, authors concluded that differences in belief systems and religious attitudes towards medicine might influence use of maternal health services beyond socioeconomic status. The authors did not examine the extent to which religion interacted with place of residence and education to influence health care use.

A qualitative study by Ngomane and Mulaudzi (2012) in a rural South African district revealed additional beliefs and perceptions that may influence women's use of prenatal care. In-depth interviews with a purposive sample of 12 women at their first prenatal care visit suggested that while women perceived pregnancy as good and desired the best outcome for their unborn baby, they tended to delay prenatal care and use traditional birth attendants rather than nurses or other skilled health professionals because of traditional beliefs. Women believed that harm could come to their baby if they revealed pregnancy early. Women also trusted the care provided by traditional birth

attendants, such as their use of traditional herbs, and disliked the impoliteness of nurses providing care at health facilities. These beliefs and perceptions suggest that both culture and community perceptions play a role in women's health behaviors. The interaction between culture and literacy or education was not clear since the study did not provide demographic characteristics of this rural sample.

Parity was an important predictor of prenatal care use in a study of factors associated with early prenatal care among Nigerian women (Oladokun, Oladokun, Morhason-Bello, Bello, & Adedokun, 2010). Findings suggested that women with one or no children had 76% greater odds of early prenatal care (OR 1.76; CI 1.11-2.79) compared to women with three or more children. Women with previous stillbirth were three times as likely to seek early prenatal care compared to women with no prior stillbirth (OR 2.97; CI 1.61-5.51). The study included 796 women delivering at a tertiary hospital. Three quarters of women in the sample had at least secondary education. Backward stepwise model selection was used to determine a final model, which included stillbirth and parity but excluded maternal education and occupation. Non-significant findings regarding maternal education may be due to higher literacy level in this population delivering at a health facility.

2.7 Contextual Determinants of Prenatal Care Use and Infant Mortality

Few studies have examined contextual determinants of prenatal care use, and even fewer studies have examined how context influences prenatal care use in developing countries. Bradley et al. (2011) examined associations between health expenditures and health outcomes in 30 OECD countries and found that countries that spent more on social services relative to health had lower rates of infant mortality. In an analysis of data from

117 low-income countries, Anand and Bärnighausen (2004) found that both gross national income (GNI) and doctor density were associated with rates of maternal and infant mortality. Additional ecological studies by Alvarez et al. (2009) and Olafsdottir et al. (2011) found that education rates, socioeconomic status, GNI per capita, government health expenditure and governance were additional contextual factors associated with prenatal care coverage, maternal mortality rate, and under–five mortality rate. Community-level factors such as health knowledge (Stephenson & Elfstrom, 2012) and level of trust in the health care system (Lori & Boyle, 2011) may also be correlated with the use of prenatal care.

2.7.1 National Wealth and Maternal and Infant Health

Studies examining the effect of national monetary resources on prenatal care use, maternal mortality and infant mortality have focused on the following measures: GNI per capita, health expenditures as a percentage of gross domestic product (GDP), public spending on health care and gross national product (GNP). The following is a review of studies examining the impact of these factors on prenatal care and infant mortality.

Using data from the OECD Health Data 2009 Statistics and Indicators, Bradley et al. (2011) examined the relationship between the percent of GDP spent on health and social services and health outcomes in 30 countries during 1995 to 2005. Mixed effect models applied to pooled data suggested that health expenditures alone were not significantly associated with infant mortality rate when adjusted for GDP per capita. However, social expenditures and the ratio of social to health expenditures were both negatively associated with infant mortality rates when adjusted for GDP per capita. Health expenditures were defined to include spending on medical care, healthcare

infrastructure, health insurance, and public health, while social expenditures were defined to include pension, disability and illness benefits, employment programs, housing subsidies, family support, and other social services not classified under health (Bradley et al., 2011). Findings suggest that in industrialized countries, social spending may be more important than health spending for improving infant mortality.

Anand and Bärnighausen (2004) measured the impact of GNI per capita on maternal mortality, infant mortality, and under-five mortality in 117 countries included in the 2004 WHO dataset, Estimates of Health Personnel. Using values adjusted to reflect purchasing power parity (PPP), this ecological study found that each one percent increase in GNI per capita was associated with a decrease of 0.57% to 0.71% in infant mortality rate per 1,000 live births.

Another ecological study by Alvarez et al. (2009) examined health system, educational, and economic indicators associated with the maternal mortality ratio in 45 sub-Saharan African countries. Correlational analysis showed that maternal mortality had a high positive correlation with infant mortality rate and significant negative correlations with GNI per capita and per capita government spending on health. Adult literacy and contraceptive prevalence were also negatively correlated with maternal mortality. A limitation of this analysis was lack of multiple regression models to distinguish how individual factors contribute to mortality.

In an analysis of the association between maternal age and prenatal care use in 21 sub-Saharan countries, Magadi et al. (2007) found that each one dollar increase in GNI per capita was associated with 24% lower odds of late prenatal care. Each one-point increase in percent literate women was associated with 3% higher odds of late prenatal

care and 3% lower odds of less than four prenatal care visits. Models included individual demographic characteristics (age, rural residence education, birth order, and marital status) as well as health expenditure per capita and health expenditure as a percent of GNI, which were both non-significant.

2.7.2 Health Resources, Prenatal Care Use, and Health Outcomes

Access to quality care and adequate numbers of skilled health professionals has been identified as an important factor for improving maternal health outcomes in sub-Saharan Africa (Gerein, Green, & Pearson, 2006). Gage (2007) used multilevel modeling to assess the impact of contextual factors on the use of prenatal care by women in rural Mali. The study sample included 6,479 births in the 2001 Mali DHS. Gage examined the following contextual factors: medical establishments within 5 km, emergency obstetric care within 5 km, accessibility of roads to the nearest urban area, time to nearest public transportation, presence of emergency transportation, distance to the nearest source of prenatal care, region, percent of population with secondary education, poverty rate, prenatal care percentage, and ethnicity distribution. Individual factors examined included education, household wealth, gender of head of household, childcare burden, birth order, and an index of barriers to prenatal care determined from principal components analysis. The availability of medical establishments within 5 km and the percent of women receiving prenatal care were the only area-level factors that remained significant predictors of early prenatal care in models including individual factors. Time to public transportation was significantly associated with receipt of four or more prenatal care visits. Household wealth, maternal education and barriers to care remained significantly associated with both early and adequate prenatal care use.

Longitudinal analysis by Farahani et al. (2009) examined associations between infant mortality and health resources during 1960 to 2000 using data for 99 countries with reliable infant mortality data. Results showed that adding one physician per 1,000 population was associated with a 14% decrease in infant mortality rate in the short run (within 5 years) and a 45% decrease in infant mortality rate in the long run (>5 years). Models controlled for GDP per capita, average years of schooling among adults 15 and older, and time. The study included 30 African countries, 36 countries from the Americas, 20 countries from the Middle East, and 17 countries from Asia. While these findings suggest that increasing physician supply is beneficial for infant health, it is unclear whether low-income and high-income countries would achieve similar benefits.

Analysis by Anand and Bärnighausen (2004) also examined the impact of health resources on infant mortality. The authors examined the impact of the density of doctors, nurses, and midwives on infant mortality using data for 117 countries in the Estimates of Health Personnel dataset. In models controlling for GNI per capita, sanitation, poverty, and female adult literacy rate, results showed that a one percent increase in health resource density was associated with a 0.21% decrease in infant mortality. Notably, the female literacy rate was not significant in these models.

2.7.3 Governance, Culture and Maternal and Child Health

The impact of political and economic climate on health was examined in an ecological study by Olafsodittor et al. (2011), which involved cross-sectional data from 46 sub-Saharan African countries. The authors used under-five mortality as a measure of health system performance and examined two indices of governance: (i) Rule of Law, Transparency and Corruption, which captures legal stability; and (ii) Sustainable

Economic Opportunity, which captures macroeconomic stability. Regression models adjusting for healthcare, finance, education, and water supply showed that countries with higher rankings as a sustainable economic opportunity had lower rates of under-five mortality. Sustainable economic opportunities include countries where the government supports freedom to create wealth, provides necessary infrastructure for business development (electricity, telecommunications, roads, etc.), and has sound fiscal policy (Mo Ibrahim Foundation, 2012). Governance was not significantly associated with health equity as defined by the ratio of under-five mortality for the wealthiest vs. poorest quintile. Although generalizability of results are limited by the ecological study design, sustainable economic opportunities involve higher literacy rates and gender equity, which are both associated with improved maternal and child health outcomes (Wall, 2012).

Stephenson and Elstrom (2012) examined community-level factors associated with the use of prenatal care for women in Bangladesh, Egypt and Rwanda. The authors used DHS data for a sample of 17,637 women who had given birth within three years prior to interview. The authors derived the following community-level variables by averaging individual responses within the same primary sampling unit: health knowledge, household wealth, women's decision-making autonomy, ratio of males to females with primary education, and ratio of employed males to females. Results from multilevel logistic regression analysis showed that earlier prenatal care was associated with higher community knowledge of HIV in Bangladesh. In Bangladesh, higher community knowledge of HIV was also associated with increased odds of having any prenatal care and with having at least four prenatal care visits. For Egypt, results showed higher odds of early prenatal care for women living in communities with higher reproductive health

knowledge and higher female autonomy. In Rwanda, early prenatal care was associated with communities having a higher ratio of male versus female employment. Models controlled for individual demographic characteristics including age, parity, education, religion, marital status, household wealth, prior use of contraception, and media exposure. Differences in factors associated with prenatal care in these three countries suggest that community-level factors associated with use of prenatal care may vary by context.

Cultural influences on pregnancy behavior were identified in a study by Lori and Boyle (2011). In-depth interviews with 10 postpartum women and 44 family and community members in rural Liberia suggested that secrecy and autonomy were prominent components of cultural attitudes towards pregnancy. Women kept pregnancy and labor secret for fear of witchcraft, which could harm their unborn child, and lack of decision-making autonomy prevented women from receiving timely care. Similar findings regarding vulnerability of pregnancy to witchcraft and lack of decision-making autonomy were reported by 68 female and male participants during focus groups and in-depth interviews in a rural area of Zimbabwe (Mathole, Lindmark, Majoko, & Ahlberg, 2004). In discussions about specific aspects of care, women were agreeable to being weighed; however, women expressed fear about referrals for cesarean section and fear of potential disclosure of results of HIV tests (Mathole et al., 2004). These studies suggest that culture may play a key role in uptake of prenatal care programs. Findings also suggest an opportunity for education and care delivery that is sensitive to cultural norms.

2.8 Prenatal Care and Infant Mortality

In 2010, 3.6 million of the 7.6 million child deaths worldwide occurred in Africa. The major causes of deaths in children under five are preterm birth, pneumonia, diarrhea and malaria, which account for half of under-five deaths worldwide (Liu et al., 2012). While deaths due to measles, AIDS and tetanus are rapidly declining, data suggest smaller declines in preterm birth complications (Liu et al., 2012). Strategies to address infant mortality include a continuum of care beginning with family planning, preconception care, prenatal care and skilled delivery, and continuing with adequate postnatal care, newborn care and child health care including vaccinations (Kinney et al., 2009; Lawn, Kerber, Save the Children, & BASICS, 2006; Lu & Halfon, 2003). Mechanisms through which prenatal care may influence infant mortality include early identification of complications, tetanus immunizations, establishing a birth plan that includes skilled delivery, education on postnatal care, and treatment for malnutrition and sexually transmitted infections. Interventions and education provided during prenatal care can set the stage for continued healthy behaviors and outcomes (De Graft-Johnson et al., 2006; Lawn et al., 2006) . International studies suggest an inverse relationship between prenatal care and infant mortality. Most studies examining associations between prenatal care and infant mortality have been observational. Because prenatal care is considered beneficial, randomized controlled trials use a standard model of prenatal care as the control rather than randomize women to no care.

2.8.1 Cohort Studies of Prenatal Care and Infant Mortality

Using a cohort of 28.7 million U.S. births, Partridge et al. (2012) found that odds of infant death increased with decreasing adequacy of prenatal care as defined by the

APNCU index. Women with inadequate care had 79% greater odds of infant mortality (CI 1.76-1.82) compared to women with adequate care. Younger women, minority women, and women with less than high school education were at greater risk of infant mortality. These results were similar to those of another study by Chen et al. (2007), who found that inadequate prenatal care was associated with increased neonatal mortality regardless of risk in a sample of U.S. births occurring between 1995 to 2005.

Volpe et al. (2009) examined associations between health resources and infant mortality rates in Brazil from 2000 to 2005. Using an ecological study design and correlation and regression analysis, changes in infant mortality rates for 27 states were evaluated against measures of public health expenditure, water supply, prenatal care utilization, cesarean delivery rate, and hospital delivery rate. Multiple regression results showed that declines in infant mortality were associated with simultaneous increases in prenatal coverage, improvements in water supply, and increases in public expenditure on health.

In an analysis of data from a 2001 survey of a nationally representative sample of Chinese women aged 15 to 49, Song (2011) found that odds of infant mortality were lower for better educated women particularly because of their better use of prenatal care and skilled delivery. In models adjusted for urban residence, child's gender, age at childbirth, birth order, ethnicity, maternal education, and skilled delivery, prenatal care was associated with 33% to 72% lower odds of infant mortality. Song used efficacy as a conceptual framework to describe how better educated women were able to access and use needed maternal health services throughout the period from 1970 to 2001.

McCurdy et al. (2011) used logistic regression to assess the association between having prenatal care by a skilled provider and neonatal mortality. Data from 89,655 women aged 15 to 49 in the 17 least developed countries in sub-Saharan Africa showed that having prenatal care by a skilled provider was associated with 30% lower odds of neonatal death (CI 0.62–0.80). Results suggested no association between maternal education or wealth and neonatal mortality; however, both were associated with having a skilled provider for prenatal care.

A prospective study by Diallo et al. (2011) found no significant association between having at least one prenatal care visit and neonatal mortality among a cohort of 864 pregnant women in Burkina Faso. Factors associated with neonatal mortality in unadjusted logistic regression models were parity, living in a polygamous household, twin birth, and having a skilled birth attendant. When entered into multivariable logistic regression models, all factors remained significant except skilled birth attendant. Findings in this study may be limited by the small sample size and small number of deaths (n=40) occurring in this sample.

Hong (2008) examined associations between maternal HIV infection and infant mortality in a sample of 2,020 women randomly selected for HIV testing as part of the 2004 Malawi DHS. Analyses included 2,618 children under age five. Infant mortality rate per 1,000 live births was 46.2 for women with at least one prenatal care visit, compared to 126.4 for women who did not receive prenatal care. Women with no prenatal care had 2.3 times greater risk of infant mortality ($p<0.01$). Proportional hazards regression models adjusted for HIV status, gender, birth order, birth weight, delivery by a health professional, marital status, household wealth, safe drinking water, toilet facilities, type

of cooking fuel, urban/rural residence, geographic region, maternal age, body mass index, working status, and years of schooling. In addition to HIV status, birth weight, child's gender, maternal age, and urban/rural residence remained significantly associated with infant mortality in adjusted models. Findings were similar in analyses of 3,389 births in the 2003 Ghana Demographic Survey (Hong, Banta, & Kamau, 2007). In adjusted proportional hazards models, having no prenatal care was associated with 1.7 times greater risk of infant mortality (CI 1.3-2.4); maternal HIV status, birth weight and type of cooking fuel used in household remained significantly associated with infant mortality (Hong et al., 2007).

Findings from an in-depth case study of Niger suggested that recent interventions in Niger, including free health care for all pregnant women and children beginning in 2006, might have contributed to reductions in child mortality (Amouzou, Habi, & Bensaïd, 2012). Mortality among children under five years old declined from 226 deaths per 1,000 live births in 1998 to 128 deaths per 1,000 live births in 2009. During the same period, the percentage of women with at least one prenatal care visit increased from 40% to 81%; the percentage of women with at least four prenatal care visits increased from 10% to 26%. Other interventions with significant increases during the period included tetanus, diphtheria, and measles vaccinations, vitamin A supplementation for children, and use of insecticide-treated bed nets. Neonatal mortality did not decrease significantly over the period. Policy changes, supported by government buy-in, also increased access to care by building community health centers in rural areas.

2.8.2 Randomized Controlled Trials of Prenatal Care

Because prenatal care is widely viewed as beneficial for pregnant women, no published experimental studies have assessed the impact of receiving any prenatal care as compared with no care. However, researchers have examined the effect of standard models of care with 12 or more visits to a model with fewer recommended visits. Randomized trials (Majoko et al., 2007; Villar et al., 2001) and a meta-analysis of seven randomized controlled trials (Carroli, Villar, et al., 2001) conducted in developing countries compared four to five prenatal care visits to a standard model of at least nine visits and found no difference in risk of fetal or neonatal mortality among other outcomes examined. Results from these trials, described in detail in section 2.5.1, suggest that prenatal care can be delivered in fewer focused visits without adversely affecting maternal and infant outcomes.

2.9 Literature Synthesis and Implications for Maternal and Child Health

It is widely accepted that prenatal care is beneficial for maternal health, and many agree that improved maternal health benefits infant health. Prenatal care is considered a useful avenue for providing health promotion activities, particularly for women who have no other interactions with the health care system. The benefits of prenatal care have not translated into high utilization rates for women in sub-Saharan Africa. In fact, progress towards universal coverage of prenatal care has become stagnant. Results from cross-sectional studies suggest that wealth, literacy/education, and distance to health centers are key factors contributing to women's use of prenatal care. Maternal age, religion, and women's autonomy are additional factors that may influence use of prenatal care.

While many studies have examined individual determinants of prenatal care use in sub-Saharan Africa, few studies have examined contextual determinants. Such analyses require data from multiple settings; most studies have focused on a single country or region. Findings from these studies and studies conducted in other developing countries suggest that GNI, health expenditures, and education rates are key factors associated with the use of prenatal care and outcomes such as infant and maternal mortality. Other contextual factors that may be correlated with infant mortality are water supply and sanitation. Physician supply may be associated with both infant mortality and use of prenatal care. Additional studies in sub-Saharan Africa are needed to support our understanding of how context affects prenatal care use.

Evidence exists from observational studies that prenatal care is associated with reduced risk of infant mortality. However, studies in developing countries are sparse. McCurdy et al. (2011) found significant associations between prenatal care by a skilled provider and neonatal mortality in a sample of births to women in 17 sub-Saharan countries. Additional studies have found significant associations between having any prenatal care and infant mortality in adjusted multivariate models using data from Ghana (Hong et al., 2007) and Malawi (Hong, 2008). Prenatal education, health screening, and potential for developing trust with the health care system are benefits of prenatal care that could promote better postnatal care and immunization uptake for children and reduce the risk of infant mortality. Women who seek prenatal care may also have different levels of education and socioeconomic status than women who do not seek prenatal care. Previous analyses suggest that prenatal care remains significantly associated with neonatal and infant mortality when adjusted for other confounders. Further analyses accounting for the

adequacy of prenatal care and contextual variations between countries can help to clarify characteristics of care that may be useful in improving outcomes.

A limitation of empirical studies examining prenatal care in sub-Saharan Africa and other developing countries is the lack of consistency in defining adequate prenatal care. Unlike infant mortality, which has a set definition that is internationally accepted (death prior to age one), measures for adequate prenatal care are varied. Current research in developing countries tends to adopt the WHO minimum recommendations of at least four visits for normal low risk pregnancies. This adaptation of the WHO recommendations focuses on quantity of care and not on quality of care. This is also a limitation of the APNCU and the GINDEX, which combine number of visits with gestational age to determine adequate use of prenatal care. While studies suggest that the APNCU and GINDEX may predict poor outcomes, standards used to develop these indices extend beyond what is reasonable or feasible in most developing countries where data on timing of prenatal care visits are often lacking. Improved understanding of adequate prenatal care requires studies that use standard definitions of adequate prenatal care in developing countries.

2.10 Gaps in the Literature

Important gaps remain in our understanding of prenatal care use and related outcomes for women in sub-Saharan Africa. First, while studies have described the prevalence of prenatal care use, no large studies have examined patterns of prenatal care use and content by wealth or education. This is an important first step in understanding shortcomings in care for socially and economically disadvantaged women. Additionally, a standard definition for adequate prenatal care in developing countries is lacking. The

WHO model includes specific services delivered over four prenatal care visits; however, not all components of care have been examined. Studies have focused on number of visits and early initiation of visits as separate or composite measures. With the exception of one study (Mbuagbaw & Gofin, 2011), research has not included type of provider or screenings as part of a composite measure. Few studies have examined how government spending on healthcare or national wealth may influence use of prenatal care in sub-Saharan Africa. Countries making progress towards universal coverage of prenatal care can serve as guides for countries where progress is slow or stagnant. Cross-national analyses may help facilitate policy development and collaboration towards improving health outcomes. Finally, only a few studies have examined associations between prenatal care and infant mortality in sub-Saharan Africa. While self-selection into prenatal care presents some analytical challenges, such analyses are useful for garnering support for linking interventions with measurable outcomes.

2.11 New Contributions

The purpose of my research is to identify disparities in prenatal care use among women in sub-Saharan Africa, focusing on the West African region. Using the behavioral model of health services use as a framework, I will examine how wealth and literacy influence prenatal care use and whether the effect of wealth and literacy vary by level of investment in health systems. I will also examine whether wealth interacts with adequacy of prenatal care to influence infant mortality, which accounts for the largest proportion of under-five deaths.

My research will add to existing literature in three main areas. First, I will examine characteristics of prenatal care use among women in sub-Saharan Africa to

determine whether wealth and literacy are associated with patterns of prenatal care use. Few studies have examined how wealth and literacy influence use and content of prenatal care in this population. My research will also examine differences in prenatal care utilization within and between countries to determine how all countries can potentially make greater strides towards equity in maternal health care. Although many studies have examined social factors associated with prenatal care use, very few have compared multiple countries in sub-Saharan Africa. Even less research has explored contextual variations between countries that could account for differences in utilization. In addition, I examine a potential modifying effect of wealth on associations between prenatal care and infant mortality. For this analysis, I build on previous research by McCurdy et al. (2011) who found that receiving prenatal care from a skilled provider was associated with lower risk of neonatal mortality. I extend the research of McCurdy and colleagues by examining whether there is a significant association between prenatal care and infant mortality; I also examine whether this association varies by wealth quintile in models using an expanded set of covariates. Findings from this study will help to inform policy and discussions about potential strategies to address poor maternal health indicators in one of the poorest regions of the world.

Table 2.1 Key components of prenatal care for women with low-risk pregnancies as recommended by major health organizations

	WHO (1999)	ACOG (2002)	ICSI (2012)	NICE (2008)
Total visits	4 visits	14 visits	11 visits	7(10) visits[a]
First visit	By 16 weeks	< 8 weeks	6-8 weeks	By 10 weeks
Schedule of subsequent visits by weeks of gestation	24-28, 32, 36	8, 12, 16, 20, 24, 28, 30, 33, 36, 37, 38, 39, 40, 41	10-12, 16-18, 22, 28, 32, 36, 38, 39, 40, 41	16, (25), 28, (31) 34, 36, 38, (40), 41 [a]
Begins with preconception visit	b	✓	✓	b
Care Provision				
Risk monitoring	✓	✓	✓	✓
Individualized delivery plan	✓	✓		✓
Psychosocial support	✓	✓		✓
Assessments				
Medical history	✓	✓	✓	✓
Height, BP, anemia	✓	✓	✓	✓
Weight/BMI		✓	✓	✓
Depression			✓	
Obstetric history	✓	✓	✓	
Domestic violence/abuse	✓		✓	✓
Fetal growth /well-being	✓	✓	✓	✓
Pelvic/cervical exam		✓	✓	✓
Lab Tests				
Syphilis, HIV, anemia	✓	✓	✓	✓
Blood typing, urine culture		✓	✓	✓
Gestational diabetes		✓	✓	✓
Streptococcus, hepatitis		✓	✓	✓
Gonorrhea, chlamydia, cervical cancer		✓	✓	
Genetic/blood screening		✓	✓	✓

Table 2.1 (continued)

	WHO (1999)	ACOG (2002)	ICSI (2012)	NICE (2008)
Immunizations/Prophylaxis				
Tetanus	✓	✓	✓	✓
Influenza		✓	✓	✓
Hepatitis B			✓	✓
Iron	✓	✓		
Folic Acid	✓	✓	✓	✓
Education				
Nutrition	✓	✓	✓	✓
Exercise, travel, work		✓	✓	✓
Smoking/alcohol cessation	c	✓	✓	✓
Substance abuse		✓	✓	✓
Hygiene, Rest	✓			✓
Pregnancy danger signs	✓	✓	✓	✓
Fetal development		✓	✓	✓
Labor symptoms, delivery	✓	✓	✓	✓
Genetic screening		✓	✓	✓
Newborn care, breastfeeding	✓	✓	✓	✓
Family planning	✓	✓	✓	
Postpartum depression		✓	✓	✓

[a] Values in parentheses apply to nulliparous women

[b] The WHO recommends a care continuum including family planning, prenatal care, safe delivery and essential obstetric care; NICE recommendations for preconception visits are included in separate guidelines.

[c] Country-specific

ACOG, American College of Obstetricians and Gynecologists; BP, blood pressure; BMI, body mass index; ICSI, Institute for Clinical Systems Improvement; NICE, National Institute for Health and Clinical Excellence; WHO, World Health Organization;

CHAPTER 3: WEALTH, LITERACY, AND USE OF PRENATAL CARE AMONG WOMEN IN TEN SUB-SAHARAN AFRICAN COUNTRIES

3.1 Introduction

Sub-Saharan Africa has the highest rate of poverty and undernourishment, and the lowest rates of primary education in the world (Wall, 2012). These conditions coexist with high regional rates of under-five child mortality (121 per 1,000 live births in 2010) and the highest regional rates of maternal mortality (500 per 100,000 live births in 2010) (Wall, 2012). Over half of maternal, newborn, and child deaths occur in sub-Saharan Africa despite the fact that this region comprises less than 15% of the world's population (Friberg et al., 2010). The greatest burden falls on the poorest families, as regional data suggest a marked socioeconomic gradient in access to clean water, primary education, and child mortality (Wall, 2012). Associations among education, socioeconomic status, and health are not unique to sub-Saharan Africa. However, the burden of disease and disability from preventable causes is much greater in sub-Saharan Africa than in developed countries.

Initiatives such as the United Nations Millennium Development Goals (MDGs) and the Safe Motherhood Initiative challenge us to address inequities in maternal and child health that stem from poverty and a lack of education. One strategy is to improve access to maternal health services such as delivery by skilled health professionals and timely prenatal care. Prenatal care may help to reduce maternal and infant morbidity and

mortality by addressing risk factors for adverse outcomes. Prenatal care also provides a useful opportunity for delivering educational interventions that may increase use of early childhood immunizations and disease prevention measures (Choi & Lee, 2006; Kogan, Alexander, Jack, & Allen, 1998).

Important gaps remain in our understanding of prenatal care use and related outcomes for women in sub-Saharan Africa. First, while studies have described the prevalence of prenatal care use, no large studies have examined patterns of prenatal care use and content by wealth or education. This is an important first step in understanding shortcomings in care for socially disadvantaged women. Additionally, few studies have defined adequate use of prenatal care beyond the number of prenatal care visits. Studies have focused on number of visits and early initiation of visits as separate or composite measures. Only one previous study included type of provider. In that study this measure was included as part of a composite measure; its independent effect was not separately estimated (Mbuagbaw & Gofin, 2011). Cross-national analyses may help facilitate policy development and collaboration towards improving health outcomes.

This study examines whether household wealth and individual literacy are associated with receiving any prenatal care, and with having adequate prenatal care, for women in ten West African countries. Adequate prenatal care is a composite measure that includes number of visits, type of provider and timing of first visit. I extend previous research by examining a measure of prenatal care that is more quality-focused compared to previous studies. This study also identifies potential inequities in content of care by wealth and literacy. Findings from this study can help to inform policies for improving realized access to adequate prenatal care for women in sub-Saharan Africa.

3.2 Literature Review

Single-country studies and meta-analyses including selected regions within sub-Saharan Africa suggest that wealth and education are important predictors of health care use. With regard to maternal health care, studies have found that women who are wealthier and have more education tend to seek prenatal care early and more often (De Allegri et al., 2011; Mbuagbaw & Gofin, 2011; Ochako et al., 2011). Studies have also found that women with husbands who have more education also tend to have better use of prenatal care (Ali et al., 2010). The following is a brief review of key studies on the subject.

3.2.1 Wealth and Use of Prenatal Care

A cross-sectional study by Mbuagbaw and Gofin (2011) found that both household wealth and maternal education were significantly associated with optimal prenatal care for women in Cameroon. The authors defined optimal prenatal care as a minimum of four visits, with at least one visit in the first and third trimesters, and at least one visit with a skilled provider. Data representing 2,540 women who reported timing of prenatal care in the 2004 Cameroon DHS were analyzed. Results showed that women in the middle wealth quintile had 33% higher odds of having optimal prenatal care than women in the two poorest quintiles (95% confidence interval, CI 1.01-1.69), while women in the two wealthiest quintiles had twice the odds. Control variables in the model included age, place of residence, marital status, health care autonomy, religion, parity, age at first birth, and history of terminated pregnancy. A limitation of the outcome measure used in this study was that 66% of women with recent births lacked information

on frequency and timing of prenatal care; this information helped to determine optimal or suboptimal prenatal care.

Analysis of the 2008 Ghana Demographic and Health Survey (DHS) by Arthur (2012) also found a wealth gradient in prenatal care use after implementation of policies to support free maternal health services. All 2,118 participants with births in the previous five years were represented in logistic regression analysis examining the association between wealth and the number prenatal care visits (0, 1, 2, 3 or ≥4). Models controlled for age, education, parity, transportation, health insurance, employment status, urban/rural residence, and region of residence. Women in the wealthiest quintile had 3.7 times greater odds of four or more visits compared with women in the poorest quintile (CI 1.4-6.1). While estimates for wealth were in the expected direction, the analysis did not include controls for socio-cultural factors such as religion and autonomy, which may also influence use of prenatal care.

Further evidence of a wealth gradient in prenatal care use was seen in analysis of births to married adolescents aged 15 to 19 in the 2008 Nigeria DHS (Rai, Singh, & Singh, 2012). Logistic regression analysis using a sample of 2,434 women showed that women in the wealthiest quintile had five times greater odds of receiving at least four prenatal care visits compared to women in the poorest quintile (CI 2.4-9.7). In models adjusted for parity, religion, and employment status, additional factors associated with prenatal care use were maternal education, husband's education, urban residence, and media exposure. Media exposure was defined by reading the newspaper, watching television, or listening to the radio. Findings suggest that poor adolescents have greater odds of inadequate care and poor outcomes because of age and socioeconomic position.

3.2.2 Education and Use of Prenatal Care

Education may influence use of prenatal care by increasing exposure to health guidelines and ability to apply that knowledge to one's personal circumstances. Ewbank (1994) argues that maternal education influences child outcomes through interaction with the social environment including social expectations and level of autonomy. LeVine et al. (2001) suggest further that education may influence women's maternal health behavior by creating aspirations, improving communication, building empowerment, and providing a model of how to interact with health providers. For women in sub-Saharan Africa, where use of untrained birth attendants may be common, education may increase women's ability to make decisions regarding their health and provide the knowledge needed to obtain safe and timely care.

Studies examining associations between education and use of prenatal care have also found a consistent positive relationship. Ali et al. (2010) used survey data from a random sample of 900 women with a recent or current pregnancy greater than 14 weeks gestation to examine factors associated with inadequate prenatal care use in eastern Sudan. The region had 28 health centers and 3 hospitals providing free prenatal care to a population of 260,000. Multivariate logistic regression models showed that while maternal education was not significantly associated with having inadequate prenatal care, low husband's education was associated with greater odds of having inadequate prenatal care. Additional factors included in regression models were age, parity and rural residence, of which only parity ≥3 was significant. Results suggest that in a region with high access to care, compared with the wife's education, the husband's education may be

a more important predictor of access to care or its use. Findings may also reflect cultural norms around women's decision-making autonomy.

A simulation study by Overbosch et al. (2004) found that increasing education for women and men to a minimum of 9 years increased demand for adequate prenatal care. The authors applied a discrete choice model to data from the 1998 Ghana Living Standard Survey to evaluate seven combinations of number of prenatal care visits (0, 1 to 3, ≥4) and type of provider (doctor, nurse, and midwife). Cost, age, parity, years of schooling, religion, and distance to prenatal care were included as covariates. The authors concluded that increasing the supply of prenatal care in rural areas was important for choice, while increasing education was important for changing attitudes towards prenatal care.

Simkhada et al. (2008) reviewed 28 articles examining determinants of prenatal care use in developing countries in Africa, Asia, the Middle East, South America, and the Caribbean. Sixteen studies identified maternal education as a significant predictor of prenatal care. Studies reviewed found that higher maternal and husband education were associated with earlier initiation of prenatal care and with receipt of the recommended number of prenatal care visits. These findings are consistent with those of Rai et al. (2012) and Arthur (2012) who also found that maternal education was associated with use of prenatal care in studies of Nigeria and Ghana, respectively.

3.3 Study Objectives and Hypotheses

This study examined the associations of maternal literacy and wealth with two outcomes: (i) prenatal care use, and (ii) adequacy of prenatal care. The findings of the studies just reviewed supported two hypotheses. The first hypothesis is that individual

education and wealth will be positively associated with use of prenatal care. Characteristics of prenatal care examined include timing, source, provider, number of visits, and screenings or services received. The second hypothesis is that after adjusting for other demographic and reproductive characteristics, greater individual education and wealth will be associated with a greater individual likelihood of having adequate prenatal care, where adequacy is defined as recommended by the World Health Organization (WHO).

3.4 Conceptual Framework

Major health organizations, including the WHO and the Institute of Medicine, have described equitable healthcare as an important goal (Smedley, Stith, & Nelson, 2003; The World Bank, 2005). Individual development and future participation in economic, political and social activities can be greatly affected by inequities present at birth (The World Bank, 2005). Aday and Andersen (1981) describe equity in access to health care by exploring the concepts of merit, supply and demand, and need. Using principles of social justice the authors suggest that only need, i.e. level of illness, should determine the amount of health care available to a person in an equitable health care system (Aday & Andersen, 1981). From the perspective of economics, the utility of need for determining service availability should be balanced with demand for care to reduce waste (Feldstein, 2011). Nonetheless, for services that have known benefits such as prenatal care, the objective would be to increase demand to an amount that reduces levels of adverse outcomes, assuming that this can be accomplished with costs that society considers acceptable. The 1978 WHO declaration of Alma-Ata, asserts that primary health care, including prenatal care, should be a basic human right (WHO, 1978).

For women who are pregnant or planning to become pregnant, equitable health care systems would mean that appropriate preconception, prenatal and delivery services would be available regardless of resources, residence, or education. Therefore, factors such as income, education, and residence can identify disparities in access to health care. When maternal health services are available, economic theory based on theory of rational choice argues that patients are rational thinkers and can choose between health care and other goods (Folland, Goodman, & Stano, 2007). However, with individual and societal factors such as poverty, civil unrest, and reduced autonomy, more emergent needs of safety and nutrition reduce an individual's ability to make rational decisions about seeking health care. Under such circumstances, equitable health care addresses affordability and knowledge barriers that may prevent access to needed care.

The behavioral model of health services use (Andersen & Davidson, 2007b; Andersen, 1995) provides a useful conceptual framework for exploring social determinants of maternal health service use in sub-Saharan Africa. The model identifies the influence of contextual and individual characteristics on health behaviors and health outcomes. Figure 3.1 shows individual and contextual factors that are relevant to prenatal care use. In the vocabulary of the model, these characteristics are grouped into three domains: predisposing, enabling and need. Predisposing characteristics include inherent factors such as gender and age. Enabling factors include resources such as wealth, transportation and rural/urban residence and the availability of health care providers. Finally, the need domain includes measures of perceived and evaluated health, such as prior cesarean and pregnancy wantedness. The behavioral model is nonlinear: both health

behaviors and health outcomes create a feedback loop that influences other contextual and individual characteristics.

Using the behavioral model one can propose a demand function for maternal health care services that includes individual and community beliefs, resources and need. Economic demand theory suggests that demand for maternal health services will increase as associated costs decrease. Predisposing, enabling and need factors would serve as demand shifters. Consistent with other studies (De Allegri et al., 2011; Houweling, Ronsmans, Campbell, & Kunst, 2007; Ochako et al., 2011) the expectation is that demand would be higher for women in higher wealth categories, and lower for women with other competing needs. In countries with lower costs, greater availability of care and greater satisfaction with care, the expectation is that the disparity between wealthy and poor women would be less (De Allegri et al., 2011; Kruk & Prescott, 2012).

3.5 Study Design and Methods

3.5.1 Study Design

This cross-sectional study examines characteristics of prenatal care use and the association between use of prenatal care and sociodemographic characteristics for women in ten West African countries.

3.5.2 Setting

The West African region includes some of the poorest countries in sub-Saharan Africa, and has poorer maternal health statistics than Eastern and Southern Africa (UNICEF, 2011). West Africa is also home to the regional West African Health Organization (WAHO). The WAHO serves member states of the Economic Community of West African States (ECOWAS) by promoting strategies to address pertinent health

issues ("West African Health Organization," n.d.). This study uses data from ten of 16 countries in West Africa based on availability of data collected in 2003 or later. Data included in this study are from the most recent Demographic and Health Survey (DHS) for each included country.

3.5.3 Overview of the Demographic and Health Surveys

The DHS is a national household survey funded by the United States Agency for International Development (USAID) in over 90 developing countries (www.measuredhs.com). The goal of the DHS is to help governments collect data on health and nutrition, with a specific focus on maternal and child health and diseases such as HIV/AIDS and malaria. A U.S.-based organization, ICF International (previously Macro International), provides technical assistance, including standardized questionnaires and training manuals. Local staff receive training in survey techniques and conduct interviews.

The DHS uses a stratified two-stage cluster design, where clusters are determined by enumeration areas from census files. The DHS is designed to be representative at the levels of region, rural and urban residence, and nation. Eligible participants are men and women aged 15 to 49. DHS respondents do not receive incentives for participation. Individual reports for each country-specific survey provide further detail about the DHS sampling and data collection procedures (www.measuredhs.com).

3.5.4 The DHS Questionnaire

The standard DHS survey includes three separate questionnaires for households, women, and men. The outline of questionnaires for individual countries begins with the DHS core questionnaire, which allows for comparison of measures across countries.

Agencies administering surveys in individual countries may add additional country-specific questions and country-specific responses and delete irrelevant questions as needed (Rutstein & Rojas, 2006). The core questionnaire is updated in approximate five-year intervals consistent with the overlapping phases of the DHS. Each phase also includes a set of optional modules (e.g. malaria) that countries may adapt (Rutstein & Rojas, 2006). There is no requirement for countries to participate in every phase of the DHS. Phase five of the DHS ran from 2003 to 2008; phase six of the DHS runs from 2008 to 2013.

Core questionnaires for phase five and six both begin with informed consent. The phase six core household questionnaire lists all household members, household characteristics, and height, weight and anemia status for eligible women and children aged 0 to 5 (ICF International, 2011). The women's questionnaire for phase six (2008-2013) includes ten sections. Topics covered include basic demographics, reproductive history, contraceptive use, prenatal, delivery and postnatal care, child immunization and nutrition, marriage and sexuality, fertility, employment, HIV/AIDS and issues related to health care access (ICF International, 2011). Standardized manuals for sampling procedures, interviewers and field supervisors add to the quality of survey results and consistency between countries (Rutstein & Rojas, 2006).

3.5.5 Study Sample

For each country, data from the most recent survey year was used. Included countries and survey year were Benin (2006), Burkina Faso (2010), Ghana (2008), Guinea (2006), Liberia (2007), Mali (2006), Nigeria (2008), Niger (2006), Senegal (2010), and Sierra Leone (2008). The response rate ranged from 92.7% for Senegal to

99.0% for Burkina Faso. A total of 135,096 women were surveyed across the ten countries. Women were included in the present analysis if they had given birth within three years of the DHS survey. Women were excluded if they had no recent birth (n=73,003), or missing data on: literacy (n=675), receipt of any prenatal care (n=187), number of prenatal care visits (n=2,434), or timing of prenatal care visits (n=283). Two women were excluded because of missing marital status. All women had data on household wealth. The final analytic sample included 58,512 women who met inclusion criteria (Figure 3.2). Representation of each country in the final analytic sample was proportional to population size.

3.5.6 Measures

The primary outcome measure was adequate prenatal care, measured using the WHO recommendations of at least four prenatal care visits, beginning in the first trimester, and at least one visit with a skilled provider. Women reported the number of prenatal care visits and the timing of their first prenatal care visit. Women also listed all persons from whom they received prenatal care. Skilled providers included doctors, nurses, midwives, or auxiliary midwives. In addition to an overall measure of adequate prenatal care, I examined the timing of prenatal care (first, second or third trimester), recommended screenings or services received (blood pressure, blood test, iron supplementation, urinalysis, tetanus immunization), providers (doctor, nurse/midwife, auxiliary midwife, traditional birth attendant, relative or other), and the location where prenatal care was received (government facility, private facility, home). Auxiliary midwives are distinct from midwives because they learn midwifery skills through apprenticeship and do not have the full qualifications of a midwife (WHO, 2012a).

Traditional birth attendants are local women with childbirth experience (Lefèber & Voorhoever, 1997), who may be trained or untrained in midwifery skills.

The primary exposure variables were wealth and education. Wealth was measured using the DHS wealth index, which is a summary measure of economic capital (Rutstein & Johnson, 2004). The wealth index is computed using principal components analysis to weight indicators for various household assets including appliances, vehicles, telephone, type of roofing and flooring materials, land ownership, electricity, water supply, and sanitation facilities. Members of a single household receive the same wealth index score. The weighted sample population is ranked at the national level to determine wealth quintile. While the DHS wealth index is not a proxy for income, it has been shown to adequately discriminate between wealthier and poorer individuals, and to measure the ability of participants to pay for health services (Rutstein & Johnson, 2004).

Education is measured using literacy, a dichotomous variable indicating persons who can or cannot read. Literacy is highly correlated with years of schooling, and is associated with women's ability to comprehend basic health information (LeVine et al., 2004). DHS interviewers determined literacy by having respondents read a simple sentence in the language of the region. Only participants who never attended school, or who attended only primary school (generally grades 1-6) were asked to read. Women with secondary education or higher were considered literate.

Additional potential confounding variables were examined consistent with Andersen's behavioral model of health service use. Predisposing characteristics examined included maternal age, education, parity (1, 2, 3, 4 or ≥5), marital status (married vs. never married, cohabitating, widowed or divorced), and religion (Christian, Islam,

traditional African religion, other or no religion). Enabling characteristics examined included occupation (agricultural, professional, sales, manual, or not working) and involvement in family decision-making (yes or no). Involvement in family decision-making was determined from two questions: (1) "Who usually makes decisions about health care for yourself: you, your husband/partner, you and your husband/partner jointly, or someone else?" (available for all countries except Liberia); and (2) "Who has the final say on making large household purchases?" Women were coded as being involved if they indicated involvement in either of these decisions. Need characteristics included body mass index (BMI), history of cesarean delivery, multiple birth, and pregnancy wantedness. BMI was grouped into four categories based on the WHO definitions of underweight (<18.50), normal weight (18.50-24.99), overweight (25.00-29.99), and obese (≥30) (WHO, 2000).

3.5.7 Ethical Considerations

Approval for this study was obtained from the University of North Carolina at Charlotte Institutional Review Board. MEASURE-DHS approved access to data sources. All study data were deidentified for public dissemination via the MEASURE-DHS website.

3.5.8 Statistical Analysis

Descriptive statistics included means and percentages and were calculated for the entire sample. Bivariate comparisons between groups were conducted using t-tests for continuous variables and chi-square tests for categorical variables. Multivariate logistic regression models estimated the odds of adequate prenatal care after adjusting for confounding variables. Models adjusted for the following predisposing, enabling and

need characteristics that were available for all countries: age, parity, marital status, rural/urban residence, religion, multiple birth, pregnancy wantedness, and involvement in decision-making at home. Sample weights were applied to all analyses. The weights used were DHS normalized weights, which are calculated by dividing each individual weight by the sum of all weights (MEASURE DHS, 2012). The resulting weighted sample size is the same as the unweighted sample size when the full dataset is used. Proportions calculated using these weights reflect those in the population. Analyses were conducted using SAS (version 9.2). All tests were two-sided. A significance level of alpha=0.05 was used to indicate statistical significance.

The multivariate models examined whether wealth (an enabling factor) and education (a predisposing factor) were independently associated with adequate prenatal care after adjusting for other predisposing, enabling and need characteristics. The goal of this analysis was to characterize use of prenatal care by wealth and education groups. Each model included country fixed effects to adjust for correlations among women from the same country.

Receipt of adequate prenatal care differed notably across the 10 countries in the study. For example, 48.9% percent of women in Liberia received adequate prenatal care, compared to 12.4% for women in Nigeria (data not shown in a table). Additional analyses examined country-specific models for Liberia and Nigeria to determine associations between maternal characteristics and use of prenatal care in these countries. Pooled models provide estimates for each effect that are averaged across all countries in the model. In contrast, country-specific models provide estimates of the magnitude and/or direction of association for wealth and literacy within each country, controlling for

individual predisposing, enabling and need characteristics averaged across individuals in the given country.

3.6 Results

3.6.1 Sample Characteristics

Table 3.1 shows characteristics of the overall sample, women who had received prenatal care during their most recent pregnancy and women who had received no prenatal care. The total weighted sample included 57,951 women who had given birth in the 3 years before the survey. A total of 45,356 women (78.3%) received prenatal care during their most recent pregnancy. As shown in Table 3.1, 78.2% of women were unable to read, and 69.6% reported having no education. The overall sample included fewer women from the wealthiest quintile (16.3%) and slightly more women from the poorest quintile (22.3%). A large majority of women (89.4%) were married.

A substantially higher percentage of women who received prenatal care during their most recent pregnancy were literate when compared to women who received no prenatal care (26.3% vs. 5.6%, $p<0.001$). Women who received prenatal care were also more likely to belong to the wealthiest quintile (20.1% vs. 2.9%, $p<0.001$). Women who received no prenatal care were less likely to be involved in decision-making (28.3% vs. 41.8% $p<0.001$), and more likely to live in a rural area (90.8% vs. 67.1%, $p<0.001$) than women who received prenatal care. The distribution of women by country showed that a larger percentage of women with no prenatal care resided in Nigeria and Niger than did women with prenatal care ($p<0.001$).

3.6.2 Timing, Frequency, Source and Content of Prenatal Care

Table 3.2 describes the timing, frequency, source and content of prenatal care for women with at least one prenatal care visit. Among women with at least one prenatal care visit, 13,492 (29.7%) had adequate care (at least four visits beginning in the first trimester with at least one visit with a skilled provider). All other women were classified as having inadequate care. Compared to women receiving inadequate care, women receiving adequate care were more likely to receive care from a doctor, nurse, or midwife ($p<0.001$). While 12.2% of women with inadequate care reported care from a traditional birth attendant, only 1.4% of women with adequate care did. Women who had adequate care were more likely to receive blood pressure screenings and provide a sample of blood and urine for analysis ($p<0.001$). Women with adequate prenatal care also reported receiving tetanus immunizations, information about pregnancy complications and iron supplementation more often than did women with inadequate care.

3.6.3 Wealth and Prenatal Care Use

Table 3.3 describes characteristics of prenatal care by wealth quintile for women who received prenatal care during their most recent pregnancy ending in a live birth. Receipt of adequate prenatal care ranged from 20.4% in the poorest quintile to 44.4% in the wealthiest quintile. Thirty-six percent of poor women initiated prenatal care in the first trimester compared to 53.5% of more affluent women ($p<0.001$). Less than 3% of poor women had ten or more prenatal visits, compared to 17.2% of more affluent women. Women in the wealthiest quintiles were significantly more likely to receive care from a doctor ($p<0.001$) and have recommended screenings. All characteristics of prenatal care showed a significant trend by wealth quintile using the Cochran Armitage test for trend.

3.6.4 Literacy and Prenatal Care Use

Table 3.4 presents results for bivariate associations between literacy and characteristics of prenatal care use for women who received prenatal care during their most recent pregnancy. Adequate use of prenatal care was 38.9% among literate women compared to 26.5% among women who were not literate. A higher percentage of literate women began prenatal care early, used skilled providers, and had recommended screenings and education. For example, 82.9% of literate women had a urine sample tested compared to 66.3% of women who could not read. Similarly, 58.1% of literate women reported receiving education about pregnancy complications compared to 40.9% of women who could not read.

3.6.5 Unadjusted Odds Ratios

Table 3.5 shows unadjusted odds ratios for associations between the exposure variables literacy and wealth, and the outcomes of any prenatal care use and adequate prenatal care. Results indicate that women who could not read had 83% lower odds of any prenatal care (CI 0.15-0.19) and 58% lower odds of adequate prenatal care (CI 0.39-0.44). Poor women had 93% lower odds of any prenatal care (CI 0.06-0.08) and 80% lower odds of adequate prenatal care (CI 0.18-0.22) compared to women in the wealthiest quintile.

3.6.6 Multivariate Models for Any Prenatal Care

The left column of Table 3.6 provides results of multivariate logistic regression models examining associations between literacy, wealth and any prenatal care use. Models included age, parity, marital status, religion, involvement in decision-making, occupation, multiple birth, pregnancy wantedness, and rural residence as confounders.

Binary variables indicating region of residence (e.g. Northern Liberia) were included as fixed effects. Models adjusted for survey design. All covariates were statistically significant except marital status; this finding may be attributable to the fact that most women in the sample were married. Women who could not read had 71% lower odds of any prenatal care (CI 0.26-0.33) compared to literate women. Women in the poorest quintile had 86% lower odds of any prenatal care (CI 0.11-0.18) compared to women in the wealthiest quintile. A test for trend (not shown in the table) showed a significant wealth gradient in prenatal care use ($p<0.001$). Findings for control variables of interest were 45% lower odds of any prenatal care (CI 0.46-0.65) for women living in rural areas, and 43% lower odds of any prenatal care (CI 0.36-0.90) for women employed in agriculture compared to women in professional or technical occupations.

3.6.7 Multivariate Models for Adequate Prenatal Care

The right column of Table 3.6 shows results of multivariate logistic regression models examining associations between literacy, wealth, and having adequate prenatal care. Models were constructed in the same manner as those for any prenatal care use. As with models predicting any prenatal care, all covariates were statistically significant except marital status. Women who could not read had 27% lower odds of having adequate prenatal care (CI 0.68-0.78) compared to literate women. Women in the poorest quintile had 69% lower odds of having adequate prenatal care (CI 0.27-0.35) compared to women in the wealthiest quintile. As with any prenatal care, trend tests showed a significant wealth gradient in the odds of having adequate use of prenatal care (data not shown in a table). Women living in rural areas had 14% lower odds of having adequate prenatal care (CI 0.79-0.93) compared with urban women.

3.6.8 Multivariate Models for Liberia and Nigeria

In Liberia, 48.9% of pregnant women had adequate prenatal care, compared to 12.4% in Nigeria (data not shown in a table). Table 3.7 presents results of separate logistic regression models examining the association between adequate prenatal care use, wealth, and literacy for women in these countries. Results for Liberia showed no difference in adequate prenatal care by literacy. Liberian women in the poorest quintile had 48% lower odds of adequate prenatal care (CI 0.34-0.79) than did women in the wealthiest quintile. In contrast to findings in Liberia, Nigerian women who could not read had 36% lower odds of adequate prenatal care (CI 0.53-0.76) compared to women who were literate. In addition, Nigerian women in the poorest quintile had 77% lower odds of adequate prenatal care use (CI 0.17-0.31) compared to women in the wealthiest quintile. While pooled analyses suggest significant associations for both wealth and literacy across the region, the results shown in table 3.7 suggest that these effects may vary between countries when adjusting for other individual predisposing, enabling and need characteristics.

3.7 Discussion

This study examined characteristics of prenatal care use and associations with wealth and literacy in a sample of women from ten West African countries. Consistent with the study hypotheses, in adjusted logistic regression models, I found that women who were not literate had lower odds of having any prenatal care as well as lower odds of adequate prenatal care. Similarly, results showed a significant wealth gradient for both outcomes: receipt of any prenatal care and receipt of adequate prenatal care. The magnitude of differences between less advantaged, in terms of literacy and wealth, and

more advantaged women was larger for receiving any prenatal care than for adequate prenatal care. This result may in part reflect the low percentage of women who initiate care in the first trimester. Among women receiving prenatal care, only 53.5% in the wealthiest quintile and 36.7% in the poorest quintile began prenatal care in the first trimester. Findings from this study add to the literature on prenatal care use in sub-Saharan Africa by showing that illiteracy and poverty may both increase the likelihood of inadequate prenatal care even when overall use of prenatal care may be high. Findings suggest that adequate use of prenatal care may be more strongly associated with wealth and other factors such as parity in a region with large urban/rural variations in access to care.

While experts agree that prenatal care is a useful intervention for improving the health of mothers and newborns (Abou-Zahr & Wardlaw, 2003; Lincetto et al., 2006), only 78.3% of women in this study received prenatal care. This result is consistent with the 77% rate of prenatal care use in sub-Saharan Africa (Wall, 2012). However, the findings of the present study regarding adequate use of prenatal care show that a low percentage of women (23.3%) received adequate prenatal care. In contrast, Mbuagbaw (2011) found that 66% of women in a Cameroonian sample had optimal prenatal care; that is, women in this study had at least four visits including first and third trimester visits, with at least one visit with a skilled provider. Findings of the present study are more consistent with recent statistics indicating that 46% of sub-Saharan women receive at least four prenatal care visits (Wall, 2012). In addition to different definitions used in prior studies, prevalence of at least four prenatal care visits is higher in Cameroon

(62.2%) (Institut National de la Statistique & ICF International, 2012) than in the current sample (46.6%).

There are several strengths of the measure of adequate prenatal care used in the present study. First, randomized trials have shown that a minimum of four prenatal care visits is as effective for reducing adverse outcomes, compared to more frequent schedules (Carroli, Villar, et al., 2001; Villar et al., 2001). Additionally, skilled providers, such as doctors, nurses and midwives, have the training necessary to manage pregnancy, identify complications and make referrals when necessary (WHO, 2004). The final component of this measure, timing of first visit, allows for early identification of anemia and other risk factors (WHO, 1999). The content of care was not explicitly included in this measure of prenatal care adequacy. However, results of the present study showed that women who received adequate prenatal care were more likely to receive recommended blood pressure screenings, urine and blood analysis, as well as education about pregnancy complications. Recent studies emphasizing the content of prenatal care (Beeckman et al., 2012; Bhutta et al., 2005) suggest that measures beyond the quantity of visits may be useful for understanding the relationship between prenatal care and pregnancy outcomes.

Disparities in prenatal care use by wealth and literacy shown in the present study are consistent with previous research. The findings of the present study showed a wealth gradient in prenatal care use similar to findings using data from the Ghana DHS (Arthur, 2012). This finding suggests that economic capital may play a large role in women's use and access to prenatal care. Women who could not read had 71% lower odds of having any prenatal care, but only 27% lower odds of adequate prenatal care compared to literate women. Literacy, a measure of ability to read and comprehend health information, has

been associated with health and health care use (Berkman 2011). Other studies examining the relationship between education and prenatal care use have found similar associations (Magadi et al., 2007; Mbuagbaw & Gofin, 2011). Research by McTavish (2010) showed that national female literacy rates were associated with use of maternal health services in sub-Saharan Africa, while a study by McGinn (2006) found that participation in a literacy program was associated with improved safe sex behavior in a sample of 549 female refugees. Findings of the present study suggest that women who cannot read access prenatal care less frequently. Reasons may include lack of knowledge, limited availability of care in the areas where these women live, and poorer health behaviors.

Findings from this study should be viewed with data limitations in mind. First, the sample was selected from ten West African countries. While findings may be generalizable to other sub-Saharan countries, applicability to other developing countries may be limited. The survey data were cross-sectional, which do not provide a basis to infer causality. There is a potential for recall bias, especially regarding the content of prenatal care. The analysis addressed this potential by limiting the survey sample to women with a birth in the previous three years. However, it is likely that recall bias would equally affect all women surveyed. Potential confounding variables not addressed in this analysis because data were not available include cost of prenatal care, distance to nearest facility, gestational age, and women's attitudes towards health care and prenatal care. With regard to these considerations, indicators for wealth and rural residence should capture some of the variation related to cost and distance. Women who give birth prematurely (<37 weeks gestation) may not have the four visits required by the measure of adequate care used in the current study. Approximately 12.3% of births in sub-Saharan

Africa are preterm (Althabe, Howson, Kinney, Lawn, & World Health Organization, 2012). Applying this percentage to the study sample provides an estimate of approximately 523 women (0.9% of the analytic sample) who may have begun care in the first trimester and visited a skilled provider, but had less than four visits because of preterm delivery. Therefore, lack of gestational age should not affect results substantially.

3.8 Implications for Policy, Practice and Research

Study findings regarding the associations between use of prenatal care and wealth and literacy provide a framework for useful strategies to address inequities in access. One strategy to address wealth differentials would be to reduce fees for prenatal care in countries where there is a cost. Transportation barriers can be addressed by increasing the availability of health facilities in rural areas and improving roads. For example, in Cuba, increased distribution of hospitals in rural areas helped to facilitate greater access to maternal health services and subsequent declines in infant mortality (Thaddeus & Maine, 1994). It is likely that transportation would be a greater barrier for poor women than for wealthier women with more resources.

In addition to wealth, study findings suggest that literacy may play a role in use of prenatal care. In country specific analysis, literacy was significantly associated with adequate prenatal care for women living in Nigeria; however, literacy was not significant in analysis for Liberia. Nigeria has implemented programs for free primary education; however, large regional disparities in literacy persist (National Population Commission [Nigeria] & ICF Macro, 2009). In Liberia, literacy rates vary notably by rural/urban residence (LISGIS 2008). Increasing schooling for girls and boys may increase demand for prenatal care (Overbosch, 2004), and also has the potential to increase economic

capital and ability to pay for services. Beyond formal schooling, culturally appropriate messages about pregnancy care, delivery of care, and measures to build trust between providers and community may help increase utilization of services. Study findings also have implications for delivery of prenatal care. Women who received inadequate prenatal care were more likely to visit a government health facility or clinic for prenatal care, and more likely to use unskilled providers. Therefore, efforts to improve quality of care at government facilities and efforts to increase the availability of skilled providers may help to improve quality of prenatal care. Studies have suggested that training traditional birth attendants may be a useful supplement to delivery of quality prenatal care in developing countries (Byrne & Morgan, 2011; Ngomane & Mulaudzi, 2012; Prata, Ejembi, Fraser, Shittu, & Minkler, 2012)

Future studies may benefit from a mixed methods approach, which combines quantitative data collected through DHS with qualitative surveys of a subset of DHS participants. Reasons for not seeking care can be complex, and qualitative research has the potential to provide greater insight into cultural and other barriers to and enablers of prenatal care. Topics that would be useful to address in qualitative research include attitudes towards prenatal care, knowledge of prenatal care, beliefs about pregnancy, and husband or partner views about pregnancy. This information would be useful in designing educational interventions for areas with low use of prenatal care. Additional quantitative data that may benefit future analyses include distance to the nearest health facility and whether women had to pay for care received.

Future DHS surveys could provide further insight into women's use of maternal health services by adding questions about self-rated health, complications during

pregnancy, and reasons for not seeking care. Self-rated health may be associated with health care seeking behavior. General reasons for not seeking care including cost, distance, knowledge about services, can help to prioritize interventions. Finally, information about complications during pregnancy can provide additional information about the need for services, and whether women who are at risk receive needed care.

While experts agree about the usefulness of prenatal care, findings of the present study suggest that women who are poorer and have less education are much less likely to receive any prenatal care. Additionally, rates of recommended prenatal care are low. Achieving the full benefit of prenatal care requires additional efforts to reduce barriers to care, and to increase the number of trained providers available to deliver care.

Table 3.1 Characteristics of women with recent birth by use of prenatal care[a]

	Weighted N(%)		
	All women with recent birth	Any prenatal care	No prenatal care
	N=57,951	N=45,356	N=12,595
Outcome Variables			
Any prenatal care	45,356 (78.3)	45,356 (100.0)	
Adequate prenatal care	13,492 (23.3)	13,492 (29.7)	
Exposure Variables			
Literacy			
Can read	12,627 (21.8)	11,925 (26.3)	703 (5.6)
Cannot read at all	45,323 (78.2)	33,431 (73.7)	11,892 (94.4)
Wealth Quintile			
Poorest	12,901 (22.3)	8,158 (18.0)	4,743 (37.7)
Poorer	12,455 (21.5)	8,905 (19.6)	3,550 (28.2)
Middle	11,751 (20.3)	9,302 (20.5)	2,448 (19.4)
Richer	11,375 (19.6)	9,885 (21.8)	1,490 (11.8)
Richest	9,469 (16.3)	9,105 (20.1)	364 (2.9)
Predisposing Characteristics			
Current age			
15-17	1,495 (2.6)	1,027 (2.3)	468 (3.7)
18-34	43,790 (75.6)	34,628 (76.3)	9,162 (72.7)
35-49	12,666 (21.9)	9,702 (21.4)	2,964 (23.5)
Highest level of education			
No education	40,323 (69.6)	29,225 (64.4)	11,098 (88.1)
Primary	9,815 (16.9)	8,694 (19.2)	1,121 (8.9)
Some secondary or higher	7,808 (13.5)	7,432 (16.4)	376 (3.0)
Missing	5 (0.0)	5 (0.0)	

Table 3.1 (continued)

	Weighted N(%)		
	All women with recent birth	Any prenatal care	No prenatal care
	N=57,951	N=45,356	N=12,595
Total children ever born			
1	10,682 (18.4)	8,948 (19.7)	1,734 (13.8)
2	10,131 (17.5)	8,230 (18.1)	1,902 (15.1)
3	8,872 (15.3)	7,162 (15.8)	1,711 (13.6)
4	7,586 (13.1)	5,971 (13.2)	1,615 (12.8)
≥5	20,679 (35.7)	15,047 (33.2)	5,632 (44.7)
Current marital status			
Married	51,788 (89.4)	39,789 (87.7)	12,000 (95.3)
Not Married	6,162 (10.6)	5,568 (12.3)	595 (4.7)
Religion			
Christian	20,303 (35.0)	18,802 (41.5)	1,502 (11.9)
Islam	32,784 (56.6)	22,413 (49.4)	10,371 (82.3)
Traditional Religion	2,743 (4.7)	2,317 (5.1)	426 (3.4)
Other or no religion	2,121 (3.7)	1,825 (4.0)	296 (2.4)
Enabling Characteristics			
Occupation			
Agricultural	18,634 (32.2)	14,726 (32.5)	3,907 (31.0)
Professional/Technical	740 (1.3)	714 (1.6)	25 (0.2)
Sales, clerical and services	16,618 (28.7)	13,935 (30.7)	2,683 (21.3)
Skilled/Unskilled manual	4,177 (7.2)	3,136 (6.9)	1,041 (8.3)
Not working	17,506 (30.2)	12,612 (27.8)	4,894 (38.9)
Missing	277 (0.5)	233 (0.5)	44 (0.3)
Involved in decision-making			
No	32,980 (56.9)	24,238 (53.4)	8,742 (69.4)
Yes	22,550 (38.9)	18,981 (41.8)	3,570 (28.3)
Not assessed	2,420 (4.2)	2,138 (4.7)	282 (2.2)

Table 3.1 (continued)

	Weighted N(%)		
	All women with recent birth	Any prenatal care	No prenatal care
	N=57,951	N=45,356	N=12,595
Need Characteristics			
BMI			
Underweight <18.5	4,963 (8.6)	3,328 (7.3)	1,635 (13.0)
Normal weight 18.50-24.99	31,424 (54.2)	23,822 (52.5)	7,602 (60.4)
Overweight 25.00-29.99	5,491 (9.5)	4,678 (10.3)	813 (6.5)
Obese ≥30.00	1,805 (3.1)	1,638 (3.6)	167 (1.3)
Missing	14,268 (24.6)	11,891 (26.2)	2,377 (18.9)
Prior cesarean birth			
No	41,753 (72.0)	32,189 (71.0)	9,565 (75.9)
Yes	529 (0.9)	521 (1.1)	8 (0.1)
Missing	15,669 (27.0)	12,647 (27.9)	3,022 (24.0)
Multiple birth			
No	56,779 (98.0)	44,376 (97.8)	12,404 (98.5)
Yes	1,171 (2.0)	981 (2.2)	191 (1.5)
Wanted pregnancy			
Then	47,351 (81.7)	36,162 (79.7)	11,189 (88.8)
Later	7,886 (13.6)	6,937 (15.3)	949 (7.5)
Did not want pregnancy	2,557 (4.4)	2,190 (4.8)	367 (2.9)
Missing	157 (0.3)	67 (0.1)	90 (0.7)
Contextual Factors			
Lives in rural area			
No	16,092 (27.8)	14,938 (32.9)	1,153 (9.2)
Yes	41,859 (72.2)	30,418 (67.1)	11,441 (90.8)
Country			
Benin	8,082 (13.9)	7,227 (15.9)	856 (6.8)
Burkina Faso	8,222 (14.2)	7,872 (17.4)	350 (2.8)

Table 3.1 (continued)

	Weighted N(%)		
	All women with recent birth	Any prenatal care	No prenatal care
	N=57,951	N=45,356	N=12,595
Ghana	1,515 (2.6)	1,461 (3.2)	54 (0.4)
Guinea	3,346 (5.8)	2,758 (6.1)	588 (4.7)
Liberia	2,574 (4.4)	2,485 (5.5)	89 (0.7)
Mali	7,301 (12.6)	5,179 (11.4)	2,122 (16.8)
Niger	5,243 (9.0)	2,488 (5.5)	2,755 (21.9)
Nigeria	13,076 (22.6)	7,758 (17.1)	5,318 (42.2)
Senegal	5,938 (10.2)	5,682 (12.5)	256 (2.0)
Sierra Leone	2,654 (4.6)	2,446 (5.4)	208 (1.6)

Source: Data from Demographic and Health Surveys completed between 2006 and 2010 in Benin, Burkina Faso, Ghana, Guinea, Liberia, Mali, Niger, Nigeria, Senegal and Sierra Leone.

[a]Counts and percentages are weighted using DHS-supplied weights, which are normalized to sum to the sample size rather than the population size. Resulting proportions reflect those in the population.

Table 3.2 Timing, frequency, and content and source of prenatal care by adequacy among women with at least one prenatal care visit[a]

	Weighted N(%)		
	Inadequate prenatal care	Adequate prenatal care	
Characteristics	N=31,864	N=13,492	
Timing of 1st prenatal visit			<.001
1st trimester	5,863 (18.4)	13,492 (100.0)	
2nd trimester	21,916 (68.8)		
3rd trimester	4,086 (12.8)		
Number of prenatal visits			<.001
1 to 3 visits	18,360 (57.6)		
4 to 9 visits	11,546 (36.2)	11,932 (88.4)	
10 or more visits	1,958 (6.1)	1,560 (11.6)	
Location for prenatal care			
Home	1,048 (3.3)	164 (1.2)	<.001
Government health facility	16,243 (51.0)	7,070 (52.4)	0.005
Private health facility	2,056 (6.5)	1,295 (9.6)	<.001
Missing	12,725 (39.9)	5,111 (37.9)	<.001
Skilled provider for prenatal care	27,141 (85.2)	13,492 (100.0)	<.001
Prenatal care providers (all)			
Doctor	2,831 (8.9)	1,913 (14.2)	<.001
Nurse/midwife	19,841 (62.3)	10,765 (79.8)	<.001
Auxiliary midwife	6,607 (20.7)	2,170 (16.1)	<.001
Traditional birth attendant	3,880 (12.2)	187 (1.4)	<.001
Relative or other	1,397 (4.4)	89 (0.7)	<.001
Screenings during pregnancy			<.001
Urine sample	10,889 (34.2)	2,375 (17.6)	<.001
Blood pressure	28,688 (90.0)	12,988 (96.3)	<.001
Blood sample	16,101 (50.5)	9,332 (69.2)	<.001
Tetanus shot (≥2)	20,401 (64.0)	9,987 (74.0)	<.001
Took iron supplements	28,297 (88.8)	12,837 (95.1)	<.001

Table 3.2 (continued)

	Weighted N(%)		
	Inadequate prenatal care	Adequate prenatal care	
	N=31,864	N=13,492	
Told about pregnancy complications	13,835 (43.4)	6,763 (50.1)	<.001

Source: As for Table 3.1

[a]Counts and percentages are weighted using DHS-supplied weights, which are normalized to sum to the sample size rather than the population size. Resulting proportions reflect those in the population.

PA, physician assistant

Table 3.3 Timing, frequency and content of prenatal care by wealth among women receiving prenatal care in ten West African countries[a]

	Wealth Quintile Weighted N(%)					
Characteristics of Prenatal Care	Poorest N=8,158	Poorer N=8,905	Middle N=9,302	Richer N=9,885	Richest N=9,105	Trend p-value
Inadequate prenatal care	6,497 (79.6)	6,911 (77.6)	6,793 (73.0)	6,606 (66.8)	5,058 (55.6)	<.001
Adequate prenatal care	1,662 (20.4)	1,994 (22.4)	2,509 (27.0)	3,280 (33.2)	4,047 (44.4)	<.001
Timing of 1st prenatal visit						
1st trimester	2,990 (36.7)	3,296 (37.0)	3,752 (40.3)	4,449 (45.0)	4,867 (53.5)	<.001
2nd trimester	4,263 (52.3)	4,669 (52.4)	4,624 (49.7)	4,613 (46.7)	3,747 (41.2)	<.001
3rd trimester	905 (11.1)	941 (10.6)	926 (10.0)	823 (8.3)	491 (5.4)	<.001
Number of prenatal care visits						
1 to 3 visits	4,446 (54.5)	4,352 (48.9)	3,921 (42.2)	3,462 (35.0)	2,179 (23.9)	<.001
4 to 9 visits	3,514 (43.1)	4,202 (47.2)	4,854 (52.2)	5,551 (56.2)	5,357 (58.8)	<.001
10 or more visits	199 (2.4)	351 (3.9)	528 (5.7)	872 (8.8)	1,569 (17.2)	<.001
Location for prenatal care						
Home	287 (3.5)	329 (3.7)	272 (2.9)	195 (2.0)	130 (1.4)	<.001
Government health facility	4,441 (54.4)	4,939 (55.5)	5,101 (54.8)	5,141 (52.0)	3,691 (40.5)	<.001
Private health facility	243 (3.0)	324 (3.6)	493 (5.3)	813 (8.2)	1,478 (16.2)	<.001
Missing	3,222 (39.5)	3,355 (37.7)	3,485 (37.5)	3,856 (39.0)	3,917 (43.0)	<.001
Skilled provider for prenatal care	6,846 (83.9)	7,708 (86.6)	8,250 (88.7)	9,022 (91.3)	8,808 (96.7)	<.001

Table 3.3 (continued)

Characteristics of Prenatal Care	Wealth Quintile Weighted N(%) Poorest N=8,158	Poorer N=8,905	Middle N=9,302	Richer N=9,885	Richest N=9,105	Trend p-value
Prenatal care providers						
Doctor	376 (4.6)	529 (5.9)	687 (7.4)	1,075 (10.9)	2,078 (22.8)	<.001
Nurse/midwife	4,916 (60.3)	5,558 (62.4)	6,049 (65.0)	6,977 (70.6)	7,106 (78.0)	<.001
Auxiliary midwife	1,857 (22.8)	2,050 (23.0)	2,109 (22.7)	1,893 (19.1)	869 (9.5)	<.001
Traditional birth attendant	1,084 (13.3)	1,041 (11.7)	877 (9.4)	769 (7.8)	297 (3.3)	<.001
Relative or other	447 (5.5)	352 (4.0)	340 (3.7)	259 (2.6)	88 (1.0)	<.001
Screenings during pregnancy						
Urine sample	4,516 (55.4)	5,569 (62.5)	6,389 (68.7)	7,506 (75.9)	8,051 (88.4)	<.001
Blood pressure	7,117 (87.2)	7,911 (88.8)	8,495 (91.3)	9,323 (94.3)	8,829 (97.0)	<.001
Blood sample	3,239 (39.7)	4,052 (45.5)	4,764 (51.2)	6,021 (60.9)	7,358 (80.8)	<.001
Tetanus shot (≥2)	5,003 (61.3)	5,815 (65.3)	6,279 (67.5)	6,815 (68.9)	6,477 (71.1)	<.001
Took iron supplements	7,135 (87.5)	8,004 (89.9)	8,423 (90.5)	9,094 (92.0)	8,477 (93.1)	<.001
Told about pregnancy complications	3,105 (38.1)	3,654 (41.0)	4,052 (43.6)	4,793 (48.5)	4,993 (54.8)	<.001

Source: As for Table 3.1

[a]Counts and percentages are weighted using DHS-supplied weights, which are normalized to sum to the sample size rather than the population size. Resulting proportions reflect those in the population.

PA, physician assistant

Table 3.4 Timing, frequency and content of prenatal care by literacy among women receiving prenatal care in ten West African countries[a]

	Weighted Frequency (%)		
	Literate	Cannot read	
Characteristics of Prenatal Care	N=11,980	N= 43,379	p-value
Inadequate prenatal care	7,286 (61.1)	24,578 (73.5)	<.001
Adequate prenatal care	4,639 (38.9)	8,853 (26.5)	<.001
Timing of 1st antenatal check			<.001
1st trimester	5,641 (47.3)	13,713 (41.0)	
2nd trimester	5,449 (45.7)	16,467 (49.3)	
3rd trimester	834 (7.0)	3,251 (9.7)	
Antenatal visits for pregnancy			<.001
1 to 3 visits	2,711 (22.7)	15,650 (46.8)	
4 to 9 visits	6,911 (58.0)	16,567 (49.6)	
10 or more visits	2,303 (19.3)	1,215 (3.6)	
Location for prenatal care			
Home	440 (3.7)	773 (2.3)	<.001
Government health facility	6,554 (55.0)	16,759 (50.1)	<.001
Private health facility	2,210 (18.5)	1,142 (3.4)	<.001
Missing	2,924 (24.5)	14,912 (44.6)	<.001
Skilled provider for prenatal care	11,248 (94.3)	29,385 (87.9)	<.001
Prenatal care providers			
Doctor	2,924 (24.5)	1,821 (5.4)	<.001
Nurse/midwife/PA	8,820 (74.0)	21,785 (65.2)	<.001
Auxiliary midwife	1,306 (11.0)	7,471 (22.3)	0.074
Traditional birth attendant	624 (5.2)	3,444 (10.3)	<.001
Relative or other	252 (2.1)	1,234 (3.7)	0.099
Screenings during pregnancy			<.001
Urine sample	9,880 (82.9)	22,151 (66.3)	<.001
Blood pressure	11,218 (94.1)	30,457 (91.1)	<.001
Blood sample	9,099 (76.3)	16,334 (48.9)	<.001
Told about pregnancy complications	6,929 (58.1)	13,669 (40.9)	<.001
Tetanus shot (≥2)	8,600 (72.1)	21,788 (65.2)	<.001

Table 3.4 (continued)

	Weighted Frequency (%)		
	Literate	Cannot read	
Characteristics of Prenatal Care	N=11,980	N= 43,379	p-value
Took iron supplements	10,936 (91.7)	30,198 (90.3)	<.001

Source: As for Table 3.1

[a]Counts and percentages are weighted using normalized weights supplied with the DHS.

PA, physician assistant

Table 3.5 Unadjusted odds ratios examining association of literacy and wealth with any prenatal care and adequate prenatal care

	Any prenatal care		Adequate prenatal care	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Exposure Variables				
Literacy				
Can read	1.00		1.00	
Cannot read at all	0.17 (0.15-0.19)	<.001	0.42 (0.39-0.44)	<.001
Wealth Quintiles				
Poorest	0.07 (0.06-0.08)	<.001	0.20 (0.18-0.22)	<.001
Poorer	0.10 (0.08-0.12)	<.001	0.26 (0.23-0.28)	<.001
Middle	0.15 (0.12-0.19)	<.001	0.36 (0.33-0.40)	<.001
Richer	0.27 (0.22-0.31)	<.001	0.54 (0.50-0.59)	<.001
Richest	1.00		1.00	

Source: As for Table 3.1

OR, odds ratio

Table 3.6 Logistic regression predicting the likelihood of any prenatal care and adequate prenatal care during most recent pregnancy

	Any prenatal care		Adequate prenatal care	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Exposure Variables				
Literacy		<.001		<.001
Can read	1.00		1.00	
Cannot read at all	0.29 (0.26-0.33)		0.73 (0.68-0.78)	
Wealth Quintile		<.001		<.001
Poorest	0.14 (0.11-0.18)		0.31 (0.27-0.35)	
Poorer	0.21 (0.17-0.27)		0.38 (0.33-0.42)	
Middle	0.28 (0.22-0.34)		0.49 (0.44-0.55)	
Richer	0.39 (0.33-0.47)		0.65 (0.59-0.73)	
Richest	1.00		1.00	
Predisposing Characteristics				
Current age - respondent		0.050		<.001
15-17	0.80 (0.67-0.96)		0.62 (0.51-0.75)	
18-34	1.00		1.00	
35-49	1.01 (0.93-1.10)		1.08 (1.00-1.16)	
Total children ever born		<.001		<.001
1	1.33 (1.19-1.48)		1.53 (1.41-1.67)	
2	1.07 (0.97-1.17)		1.35 (1.24-1.46)	
3	1.07 (0.98-1.18)		1.22 (1.12-1.33)	
4	1.08 (0.98-1.19)		1.12 (1.02-1.22)	
≥5	1.00		1.00	
Current marital status		0.379		0.815
Married	1.00		1.00	
Not Married	0.93 (0.79-1.10)		1.01 (0.91-1.12)	
Religion		<.001		<.001
Islam	1.00		1.00	
Christian	1.78 (1.49-2.11)		1.19 (1.09-1.30)	
Traditional Religion	0.81 (0.64-1.02)		0.86 (0.74-0.99)	

Table 3.6 (continued)

	Any prenatal care		Adequate prenatal care	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Other or no religion	1.14 (0.91-1.43)		0.85 (0.74-0.97)	
Enabling Characteristics				
Respondent's occupation		<.001		<.001
Professional/Technical	1.00		1.00	
Agricultural	0.57 (0.36-0.90)		0.64 (0.53-0.78)	
Sales, clerical and services	0.80 (0.51-1.25)		0.74 (0.62-0.89)	
Skilled/Unskilled manual	0.76 (0.48-1.20)		0.70 (0.58-0.85)	
Not working	0.59 (0.38-0.92)		0.61 (0.51-0.73)	
Missing	0.81 (0.43-1.54)		0.86 (0.61-1.22)	
Respondent involved in decision-making		<.001		<.001
Yes	1.00		1.00	
No	0.85 (0.78-0.93)		0.91 (0.85-0.97)	
Not assessed	0.69 (0.55-0.88)		0.77 (0.66-0.89)	
Need Characteristics				
Multiple birth		0.014		<.001
No	1.00		1.00	
Yes	1.30 (1.05-1.61)		1.39 (1.19-1.63)	
Time wanted pregnancy		0.011		<.001
Then	1.00		1.00	
Later	1.01 (0.91-1.13)		0.80 (0.74-0.86)	
No more	0.78 (0.66-0.93)		0.73 (0.63-0.85)	
Missing	0.67 (0.40-1.10)		0.61 (0.31-1.23)	
Contextual Characteristics[a]				
Lives in rural area		<.001		<.001
No	1.00		1.00	
Yes	0.55 (0.46-0.65)		0.86 (0.79-0.93)	

Source: As for Table 3.1

[a]In addition to variables shown in table, models adjust for region of residence (e.g., Northern Liberia)

Table 3.7 Logistic regression predicting the likelihood of adequate prenatal care during most recent pregnancy for women in Liberia and Nigeria[a]

	Liberia (N=2,550)		Nigeria (N=13,076)	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Exposure Variables				
Literacy		0.407		<.001
Can read	1.00		1.00	
Cannot read at all	1.11 (0.87-1.42)		0.64 (0.53-0.76)	
Wealth Quintile		<.001		<.001
Poorest	0.52 (0.34-0.79)		0.23 (0.17-0.31)	
Poorer	0.62 (0.41-0.91)		0.38 (0.29-0.49)	
Middle	0.98 (0.68-1.41)		0.58 (0.46-0.72)	
Richer	1.14 (0.82-1.58)		0.68 (0.56-0.83)	
Richest	1.00		1.00	
Predisposing Characteristics				
Current age - respondent		0.422		0.227
15-17	0.70 (0.41-1.19)		0.66 (0.41-1.07)	
18-34	1.00		1.00	
35-49	1.04 (0.78-1.39)		1.04 (0.87-1.25)	
Total children ever born		0.647		0.003
1	0.91 (0.61-1.35)		1.44 (1.17-1.77)	
2	1.00 (0.62-1.63)		1.22 (0.99-1.49)	
3	1.17 (0.82-1.68)		1.17 (0.94-1.45)	
4	1.02 (0.68-1.52)		0.96 (0.78-1.19)	
≥5	1.00		1.00	
Current marital status		0.029		0.017
Married	1.00		1.00	
Not Married	1.36 (1.03-1.79)		0.55 (0.34-0.90)	
Religion		0.602		0.216
Islam	1.00		1.00	
Christian	0.93 (0.64-1.36)		1.22 (0.99-1.51)	
Traditional Religion	1.51 (0.54-4.19)		0.94 (0.55-1.61)	
Other or no religion	0.71 (0.39-1.29)		0.92 (0.44-1.90)	

Table 3.7 (continued)

	Liberia (N=2,550)		Nigeria (N=13,076)	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Respondent's occupation		0.098		0.020
Enabling Characteristics				
Professional/Technical	1.00		1.00	
Agricultural	0.91 (0.35-2.39)		0.92 (0.65-1.30)	
Sales, clerical and services	1.35 (0.53-3.44)		0.91 (0.69-1.19)	
Skilled/Unskilled manual	3.31 (0.83-13.21)		0.81 (0.59-1.13)	
Not working	1.18 (0.47-2.92)		0.71 (0.53-0.96)	
Missing	1.51 (0.25-9.08)		0.50 (0.18-1.40)	
Respondent involved in decision-making		0.004		0.445
Yes	1.00		1.00	
No	0.64 (0.47-0.86)		0.97 (0.84-1.13)	
Not assessed	0.66 (0.48-0.89)		1.36 (0.80-2.32)	
Need Characteristics				
Multiple birth		0.522		0.093
No	1.00		1.00	
Yes	1.33 (0.55-3.21)		1.44 (0.94-2.22)	
Time wanted pregnancy		0.660		0.008
Then	1.00		1.00	
Later	0.99 (0.80-1.23)		0.80 (0.62-1.02)	
No more	0.81 (0.51-1.28)		0.65 (0.50-0.85)	
Missing			1.02 (0.41-2.53)	
Contextual Characteristics				
Lives in rural area		0.088		0.850
No	1.00		1.00	
Yes	0.78 (0.58-1.04)		1.02 (0.85-1.21)	

Table 3.7 (continued)

	Liberia (N=2,550)		Nigeria (N=13,076)	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Region of Liberia		<.001		
Monrovia	1.00			
North Central	0.55 (0.37-0.82)			
North Western	1.23 (0.60-2.53)			
South Central	0.85 (0.58-1.23)			
South Eastern A	0.65 (0.40-1.04)			
South Eastern B	0.41 (0.27-0.64)			
Region of Nigeria				<0.001
South West			1.00	
North Central			2.00 (1.55-2.60)	
North East			1.15 (0.81-1.64)	
North West			0.44 (0.29-0.66)	
South East			1.27 (0.96-1.67)	
South South			0.96 (0.74-1.24)	

Source: Data from the 2007 Liberia DHS and the 2008 Nigeria DHS.

[a]Models adjust for complex survey design.

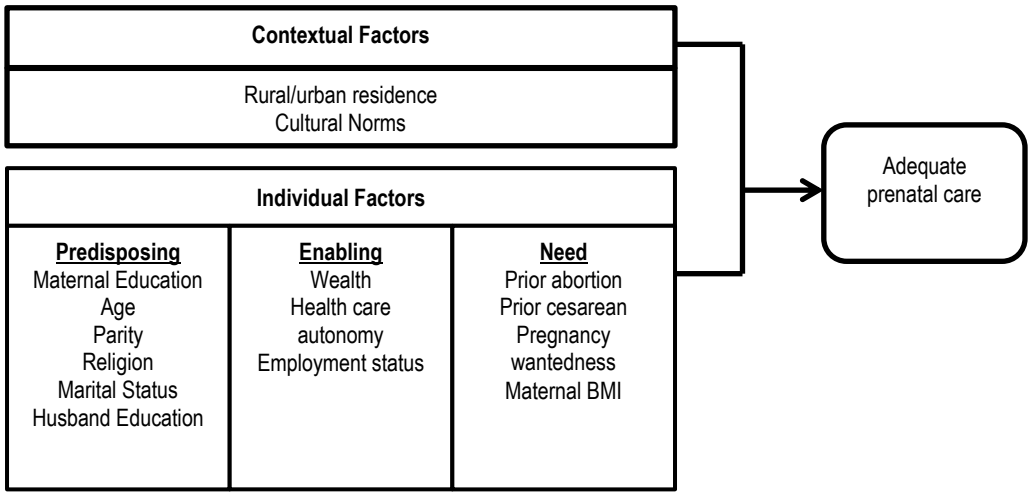

Figure 3.1 Diagram of conceptual framework, adapted from Andersen and Davidson (2007b)

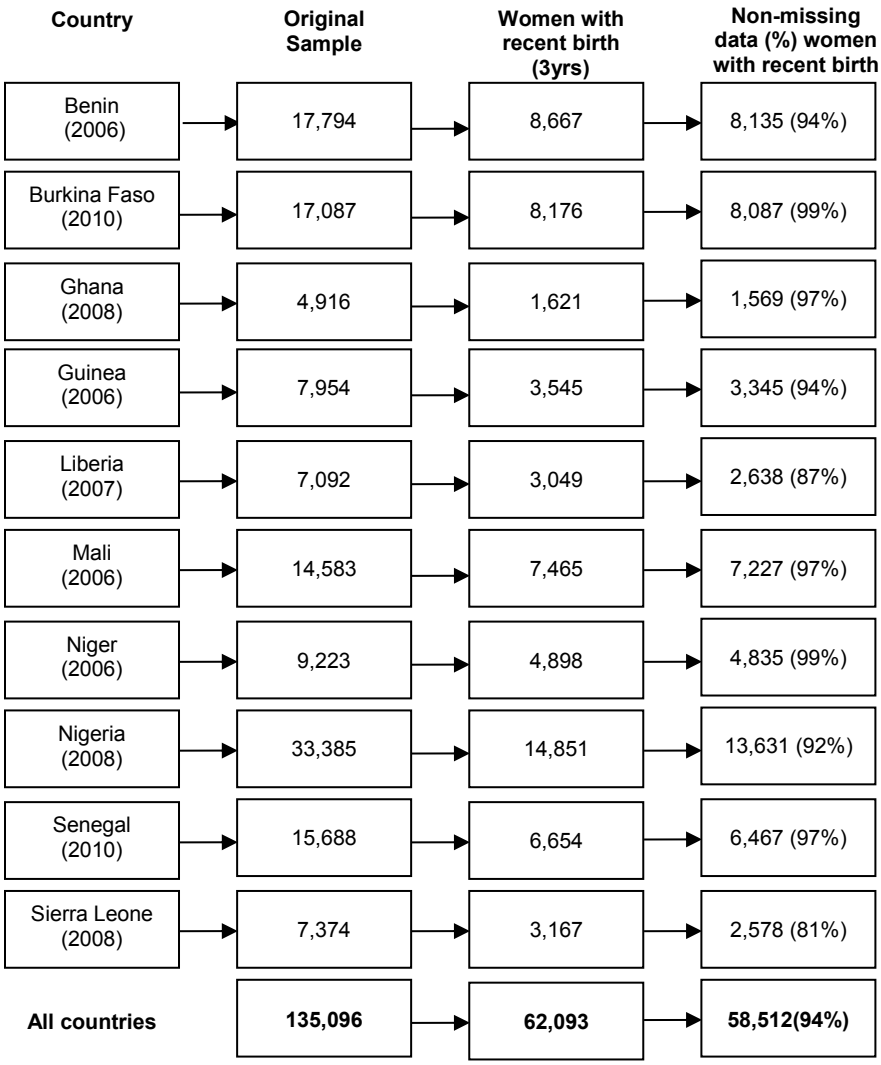

Figure 3.2 Sample selection flowchart

CHAPTER 4: RELATIONSHIP BETWEEN HEALTH CARE CONTEXT AND USE OF PRENATAL CARE IN WEST AFRICA

4.1 Introduction

In recent years, progress toward achieving universal coverage of maternal health services has slowed for countries in sub-Saharan Africa. Although the number of women receiving prenatal care by a skilled health professional increased from 69% in 1990 to 77% in 2010 (Wall, 2012), universal coverage remains elusive, particularly in the poorer regions of West and Central Africa. The percentage of women receiving prenatal care in 2010 was 67% for women in West Africa, 82% for women in Central Africa, and 94% for women in Southern Africa (Wall, 2012). Fewer than half of women in sub-Saharan Africa receive a minimum of four visits as recommended by the World Health Organization (WHO) (Wall, 2012). The United Nation's Millennium Development Goals for maternal health include universal access to reproductive health services and a 75% reduction in maternal mortality. For many countries, reaching these goals by 2015 seems out of reach (Bryce, Requejo, & 2008 Countdown Working Group, 2008).

Previous studies have found that several individual factors including wealth, education, and rural residence are associated with use of prenatal care in sub-Saharan African countries (Ali & Adam, 2011; Arthur, 2012; Magadi et al., 2003). Resources and services tend to be concentrated among women who are wealthier, more educated and living in urban areas (Bryce et al., 2008). Women who are wealthier and have more education tend to seek prenatal care earlier and more often than poorer

women and women with less education (De Allegri et al., 2011; Mbuagbaw & Gofin, 2011; Ochako et al., 2011).

Beyond individual characteristics, health context may play a role in use of prenatal care. Qualitative research in Tanzania suggests that women have a generally positive view of prenatal care; however, they are often challenged by cost and transportation barriers (Magoma et al., 2010; Mubyazi et al., 2010). In Burkina Faso, living more than 5 kilometers away from a health facility was associated with lower use of prenatal care, in a region where women did not have to pay for prenatal care (De Allegri et al., 2011). Other research suggests barriers related to cultural context including gender roles and beliefs regarding pregnancy. In rural Liberia, researchers found that women did not trust the health care system (Lori & Boyle, 2011). These characteristics of the context in which women receive care represent opportunities to improve access to services.

The purpose of this study was to examine whether investments in health and female literacy rates are associated with women's use of prenatal care in West Africa. Previous ecological studies have found associations between maternal mortality ratios and government health care expenditure (Alvarez et al., 2009), and between political stability, economic climate and under five mortality (Olafsdottir et al., 2011). Studies involving both individual and community effects have also found that community employment rates and economic development are associated with utilization of maternity care (Stephenson, Baschieri, Clements, Hennink, & Madise, 2006; Stephenson & Elfstrom, 2012). This study extends previous research by examining how these health context characteristics influence the likelihood of adequate prenatal care use, using a

measure that combines number of visits, timing of first visit, and type of provider. Findings from this study can help to show how macro-level factors such as government health care expenditures and availability of health care professionals are associated with adequate prenatal care. These macro-level factors may be amendable to policy changes that would help to improve maternal health outcomes.

4.2 Literature Review

Relatively few studies have examined contextual determinants of prenatal care use. Even fewer studies have examined how context influences prenatal care use in developing countries. Bradley et al. (2011) examined associations between health expenditures and health outcomes in 30 Organization for Economic Development (OECD) countries; these authors found that countries spending more on social services relative to health had lower rates of infant mortality. Anand (2004) analyzed data from 117 low-income countries and found that both gross national income (GNI) and doctor density were associated with maternal mortality ratio and infant mortality rate. Ecological studies by Alvarez et al. (2009) and Olafsdottir et al. (2011) found that education rates, socioeconomic status, GNI per capita, government health expenditure and political stability were additional contextual factors associated with maternal mortality rate, prenatal care coverage and under–five mortality rate. Community-level factors such as health knowledge (Stephenson & Elfstrom, 2012) and level of trust in the health care system (Lori & Boyle, 2011) may also be correlated with the use of prenatal care.

4.2.1 National Wealth and Maternal and Infant Health

Studies examining the effect of national monetary resources on prenatal care use or infant mortality have focused on the following measures: GNI per capita, health

expenditures as a percentage of gross domestic product (GDP), public spending on health care, and gross national product (GNP). The following is a review of studies examining the impact of these factors on prenatal care, infant mortality, and maternal mortality.

Using data from the OECD Health Data 2009 Statistics and Indicators, Bradley et al. (2011) examined the relationship between health outcomes and the percent of GDP spent on health and social services in 30 countries during 1995 to 2005. Mixed effect models applied to pooled data suggested that health expenditures alone were not significantly associated with infant mortality rate, maternal mortality rate, or rate of low birth weight, when adjusted for GDP per capita. Social expenditures were negatively associated with infant mortality rates when adjusted for GDP per capita. Health expenditures were defined as spending on medical care, health care infrastructure, health insurance, and public health. Social expenditures were defined as pension, disability and illness benefits, employment programs, housing subsidies, family support, and other social services not classified under health (Bradley et al., 2011). These findings suggest that in industrialized countries, social spending may be more important than health spending for improving infant mortality.

Anand and Bärnighausen (2004) measured the impact of GNI per capita on maternal mortality, infant mortality and under-five mortality in 117 countries included in the 2004 Estimates of Health Personnel dataset compiled by the WHO. Using values adjusted to reflect purchasing power parity (PPP), this ecological study found that each one percent increase in GNI per capita was associated with a decrease of 0.57% to 0.71% in infant mortality rate per 1,000 live births.

An ecological study by Alvarez et al. (2009) examined health system, educational, and economic indicators associated with the maternal mortality ratio in 45 sub-Saharan African countries. Correlation analysis showed that maternal mortality had a strong positive correlation with infant mortality rates. In contrast, maternal mortality was negatively correlated with GNI per capita and per capita government spending on health. Adult literacy and contraceptive prevalence also had negative correlations with maternal mortality. A limitation of this analysis was the lack of multiple regression models to adjust for the contribution of individual factors to mortality.

In an analysis of the association between maternal age and prenatal care use in 21 sub-Saharan countries, Magadi et al. (2007) found that each one dollar increase in GNI per capita was associated with 24% lower odds of late prenatal care. In the same analysis, each one-point increase in the female literacy rate was associated with 3% higher odds of late prenatal care and 3% lower odds of less than four prenatal care visits. Models included individual demographic characteristics as well as health expenditure per capita and health expenditure as a percent of GNI, neither of which were significant.

4.2.2 Health Resources, Prenatal Care Use, and Health Outcomes

Access to quality care and adequate numbers of skilled health professionals have been identified as important factors for improving maternal health outcomes in sub-Saharan Africa (Gerein, Green, & Pearson, 2006). Gage (2007) used multilevel modeling to examine the impact of access to care and other contextual factors on use of prenatal care by women in rural Mali. Analysis using data from the 2001 Mali Demographic and Health Survey (DHS) examined associations with proximity to medical care, roads and access to transportation, percent of population with secondary education, poverty rate,

and ethnic distribution for 6,479 births occurring in the five years prior interviews. Individual factors examined included education, household wealth, gender of head of household, childcare burden, birth order, and an index of barriers to prenatal care determined from principal components analysis. The availability of medical establishments within 5 kilometers and percent of women receiving prenatal care were the only area-level factors that remained significant predictors of early prenatal care in models including individual factors. Time to public transportation was significantly associated with receipt of four or more prenatal care visits. Household wealth, maternal education and barriers to care remained significantly associated with both early prenatal care and receipt of at least four prenatal care visits.

Longitudinal analysis by Farahani et al. (2009) using 1960 to 2000 data for 99 countries with reliable infant mortality data found that adding one physician per 1,000 population was associated with a 14% decrease in infant mortality rate in the short run (within 5 years) and a 45% decrease in infant mortality rate in the long run (>5 years). Models controlled for GDP per capita, average years of schooling among adults 15 and older, and time. The study included 30 African countries, 36 countries from the Americas, 20 from the Middle East, and 17 from Asia. Many developing countries lack complete vital statistics registries. Therefore, for some developing countries in this study, infant mortality rates were based on data from World Fertility Surveys and Demographic and Health Surveys (Farahani et al., 2009). One method for evaluating the reliability of survey data is to compare results of different methods applied to estimate mortality rates (United Nations, 1992). Authors of this study did not state the specific method for evaluating reliability; therefore, the impact of exclusions on these results is unclear.

Analysis by Anand and Bärnighausen (2004) provides additional evidence of a relationship between health resources and maternal health. The authors used data from 117 countries to examine the impact of health professional density (doctors, nurses, and midwives) on maternal and infant mortality. Models controlling for GNI per capita, sanitation, poverty, and female adult literacy showed that higher physician density and higher GNI per capita were associated with declines in infant and maternal mortality. Notably, female literacy rates were not significant in these models.

4.2.3 Governance, Culture and Maternal and Child Health

The impact of the political and economic climate on health was examined in an ecological study by Olafsodittor et al. (2011), which involved cross-sectional data from 46 sub-Saharan African countries. Using under-five mortality as a measure of health system performance, the impact of two indices was examined: Rule of Law, Transparency and Corruption, which captures legal stability; and Sustainable Economic Opportunity, which captures macroeconomic stability. Regression models adjusting for health care, finance, education and water supply showed that countries with higher rankings for sustainable economic opportunity had lower rates of under-five mortality. Sustainable economic opportunity is characterized by governments that support freedom to create wealth, provide necessary infrastructure for business development (electricity, telecommunications, roads, etc.), and have sound fiscal policy (Mo Ibrahim Foundation, 2012). Political climate was not significantly associated with health equity as defined by the ratio of under-five mortality for the wealthiest vs. poorest quintile. Although the generalizability of these results was limited by an ecological study design, the concept of sustainable economic opportunity further suggests the usefulness of higher literacy rates

and gender equity, which have been associated with improved maternal and child health outcomes (Wall, 2012).

Stephenson and Elstrom (2012) examined community level factors associated with use of prenatal care for women in Bangladesh, Egypt and Rwanda using data from the DHS. The study sample included 17,637 women who had given birth within three years prior to interview. Results from multilevel logistic regression analysis showed that factors associated with early prenatal care varied between countries. Community characteristics associated with earlier prenatal care included higher knowledge of HIV in Bangladesh, higher reproductive health knowledge and female autonomy in Egypt, and a higher ratio of male versus female employment in Rwanda. In Bangladesh, higher community knowledge of HIV was also associated with higher odds of any prenatal care and with having at least four prenatal care visits. Models controlled for individual demographic characteristics including age, parity, education, religion, marital status, household wealth, prior use of contraception, and media exposure. However, significant unmeasured variation among communities remained, suggesting that additional factors may contribute to the differences identified.

Cultural influences also contribute to women's use of prenatal care as seen in qualitative studies of African women (Lori & Boyle, 2011; Mathole et al., 2004). In-depth interviews with 10 postpartum women and 44 family and community members in rural Liberia suggested that secrecy and autonomy were prominent components of cultural attitudes towards pregnancy (Lori & Boyle, 2011). Women kept pregnancy and labor secret for fear of witchcraft, which could harm their unborn child; lack of decision-making autonomy prevented women from receiving timely care (Lori & Boyle, 2011).

Similar findings regarding vulnerability of pregnancy to witchcraft and lack of decision-making autonomy were reported by 68 female and male participants during focus groups and in-depth interviews in a rural area of Zimbabwe (Mathole et al., 2004). In discussions about specific aspects of care, women were agreeable to being weighed; however, women expressed fear about referrals for cesarean section and fear of potential disclosure of results of HIV tests (Mathole et al., 2004). These studies suggest a key role of culture in the uptake of prenatal care programs. Findings also indicate an opportunity for education and care delivery that is sensitive to cultural norms.

4.3 Study Objectives and Hypotheses

The objective of this study was to examine whether national investments in health and female literacy rates help to predict use of prenatal care in the West African region. Two hypotheses guided this research. First, I hypothesized that countries with greater investments in health and higher female literacy will have higher national rates of any prenatal care and adequate prenatal care, compared to countries with lower investment. The second expectation is that women residing in countries with greater investments in health and higher female literacy will have a higher individual likelihood of having any prenatal care and adequate prenatal care, compared to women in countries with less investment. This study extends a previous analysis by Magadi et al. (2007) by using more recent data, a more comprehensive measure of adequate care, and additional individual-level covariates.

4.4 Conceptual Framework

The behavioral model of health services use (Andersen & Davidson, 2007b; Andersen, 1995) provides a useful conceptual framework for exploring contextual

determinants of maternal health service use in sub-Saharan Africa. The model identifies the influence of contextual and individual characteristics on health behaviors and health outcomes. In the vocabulary of the model, these characteristics are grouped into three domains: predisposing, enabling and need. Predisposing characteristics include inherent factors such as gender and age at the individual level and culture and climate at the environmental level. Enabling factors include resources such as income, poverty, transportation, and the availability of health care providers. Finally, the need domain includes measures of perceived and evaluated health. The model is nonlinear: both health behaviors and health outcomes create a feedback loop that influences other contextual and individual characteristics.

Using the behavioral model one can propose a demand function for maternal health care services that includes individual and community beliefs, resources and need. Economic demand theory suggests that demand for maternal health services will increase as associated costs decrease. Predisposing, enabling and need factors would serve as demand shifters. Consistent with other studies (De Allegri et al., 2011; Houweling et al., 2007; Ochako et al., 2011) my expectation is that demand would be higher in countries where costs are lower and where women have higher literacy rates. In countries with lower costs, greater availability of care, and greater satisfaction with care, the expectation is that the disparity between wealthy and poor women would be smaller (De Allegri et al., 2011; Kruk & Prescott, 2012).

4.5 Study Design and Methods

4.5.1 Study Design

This study uses cross-sectional data from the Demographic and Health Survey (DHS) to examine characteristics of prenatal care use and the association between health context, i.e. national wealth, health resources, and literacy rates, and use of prenatal care for women in ten West African countries.

4.5.2 Setting

The West African region includes some of the poorest countries in sub-Saharan Africa, and has poorer maternal health statistics than Eastern and Southern Africa (UNICEF, 2011). West Africa is also home to the regional West African Health Organization (WAHO). The WAHO serves the fifteen member states of the Economic Community of West African States (ECOWAS) by promoting strategies to address pertinent health issues ("West African Health Organization," n.d.). This study includes data from ten countries with data collected in 2003 or later. Data are from the most recent DHS for each included country.

4.5.3 Overview of the Demographic and Health Surveys

The DHS is a nationally representative household survey funded by the United States Agency for International Development (USAID) in over 90 developing countries (www.measuredhs.com). The DHS seeks to assist governments in collecting data on health and nutrition, with a specific focus on maternal and child health and diseases such as HIV/AIDS and malaria. Local agencies oversee data collection, which involves interviews by trained local interviewers. A U.S.-based organization, ICF International (previously Macro International), provides technical assistance, including standardized

questionnaires and training manuals. The DHS utilizes a stratified two-stage cluster design, where clusters are determined by enumeration areas from census files. Topics covered in the women's questionnaire include basic demographics, reproductive history, contraceptive use, prenatal, delivery and postnatal care, child immunization and nutrition, marriage and sexuality, fertility, employment, HIV/AIDS, and issues related to health care access (ICF International, 2011). Surveys include country-specific questions and responses as well as standardized questions that allow comparison between countries (Rutstein & Rojas, 2006).

4.5.4 Africa Development Indicators Database

The Africa Development Indicators (ADI) database is compiled by the World Bank to represent current indicators of human and economic development for countries in Africa (World Bank, 2012b). Data are available for public download on the World Bank website (data.worldbank.org). The ADI database includes over 1,700 indicators compiled from data sources that include surveys, United Nations agencies, the World Health Organization, the Organization for Economic Development, the International Monetary Fund and the World Bank. The WHO National Health Accounts Database supplies data on health expenditure and the WHO Global Atlas of Health Workforce supplies data on health workers. This study includes the following measures derived from the ADI database: GNI per capita based on purchasing power parity (PPP), government health expenditure per capita; physicians per 1,000 population, nurses and midwives per 1,000 and literacy rate for females aged 15 and older. The GNI based on PPP is preferred over other methods because it provides an international reference for amount of goods that can be purchased (World Bank, 2012b).

4.5.5 Study Sample

For each country, data from the most recent survey year were used. Included countries and survey year were Benin (2006), Burkina Faso (2010), Ghana (2008), Guinea (2006), Liberia (2007), Mali (2006), Nigeria (2008), Niger (2006), Senegal (2005), and Sierra Leone (2008). Across the ten countries, 135,096 women were surveyed. Women were included if they had given birth within three years of the DHS. Women were excluded from analysis if they had no recent birth (n=73,003), missing data on: literacy (n=675), receipt of any prenatal care (n=187), number of prenatal care visits (n=2,434), or timing of prenatal care visits (n=283). Additionally, two women were excluded because of missing marital status. All women had data on household wealth. The final analytic sample included 58,512 women who met inclusion criteria. Representation of each country in the final analytic sample was proportional to population size.

4.5.6 Measures

The primary outcome measure was adequate prenatal care, measured using the WHO recommendations of at least four prenatal care visits beginning in the first trimester, including at least one visit with a skilled provider. Women reported the number of prenatal care visits and the timing of their first prenatal care visit. Women also listed all persons from whom they received prenatal care. Skilled providers included doctors, nurses, midwives and auxiliary midwives. In addition to an overall measure of adequate prenatal care, I examined whether women received any prenatal care, prenatal care provider (doctor, nurse, midwife, traditional birth attendant, relative, or other), timing of prenatal care (first, second or third trimester), and recommended screenings or services

received (blood pressure, iron supplementation, urinalysis, blood test, tetanus immunization).

The primary exposure variables were national wealth measured using gross national income (GNI) per capita; health context measured using government health expenditure per capita, doctors per 1,000, nurses/midwives per 1,000 population; and educational attainment among women, measured using literacy rate among adult females aged 15 and older. Literacy and health expenditure data were obtained from the ADI database (World Bank, 2012b).

4.5.7 Ethical Considerations

Approval for this study was obtained from the University of North Carolina at Charlotte Institutional Review Board. MEASURE-DHS approved access to data sources. All study data were deidentified for public dissemination via the MEASURE-DHS website.

4.5.8 Statistical Analysis

Descriptive statistics including means and percentages were calculated for the entire sample. Bivariate comparisons between countries were conducted using chi-square tests for categorical variables. Log-linear models were used to examine the effect of health care context on rates of having any prenatal care and adequate prenatal care (Agresti, 2002). Random effect logistic regression models were estimated to determine the likelihood of having any prenatal care and adequate prenatal care after adjustment for confounding variables. Models adjusted for the following predisposing, enabling and need characteristics available for all countries: age, parity, marital status, literacy, rural/urban residence, religion, multiple birth, pregnancy wantedness, wealth quintile, and

involvement in decision-making at home. Sample weights were applied to descriptive analyses. The DHS includes normalized weights, which are calculated by dividing each weight by the sum of all weights. The resulting normalized weights therefore sum to the sample size rather than the population size (MEASURE DHS, 2012). Proportions calculated using these weights reflect those in the population. Analyses were conducted using SAS (version 9.2). All tests were two-sided. A significance level of alpha=0.05 was used to indicate statistical significance.

The goal of this analysis was to identify health context characteristics associated with patterns of prenatal care use in West Africa. The first hypothesis was that countries with greater investments in health would have higher national rates of pregnant women having any prenatal care, and of adequate prenatal care, compared to countries with lower investment. The following log-linear model tested this hypothesis for each health context characteristic.

(a) $\log(\mu_i/t_i) = \alpha + \beta x_i,$

where μ_i is the number of women receiving prenatal care in the i^{th} country, t_i is the number of eligible women in the i^{th} country and x_i is the value of the health context characteristic. The log-linear model is appropriate for this analysis because it allows one to model the effect of a set of predictors on a count variable with a Poisson distribution (number of women receiving prenatal care), where the count is observed for a specific index value (number of women with a birth during the study period) (Agresti, 2002).

The second hypothesis is that after adjusting for other demographic and reproductive characteristics, women residing in countries with greater investments in health will have a higher individual likelihood of having any prenatal care and of

adequate prenatal care, compared to women in countries with lower investment. The following random effect model examined whether measures of national wealth, density of health professionals and female literacy rates were associated with any prenatal care or adequate prenatal care after adjusting for other predisposing, enabling and need characteristics.

(b) $log\left(\frac{p_{ijk}}{1-p_{ijk}}\right) = \beta_{0k} + \beta_{1j} + \beta X_{ijk}$

where in separate models p_{ij} is the probability of having either any or adequate prenatal care for the i^{th} individual in the j^{th} region of the k^{th} country; β_{0k} is the random intercept associated with each country equal to $\beta_{0k}=\gamma_{00} + \gamma_{01}$(government health expenditure per capita) + γ_{02}(skilled providers per 1,000)+ γ_{03}(female literacy rate)+ $\mu_{0j;}$; μ_{0j} represents random variation among countries; β_{1j} is the random intercept for region within country; and X_{ijk} is the matrix of individual fixed effects. Multivariate models were assessed for multicollinearity using the variance inflation factor (VIF). VIF values less than 4 indicated that multicollinearity did not influence results of final models (Stine, 1995).

4.6 Results

4.6.1 Health Care Context in Ten West African Countries

As shown in Table 4.1, countries varied with regard to wealth, health expenditure, female literacy rates and nurse density. Per capita GNI ranged from $280 international dollars in Liberia to $1,990 international dollars in Nigeria. GNI per capita showed a strong positive correlation with government health expenditures per capita (rho=0.81, p=0.004), nurse density (rho=0.73, p=0.017), and physician density (rho=0.64, p=0.045) (results not shown). The literacy rate among women ranged from 15.1% in Niger to 60.4% in Ghana. Use of prenatal care also varied and was lowest in Niger where only

47.5% of respondents reported any prenatal care use. There were large differences in rates of any prenatal care and adequate prenatal care. In Niger, only 7.3% of respondents received adequate care.

4.6.2 Sample Characteristics by Country

There were notable variations in characteristics of women with a recent birth when examined by country (Table 4.2). Individual literacy was low and ranged from 7.6% in Guinea to 39.3% in Nigeria. In all countries, the sample included fewer women from the wealthiest quintile, which is consistent with the lower fertility rate among women in the higher wealth quintiles of these countries. The DHS assessed involvement in decision-making for married and cohabitating women. Nearly three quarters of women in Burkina Faso, Mali, and Niger were not involved in decision-making. This percentage was much lower in Ghana and Liberia where less than a third of women were not involved in making decisions. In Senegal and Niger, over 50% of women reported being unemployed. In contrast, in Burkina Faso, Sierra Leone and Guinea, over half of women were employed in agriculture. Most women lived in a rural area. The percentage of non-rural women was less than 20% in Burkina Faso and Niger.

4.6.3 Prenatal Care Characteristics by Country

Table 4.3 presents characteristics of prenatal care for women who reported at least one prenatal care visit. An overwhelming majority of women reported using a skilled health provider for prenatal care except for Mali, where the percentage was 51.4%. Mali also had the highest percentage of women using a traditional birth attendant (50.7%). However, in Mali, most traditional birth attendants had received some midwifery training (Samaké et al., 2007). Early prenatal care was high among women from Ghana, Liberia

and Senegal. Most women had a blood pressure screening, while blood sampling was less frequent. The percentage of women told about pregnancy complications ranged from 25.4% in Niger to 68.2% in Ghana. This finding might be related to higher literacy for the Ghana sample compared to Niger. Additionally, recent policies in Ghana reduced user fees for maternal health services (A. Mills et al., 2012); it is likely that these policies improved access to prenatal care.

Table 4.4 shows rates of two additional measures reported for women with and without prenatal care: iron supplementation and tetanus immunization. For all countries, women with at least one prenatal care visit were much more likely to receive these interventions than were women with no prenatal care. Iron supplementation was more common than having at least two tetanus shots prior to delivery. Results suggest few sources for recommended interventions outside of a prenatal care visit.

4.6.4 Prenatal Care Use by Contextual Factors

Figures 4.1 through 4.4 depict associations between prenatal care use and contextual factors at the country level: GNI per capita, government expenditure on health, female literacy rate, and health professional density, i.e. doctors, nurses and midwives per 1,000 population. GNI, health expenditure and health professional density showed no clear relationship with any prenatal care use or adequate prenatal care use. Female literacy rate showed strong linear correlation with adequate prenatal care use (rho=0.70, p=0.025) but not with the percentage of at least one prenatal care visit (rho=0.37, p=0.294) (data not shown in a table or figure).

4.6.5 Univariate Log-linear Models for Prenatal Care Rates

Unadjusted log-linear regression models showed significant associations between health context characteristics and rates of prenatal care in the ten countries examined (Table 4.5). Notably, a ten-point increase in the female literacy rate was associated with a 12% higher rate of adequate prenatal care (CI 1.10-1.13). Findings for physician and nurse density were not in the expected direction. An increase of one physician per 1,000 was associated with a 60% lower rate of any prenatal care (CI 0.37-0.42) and an 88% lower rate of adequate prenatal care (CI 0.10-0.13). The latter results may be due in part to the fact that Nigeria, which contributed the largest sample, had the highest density of health professionals and one of the lowest rates of prenatal care use. In models excluding Nigeria, an increase of one physician per 1,000 was associated with a 4.5 times higher rate of any prenatal care (rate ratio, RR, 4.54; CI 3.10-6.64) and a 65% lower rate of adequate prenatal care (RR 0.35; CI 0.18-0.69) (results not shown in a table). In similar models excluding Nigeria, an increase of one nurse per 1,000 was associated with a 39% higher rate of any prenatal care (RR 1.39; CI 1.35-1.44) and a 2.2 times higher rate of adequate prenatal care (RR, 2.23; CI 2.10-2.37) (results not shown in a table).

4.6.6 Multivariate Models for Receipt of Any Prenatal Care

Results of a random effects model for any prenatal care are shown in the left column of Table 4.6. Models adjusted for individual characteristics and examined the effect of three health context characteristics, female literacy rate, per capita government health expenditures, and the number of health professionals per 1,000. None of the health context variables were significant. In addition, variance estimates showed that the variation among countries was not statistically significantly different from zero.

However, significant regional variation was found within countries as evidenced by a variance estimate of 0.63 ($p<0.001$). For example, random effect estimates for the southeastern B region of Liberia showed significantly lower average odds of prenatal care compared to the rest of the country (Odds Ratio, OR 0.43, CI 0.20-0.88; results not shown in a table). Several individual characteristics remained significant including wealth and literacy, which were both positively associated with prenatal care use.

4.6.7 Multivariate Models for Receipt of Adequate Prenatal Care

The right column of Table 4.6 shows results of a similar random effects model examining association between adequate prenatal care use and literacy rate, health expenditure, and density of health care professionals. Models adjusted for individual age, parity, literacy, religion, wealth, rural residence, multiple birth, pregnancy wantedness, and involvement in decision-making. The literacy rate among women was significantly associated with adequate use of prenatal care. Each one-point increase in the literacy rate among women was associated with 4% higher odds of adequate use of prenatal care (OR 1.04; CI 1.01-1.08). Individual wealth and literacy remained significantly associated with adequate use of prenatal care. Women who were not literate had 30% lower odds of adequate prenatal care use (CI 0.66-0.74). Women in the poorest quintile had 69% lower odds of prenatal care use (CI 0.28-0.34) compared to women in the wealthiest quintile. Government health expenditure and health professional density were not significantly associated with adequate use of prenatal care.

4.7 Discussion

This study extended prior research by examining the contribution of government health care expenditures, literacy rate, and density of skilled health professionals on the

use of prenatal care in West Africa, using nationally representative samples from ten countries. Consistent with my expectation, the literacy rate among women was strongly associated with adequate prenatal care. Findings suggest that higher literacy rates among women may help to promote adequate prenatal care. This is consistent with a previous study of women in 21 sub-Saharan countries (Magadi et al., 2007). A new finding of the present study is that this relationship persists in a more current dataset, controlling for women's decision-making autonomy and wealth. This result also supports the framework for the eight Millennium Development Goals, which include achieving universal primary education and improving maternal health (Wall, 2012). In countries that have a higher literacy rate among women, women may also have greater autonomy and greater economic potential.

None of the health system characteristics were associated with receipt of prenatal care. This was an unexpected finding since previous studies suggested associations between national wealth and use of maternal health services (Kruk & Prescott, 2012; Magadi et al., 2007). The present study used government health expenditure per capita, which was highly correlated with GNI per capita. The smaller variation in government health expenditures in this sample of ten countries is one possible reason for the lack of significant association between government health expenditures and prenatal care use. This finding may also reflect the high percentage of women with "any prenatal care" in most of the countries examined. Nigeria, which had the largest population, highest government health expenditure per capita and highest density of health workers, was a poor performer with regard to prenatal care use. In models excluding Nigeria, an inverse relationship between physician density and adequate care remained; however, nurse

density was positively associated with adequate care. Findings in Nigeria could be related to unequal distribution of resources across regions (National Population Commission [Nigeria] & ICF Macro, 2009). Women who seek prenatal care from a doctor may also have a higher risk profile given the low density of physicians versus nurses in these countries.

Random effect models found notable regional variations within countries. Nigeria's National Population Commission (2009) reports that health care resources are more concentrated in the South than in the North. In Liberia, the capital Monrovia has the highest percentage of educated persons (LISGIS, 2008). Similarly, in Ghana, women in the Northern regions face greater socioeconomic disadvantage (GSS, 2009). It would be useful to address these regional socioeconomic disparities to help improve prenatal care.

Findings from this study should be viewed with a few limitations in mind. The cross-sectional design limits the ability to infer causality. Health system characteristics were determined using data available for the year closest to the survey. Maternal responses about prenatal care were collected at the same time as their background characteristics. Another limitation is that country-level factors were not available at a more granular level. It would be useful to include regional measures of health professional density. Data on maternal health spending were not available. Finally, results may not be generalizable to richer countries or regions outside of sub-Saharan Africa.

4.8 Implications for Policy, Practice and Research

Findings from this study suggest opportunities for country-specific and regional policies regarding prenatal care. First, it is imperative that countries acknowledge inequities in distribution of services and develop strategies to reduce them. This requires

local knowledge and involvement of stakeholders. For example, in Nigeria, federal-state partnerships supported the 2009 Midwives Services Scheme which addresses urban/rural disparities by deploying newly graduated and retired midwives into rural areas (Abimbola, Okoli, Olubajo, Abdullahi, & Pate, 2012; Okoli et al., 2012). It may be useful if strategies to increase access to schooling accompany efforts to increase availability of providers and access to health facilities. Free primary schooling is one potential mechanism for increasing literacy. Additional national policies supporting education of girls and boys may be beneficial.

Findings also suggest an opportunity for regional policies around maternal health. Countries in this region face similar challenges of low literacy rates, and regional disparities in access to care. These countries may therefore benefit from shared goals around maternal health. Results of the present study underscore the usefulness of enhancing the literacy rate among women as a way to improve use of prenatal care. It would be useful for organizations such as the Economic Community of West African States to highlight the relationship between the literacy rate among girls and women and overall levels of economic development to its member states. Notably, the Pan African Parliament recently adopted a resolution prioritizing maternal and child health programs (The Partnership, 2012). Similar resolutions on literacy should be adopted.

Future studies may benefit from collecting information about more specific measures of health system context at the level of region. Additionally, it may be useful to differentiate between all health spending and spending on maternal health. Research evaluating how changes in education policy for girls influence women's use of prenatal care would be a logical next step.

Fiscella et al. (2000) propose that disparities compromise quality of care. Overall statistics showing inadequate use of prenatal care in most countries are largely due to the health disparities. Countries need to improve the quality of maternity care for all their citizens by addressing these stark contrasts. One useful next step among poorer developing countries such as those in sub-Saharan Africa may be to focus resources on women in the most disadvantaged groups.

Table 4.1 Health care context and prenatal care use in ten West African countries

	Health care context[a]					Use of prenatal care[b]		
Country	GNI per capita, PPP (international $)	Physicians (per 1,000 people)	Nurses and midwives (per 1,000 people)	Government health expenditure per capita (US$)	Literacy rate (females aged ≥15)	Weighted N	Any prenatal care	Adequate prenatal care
Liberia	$280	0.01	0.27	$6	54.5	2,574	96.5%	48.9%
Niger	$640	0.02	0.23	$9	15.1	5,243	47.5%	7.3%
Sierra Leone	$770	0.02	0.17	$3	30.1	2,654	92.2%	25.3%
Guinea	$860	0.10	0.04	$2	18.1	3,346	82.4%	20.4%
Mali	$980	0.07	0.20	$15	18.2	7,301	70.9%	13.7%
Burkina Faso	$1,250	0.06	0.73	$23	21.6	8,222	95.7%	21.9%
Benin	$1,330	0.04	0.84	$14	29.1	8,082	89.4%	37.1%
Ghana	$1,490	0.11	0.98	$39	60.4	1,515	96.4%	48.9%
Senegal	$1,910	0.06	0.42	$33	38.7	5,152	95.7%	39.2%
Nigeria	$1,990	0.40	1.61	$27	49.8	13,076	59.3%	12.4%

[a]Data from the World Bank Africa Development Indicators database

[b]Data from DHS Surveys for Benin (2006), Burkina Faso (2010), Ghana (2008), Guinea (2006), Liberia (2007), Mali (2006), Nigeria (2008), Niger (2006), Senegal (2005), and Sierra Leone (2008). Counts and percentages are weighted using DHS-supplied weights, which are normalized to sum to the sample size rather than the population size. Resulting proportions reflect those in the population.

Table 4.2 Characteristics of women with recent birth in ten West African countries[a]

	Weighted %									
	Benin	Burkina Faso	Ghana	Guinea	Liberia	Mali	Niger	Nigeria	Senegal	Sierra Leone
Weighted N	8,082	8,222	1,515	3,346	2,574	7,301	5,243	13,076	5,938	2,654
Individual Literacy and Wealth										
Literacy										
Cannot read at all	81.0	86.1	67.2	92.4	65.8	89.3	91.6	60.7	74.2	84.3
Can read	19.0	13.9	32.8	7.6	34.2	10.7	8.4	39.3	25.8	15.7
Wealth Quintile										
1=Poorest	20.8	19.6	23.6	24.2	22.2	20.2	21.6	25.2	23.2	22.3
2=Poorer	20.0	21.4	22.5	21.9	22.3	20.3	19.6	23.2	22.3	21.5
3=Middle	20.9	22.1	19.4	21.3	21.7	20.9	19.5	18.2	19.3	22.6
4=Richer	20.9	21.2	20.1	18.2	21.3	20.8	20.6	17.1	19.3	18.7
5=Richest	17.4	15.7	14.3	14.4	12.4	17.9	18.7	16.2	15.9	15.0
Predisposing Characteristics										
Current age - respondent										
15-17	1.4	1.5	1.3	4.2	3.2	4.1	3.7	2.5	2.1	2.8
18-34	78.8	77.5	74.9	68.9	75.9	75.6	74.1	74.7	76.0	74.0
35-49	19.8	21.0	23.9	26.8	20.9	20.3	22.1	22.8	21.9	23.2

Table 4.2 (continued)

	Benin	Burkina Faso	Ghana	Guinea	Liberia	Mali	Niger	Nigeria	Senegal	Sierra Leone
Total children ever born										
1	18.4	17.6	22.8	17.0	23.7	16.6	15.0	18.2	22.1	19.6
2	18.9	17.9	22.2	15.7	19.4	15.8	14.4	17.2	18.4	19.9
3	16.6	16.0	17.3	15.0	16.0	14.0	12.8	15.4	15.3	16.2
4	13.9	12.9	14.0	13.5	11.4	12.8	13.4	13.2	12.1	13.9
≥5	32.3	35.6	23.7	38.8	29.4	40.8	44.4	36.1	32.1	30.4
Current marital status										
Not Married	12.5	6.6	31.4	8.4	53.7	5.8	2.5	6.4	6.9	25.3
Married	87.5	93.4	68.6	91.6	46.3	94.2	97.5	93.6	93.1	74.7
Religion										
Christian	43.5	26.8	71.7	9.8	85.3	2.6	0.5	40.8	3.1	18.6
Islam	21.4	63.8	18.9	85.8	9.9	91.5	98.3	57.1	96.2	79.7
Traditional Religion	19.2	8.1	5.1	1.9	0.7	1.7	0.0	1.5	0.6	0.2
Other or no religion	15.9	1.2	4.3	2.5	4.1	4.2	1.2	0.6	0.0	1.5
Enabling Characteristics										
Lives in rural area										
No	35.4	17.8	38.2	22.6	31.7	27.7	15.2	28.8	38.9	27.1
Yes	64.6	82.2	61.8	77.4	68.3	72.3	84.8	71.2	61.1	72.9

Table 4.2 (continued)

	Benin	Burkina Faso	Ghana	Guinea	Liberia	Mali	Niger	Nigeria	Senegal	Sierra Leone
Involved in decision-making										
No	42.8	72.2	22.2	47.1	21.3	76.0	72.2	53.6	63.4	38.2
Yes	57.1	24.9	66.9	52.9	53.8	23.9	27.7	41.5	30.4	48.7
Not assessed	0.1	3.0	11.0	0.0	25.0	0.1	0.1	4.8	6.3	13.1
Occupation										
Professional/Technical	1.2	0.8	2.2	0.7	0.9	0.4	0.6	2.9	0.1	2.0
Sales, clerical and services	42.3	20.1	43.8	26.7	21.8	19.8	17.8	36.5	28.0	23.1
Agricultural	34.8	53.0	33.0	53.9	43.2	35.1	20.1	17.1	12.9	53.8
Skilled/unskilled manual	7.6	7.4	9.2	5.4	1.1	7.2	7.6	11.1	3.4	1.3
Not working	13.7	18.2	11.3	13.3	32.7	36.2	53.9	31.9	55.6	19.2
Missing	0.5	0.5	0.5	0.0	0.3	1.3	0.0	0.5	0.0	0.6
Need Characteristics										
Multiple birth										
No	97.0	98.0	97.8	97.4	98.2	98.2	98.0	98.5	98.1	98.1
Yes	3.0	2.0	2.2	2.6	1.8	1.8	2.0	1.5	1.9	1.9
Wanted pregnancy										
Then	78.9	90.6	58.1	83.4	65.9	81.4	88.8	87.6	71.1	70.7
Later	16.7	7.9	25.1	12.1	29.3	14.5	10.2	6.7	24.3	16.4

Table 4.2 (continued)

	Benin	Burkina Faso	Ghana	Guinea	Liberia	Mali	Niger	Nigeria	Senegal	Sierra Leone
Did not want pregnancy	4.2	1.5	16.7	4.4	4.7	4.0	0.5	4.9	4.6	12.7
Missing	0.1	0.1	0.0	0.1	0.0	0.1	0.4	0.8	0.0	0.3

Source: Demographic and Health Survey

[a]Counts and percentages are weighted using DHS-supplied weights, which are normalized to sum to the sample size rather than the population size. Resulting proportions reflect those in the population.

Table 4.3 Provider, timing, and content of prenatal care for women using prenatal care during last pregnancy[a]

	Weighted %									
Characteristics	Benin 7,227	Burkina Faso 7,872	Ghana 1,461	Guinea 2,758	Liberia 2,485	Mali 5,179	Niger 2,488	Nigeria 7,758	Senegal 5,682	Sierra Leone 2,446
Skilled prenatal care provider	99.8	99.2	93.5	77.8	81.2	51.4	98.4	92.0	97.1	94.8
Providers for prenatal care										
Doctor	4.8	0.8	24.5	15.2	8.8	1.9	1.4	35.1	5.8	6.2
Nurse/midwife	92.5	33.8	80.9	51.7	73.8	49.8	97.5	65.1	93.0	60.2
Auxiliary midwife	17.1	66.2	6.1	19.8	0	0	0	11.1	0	33.8
Traditional birth attendant	0.2	0	1.1	2.5	20.2	50.7	1.8	4.8	0	7.8
Relative or other	0.1	0.8	9.0	25.9	3.9	0.2	0.1	4.8	0.2	3.2
Timing of first prenatal visit										
1st trimester	46.6	42.5	57.0	37.6	60.9	42.3	28.0	25.5	63.3	32.7
2nd trimester	44.0	52.2	40.4	51.8	33.1	44.9	56.5	62.0	31.6	59.5
3rd trimester	9.4	5.3	2.6	10.6	6.0	12.7	15.5	12.6	5.1	7.8
Number of prenatal visits										
1 to 3 visits	31.8	65.5	18.5	39.6	21.8	48.8	68.2	18.4	47.6	26.7
4 to 9 visits	63.7	34.5	71.1	57.9	72.0	50.6	31.7	50.4	52.2	59.2
10 or more visits	4.4	0.1	10.4	2.5	6.2	0.6	0.1	31.2	0.2	14.1

Table 4.3 (continued)

	Benin	Burkina Faso	Ghana	Guinea	Liberia	Mali	Niger	Nigeria	Senegal	Sierra Leone
Content of prenatal care										
Blood pressure	98.7	97.2	97.1	86.2	81.5	88.5	86.6	85.5	97.3	88.6
Urine sample	91.4	84.4	90.0	58.1	47.4	43.7	37.1	74.0	84.0	40.5
Blood sample	39.0	63.3	89.9	40.7	54.5	34.3	35.4	74.0	75.1	47.9
Told about pregnancy complications	37.7	52.6	68.2	26.9	39.3	28.8	25.4	62.3	44.5	62.8

Source: Demographic and Health Survey

[a]Counts and percentages are weighted using DHS-supplied weights, which are normalized to sum to the sample size rather than the population size. Resulting proportions reflect those in the population.

Table 4.4 Use of tetanus immunizations, and iron supplementation during pregnancy by country of residence[a]

		At least 2 tetanus shots prior delivery		Took iron supplements during pregnancy	
Country	Weighted N	No prenatal care	Prenatal care	No prenatal care	Prenatal care
Benin	8,082	2.5%	63.2%	5.8%	96.7%
Burkina Faso	8,222	3.1%	73.9%	3.7%	97.3%
Ghana	1,515	5.4%	58.5%	26.7%	88.9%
Guinea	3,346	1.5%	78.2%	1.6%	89.9%
Liberia	2,574	19.7%	79.5%	32.3%	90.8%
Mali	7,301	12.5%	63.5%	9.0%	82.9%
Niger	5,243	4.2%	44.5%	9.5%	84.5%
Nigeria	13,076	3.4%	70.2%	7.9%	83.0%
Senegal	5,938	4.3%	60.4%	8.1%	97.5%
Sierra Leone	2,654	3.5%	19.4%	82.7%	85.5%

Source: Demographic and Health Survey

[a]Counts and percentages are weighted using DHS-supplied weights, which are normalized to sum to the sample size rather than the population size. Resulting proportions reflect those in the population.

Table 4.5 Results of unadjusted log-linear models examining association between contextual factors and rates of any and adequate prenatal care use

	Any prenatal care		Adequate prenatal care	
	Rate Ratio (95% CI)	p-value	Rate Ratio (95% CI)	p-value
Percent literate (females aged 15 and older)[a]	1.00 (0.99-1.00)	0.146	1.12 (1.10-1.13)	<.001
GNI per capita, PPP (international $) [a]	1.00 (1.00-1.00)	<.001	1.00 (1.00-1.00)	0.004
Government health expenditure per capita (US$) [a]	1.01 (1.00-1.02)	0.011	1.05 (1.04-1.07)	<.001
Physicians (per 1,000 people)	0.40 (0.37-0.42)	<.001	0.12 (0.10-0.13)	<.001
Nurses and midwives (per 1,000 people)	0.87 (0.86-0.89)	<.001	0.81 (0.79-0.84)	<.001

[a]Rate ratio associated with a 10-unit increase in the value of the specified measure.

GNI, gross national income; PPP, purchasing power parity

Table 4.6 Random effect model examining association of country literacy rate and wealth with adequate prenatal care

	Any prenatal care		Adequate prenatal care	
	OR (95% CI)	p	OR (95% CI)	p
Exposure Variables				
Adult female literacy rate	1.03 (0.95-1.12)	0.364	1.04 (1.01-1.08)	0.029
Government health expenditure per capita	1.04 (0.93-1.17)	0.411	1.02 (0.96-1.07)	0.497
Health professionals (per 1,000)	0.25 (0.02-3.11)	0.227	0.36 (0.11-1.16)	0.076
Individual Literacy and Wealth				
Not literate	0.31 (0.29-0.35)	<.001	0.70 (0.66-0.74)	<.001
Wealth Quintile (ref=5)				
1=Poorest	0.12 (0.10-0.14)	<.001	0.31 (0.28-0.34)	<.001
2=Poorer	0.19 (0.16-0.22)	<.001	0.38 (0.35-0.42)	<.001
3=Middle	0.25 (0.22-0.29)	<.001	0.50 (0.46-0.55)	<.001
4=Rich	0.38 (0.33-0.44)	<.001	0.66 (0.61-0.71)	<.001
Predisposing Characteristics				
Age (ref=18-34)				
Age 15 to 17	0.85 (0.73-0.98)	0.030	0.64 (0.55-0.75)	<.001
Age 35 to 49	1.03 (0.96-1.10)	0.484	1.09 (1.03-1.17)	0.006
Parity (ref=≥5)				
Parity=1	1.32 (1.21-1.45)	<.001	1.55 (1.44-1.67)	<.001
Parity=2	1.08 (0.99-1.17)	0.083	1.38 (1.28-1.48)	<.001
Parity=3	1.07 (0.99-1.16)	0.104	1.24 (1.15-1.33)	<.001
Parity=4	1.10 (1.01-1.20)	0.025	1.14 (1.06-1.23)	<.001
Married	1.14 (1.00-1.31)	0.054	1.00 (0.92-1.09)	0.994
Religion (ref=Islam)			0.89 (0.84-0.94)	<.001
Christian	1.75 (1.59-1.93)	<.001		
Traditional religion	0.77 (0.67-0.90)	<.001	1.17 (1.09-1.25)	<.001
Other or no religion	1.07 (0.91-1.24)	0.426	0.87 (0.77-0.98)	0.021
Need Characteristics				
Multiple birth	1.33 (1.10-1.62)	0.003	1.38 (1.20-1.59)	<.001

Table 4.6 (continued)

	Any prenatal care		Adequate prenatal care	
	OR (95% CI)	p	OR (95% CI)	p
Pregnancy wantedness (ref=wanted pregnancy then)				
Wanted pregnancy later	1.02 (0.94-1.11)	0.633	0.84 (0.79-0.90)	<.001
Did not want pregnancy	0.83 (0.72-0.95)	0.009	0.73 (0.66-0.82)	<.001
Unknown	0.59 (0.39-0.90)	0.015	0.64 (0.34-1.20)	0.165
Enabling Characteristics				
Lives in rural area	0.55 (0.50-0.59)	<.001	0.86 (0.76-0.98)	0.024
Involved in decisions (ref=No)				
Yes	1.20 (1.13-1.27)	<.001	1.06 (1.01-1.12)	0.012
Unknown	0.83 (0.68-1.01)	0.066	0.78 (0.69-0.89)	<.001
Occupation (ref=Agricultural)				
Professional/Technical	1.59 (1.03-2.43)	0.035	1.64 (1.38-1.95)	<.001
Sales, clerical and services	1.38 (1.27-1.49)	<.001	1.16 (1.09-1.23)	<.001
Skilled/Unskilled manual	1.26 (1.13-1.41)	<.001	1.12 (1.02-1.24)	0.018
Not working	1.00 (0.94-1.08)	0.902	0.97 (0.90-1.03)	0.298
Unknown working status	1.16 (0.80-1.68)	0.446	1.29 (0.96-1.73)	0.093
Variance Estimates (SE)				
Country	1.68 (1.01)	0.098	0.35 (0.22)	0.104
Region (Country)	0.63 (0.11)	<.001	0.20 (0.03)	<.001

CI, confidence interval; OR, odds ratio; SE, standard error

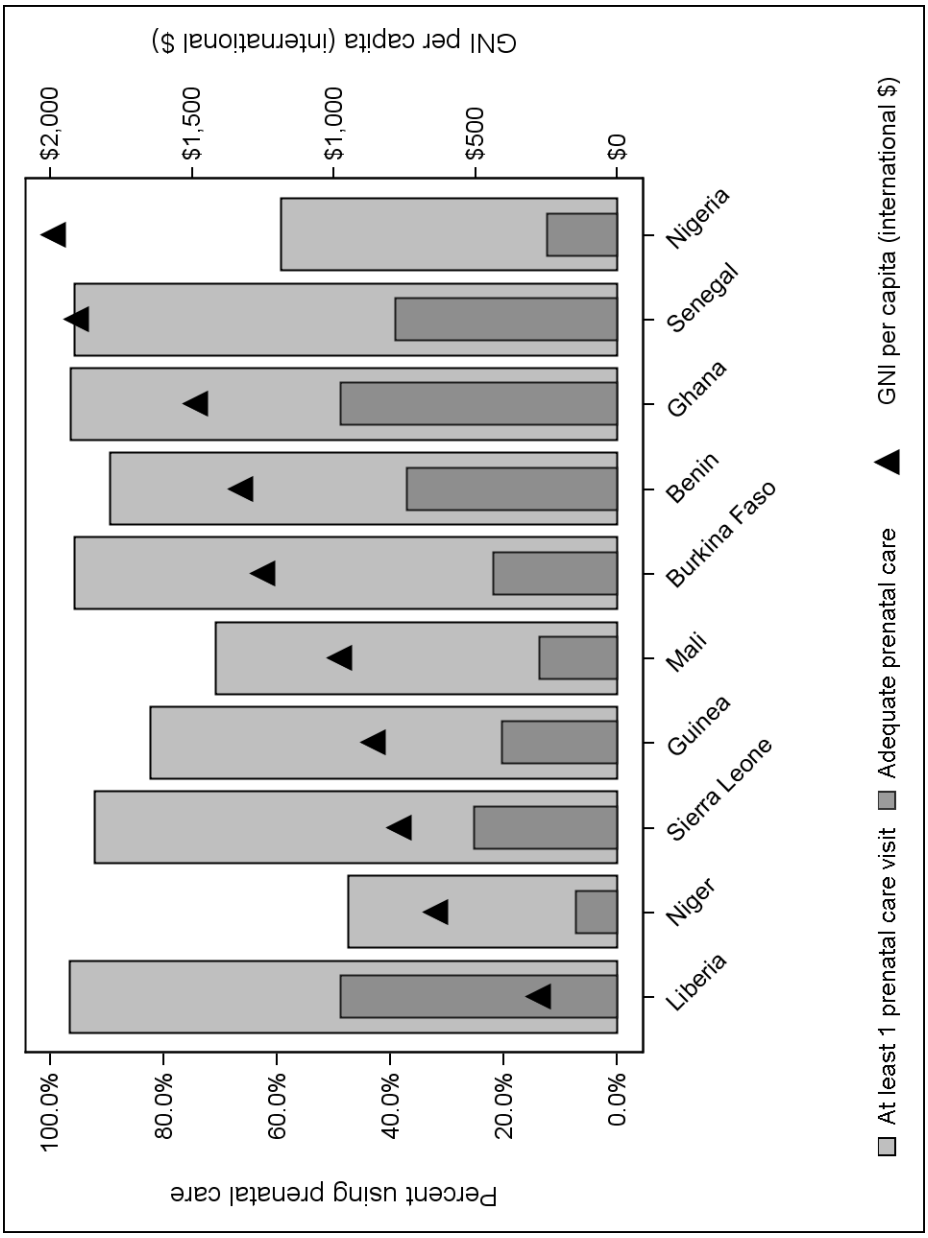

Figure 4.1 Prenatal care use among women with recent birth by gross national income (GNI) per capita, DHS

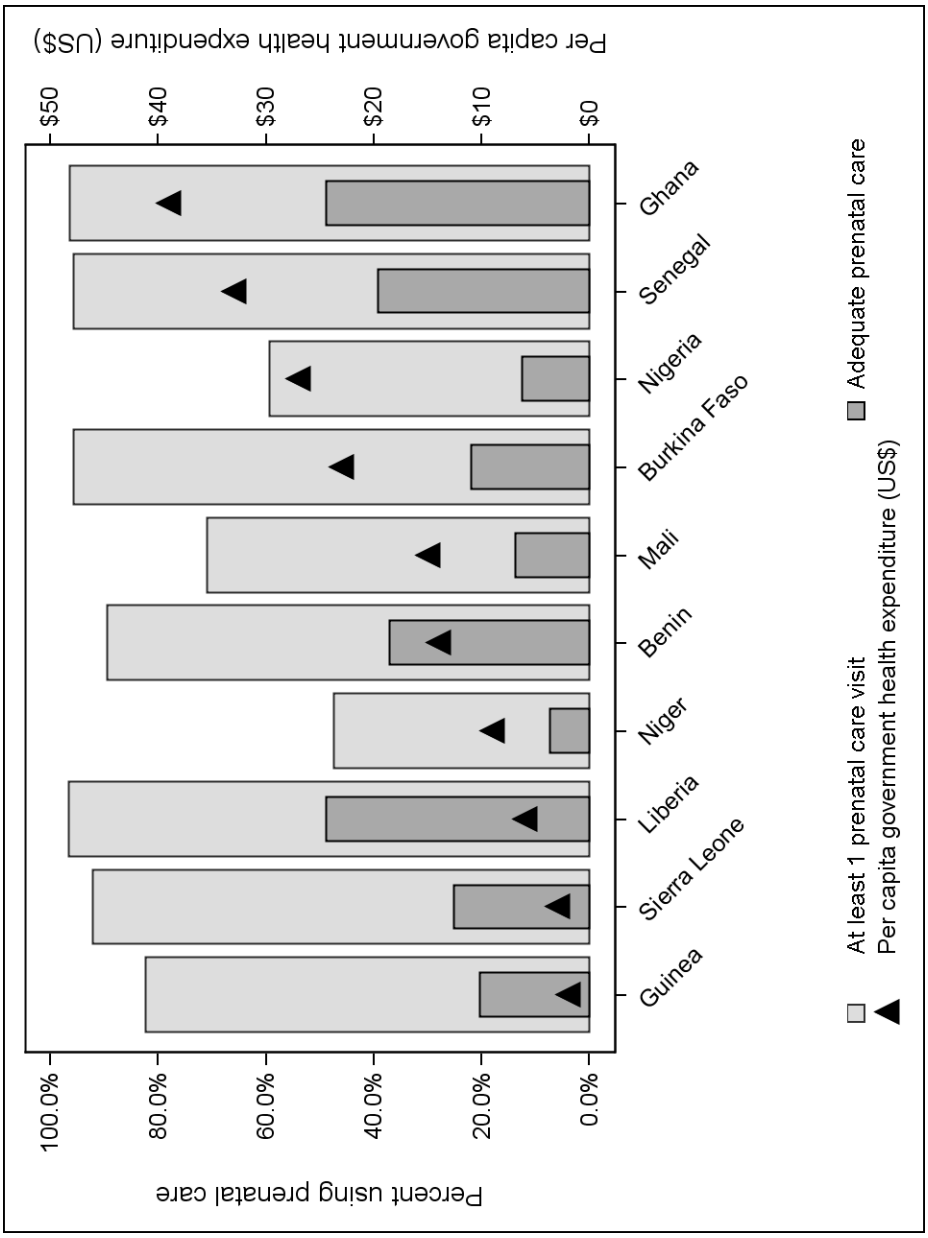

Figure 4.2 Prenatal care use among women with recent birth by government health expenditure per capita

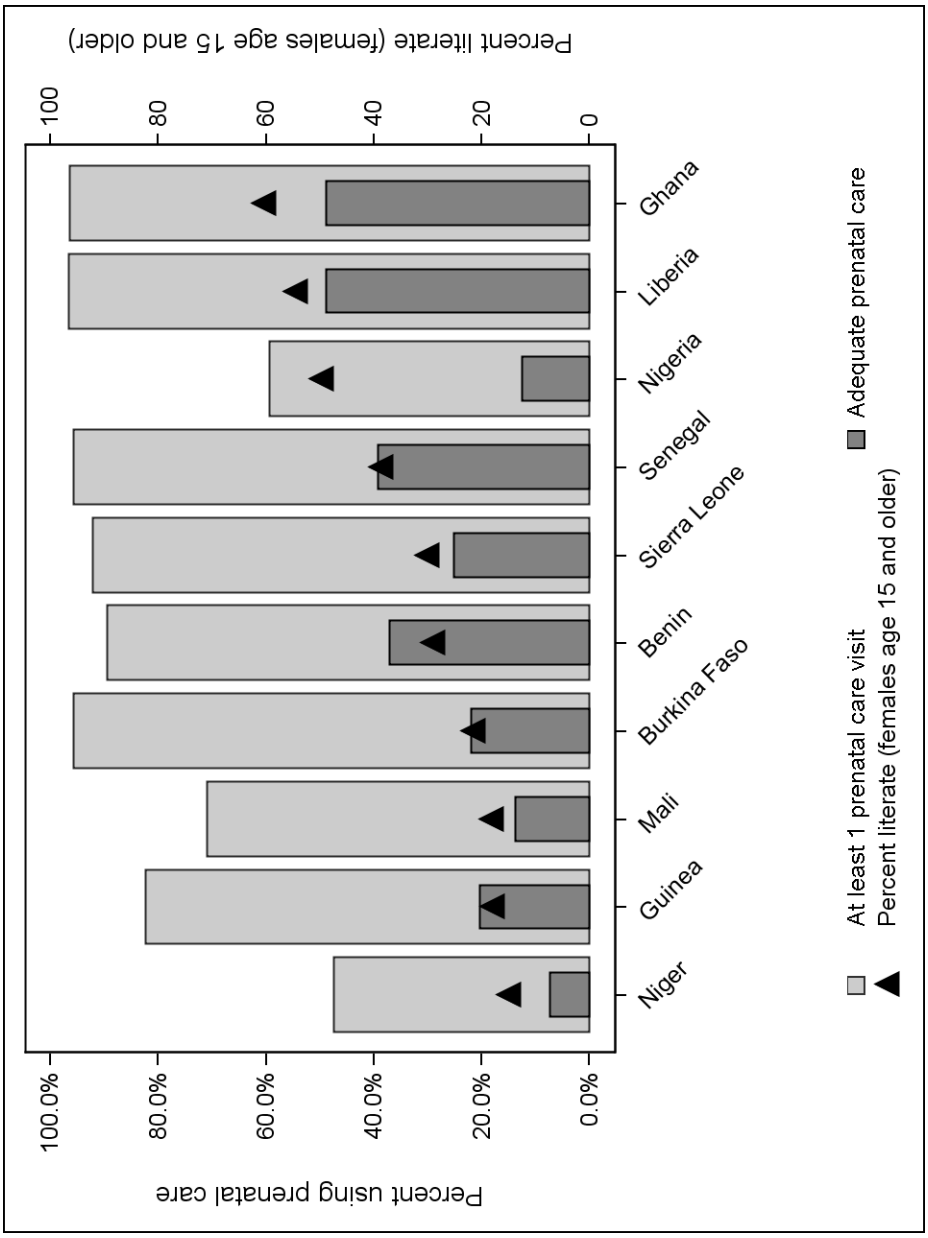

Figure 4.3 Prenatal care use among women with recent birth by adult female literacy rates

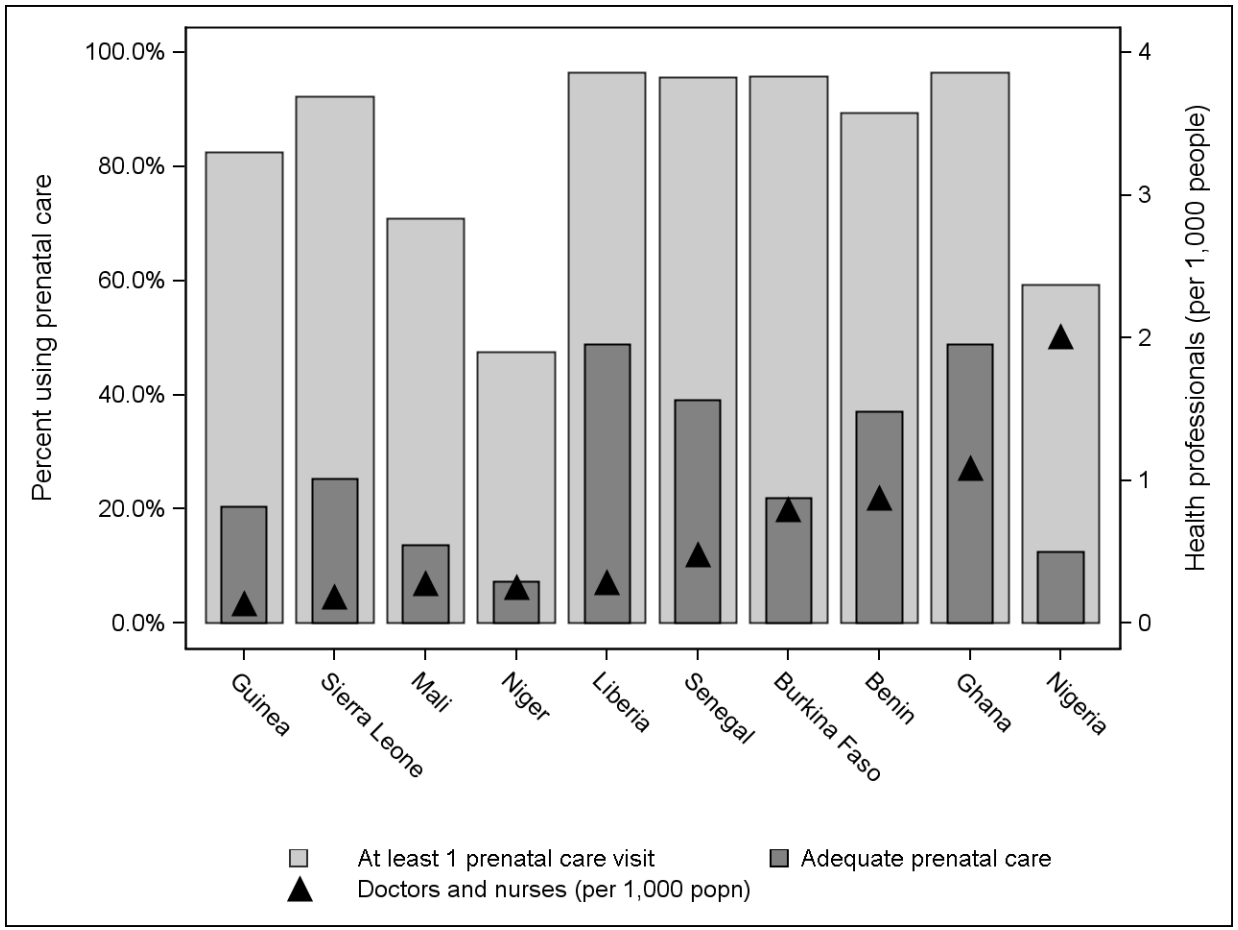

Figure 4.4 Prenatal care use among women with recent birth by health professional density. Health professionals include doctors, nurses and midwives

CHAPTER 5: ASSOCIATIONS BETWEEN ADEQUATE PRENATAL CARE AND INFANT MORTALITY IN WEST AFRICA: EVIDENCE FROM THE DEMOGRAPHIC AND HEALTH SURVEYS

5.1 Introduction

Despite overall improvements in health, and initiatives such as the Millennium Development Goals, global disparities in maternal and infant health are stark and are a cause for great concern. Many developing nations, especially those in sub-Saharan Africa, face markedly high rates of poor outcomes. In recent years, maternal mortality rates per 100,000 live births ranged from 60 in Mauritius to 1,100 in Chad; most sub-Saharan countries reported a maternal mortality rate of 250 or higher (WHO, 2012b). Similarly, infant mortality per 1,000 live births ranged from 12 in Seychelles to 119 in Sierra Leone, with a median value of 58 (WHO, 2012b). Maternal and infant deaths reflect the quality of health care systems. Maternal and infant mortality also have adverse economic impacts on society and population health. The need for interventions to improve these outcomes is great.

Research exploring the causes of maternal and infant deaths suggests many preventable causes and opportunities for improving care. Leading causes of maternal death in Africa are hemorrhage, hypertensive disorders, infections and abortion, which together account for approximately 60% of all deaths (Khan, Wojdyla, Say, Gülmezoglu, & Van Look, 2006). Hemorrhage is the single leading cause of maternal mortality, accounting for more than 30% of maternal deaths (Khan et al., 2006). Leading causes of

mortality among children under five include diarrhea, pneumonia, malaria and preterm birth complications. Together, these causes accounted for 61% of all child deaths in Africa in 2008 (Black et al., 2008). The lack of skilled health workers is a major challenge to reducing deaths resulting from pregnancy complications (Kinney et al., 2010). Additionally, economic disadvantage and factors such as under-nutrition and poor sanitation increase the risk of poor outcomes (Kinney et al., 2010) .

Prenatal care can help reduce maternal and infant morbidity and mortality by addressing risk factors for adverse outcomes. Prenatal care also provides an opportunity to provide health education that may increase use of early childhood immunizations and disease prevention measures (Choi & Lee, 2006; Kogan et al., 1998). One study of the 17 least developed countries in sub-Saharan Africa found that having prenatal care by a skilled provider reduced the odds of neonatal mortality by 30% (McCurdy et al., 2011). Previous research in Nigeria also found that maternal education and levels of community use of prenatal care interact to influence under-five mortality (Antai, 2011).

This study extends previous research by examining the association between prenatal care use and infant mortality in West Africa. This study also examines whether use of prenatal care moderates wealth disparities in infant mortality. Findings can help to inform policies for improving outcomes of care and to provide empirical support for programs that seek to reduce adverse outcomes for women in sub-Saharan Africa by improving access to prenatal care.

5.2 Literature Review

Preterm birth, pneumonia, diarrhea and malaria account for half of under-five deaths worldwide (Liu et al., 2012). In 2010, 3.6 million of the 7.6 million child deaths worldwide were in Africa where preterm birth, pneumonia, diarrhea, and malaria account for 54% of under-five deaths (Liu et al., 2012). Deaths due to measles, AIDS and tetanus are rapidly declining; however, studies indicate smaller reductions in complications associated with preterm birth (Liu et al., 2012). Strategies to address infant mortality include a continuum of care beginning with family planning, prenatal care and skilled delivery, and continuing with adequate postnatal care, newborn care, and immunizations (Kinney et al., 2009; Lawn et al., 2006). Mechanisms through which prenatal care may help reduce infant mortality include early identification of complications, tetanus immunizations, establishing a birth plan that includes skilled delivery, education on postnatal care and treatment for malnutrition, and sexually transmitted infections (Bhutta et al., 2005; Lincetto et al., 2006). Interventions and education provided during prenatal care can also set the stage for continued healthy behaviors and outcomes (Lawn et al., 2006). International studies suggest an inverse relationship between prenatal care and infant mortality.

5.2.1 Cohort Studies of Prenatal Care and Infant Mortality

Using a cohort of 28.7 million U.S. births, Partridge et al. (2012) found that the odds of infant death increased with decreasing adequacy of prenatal care, as defined by the adequacy of prenatal care utilization (APNCU) index (Kotelchuck, 1994). Inadequate care was associated with 79% greater odds of infant mortality compared to adequate care. Maternal factors associated with greater risk of infant mortality were younger age,

minority race, and less than high school education. These results were confirmed by another study of U.S. births by Chen et al. (2007) who used data from births occurring between 1995 and 2005 and found that inadequate prenatal care was associated with higher neonatal mortality regardless of the mother's risk group.

Song (2011) analyzed nationally representative data from a 2001 survey of Chinese women aged 15 to 49 and found that the odds of infant mortality were lower for women with more education, due to their better use of prenatal care and skilled delivery. Among older women with less education, only 22% used prenatal care. Among younger women with more years of education, 77% used prenatal care. In models adjusted for urban residence, child's gender, age at childbirth, birth order, ethnicity, maternal education, and skilled delivery, prenatal care was associated with 33% to 72% lower odds of infant mortality. Song used efficacy as a conceptual framework to describe how women with more education were able to access and use needed maternal health services throughout the period from 1970 to 2001.

McCurdy et al. (2011) used logistic regression to assess the association between prenatal care by a skilled provider and neonatal mortality. Data from 89,655 women aged 15 to 49 in the 17 least developed countries in sub-Saharan Africa showed that prenatal care by a skilled provider was associated with 30% lower odds of neonatal death. Results suggested no association between maternal education or wealth and neonatal mortality; however, both were associated with having a skilled provider for prenatal care.

A prospective study by Diallo et al. (2011) found no significant association between having at least one prenatal care visit and neonatal mortality among a cohort of 864 pregnant women in Burkina Faso. Factors associated with neonatal mortality in

unadjusted logistic regression models were parity, living in a polygamous household, twin birth, and having a skilled birth attendant. When entered into multivariable logistic regression models, all factors remained significant except skilled birth. Findings in this study were limited by the small sample size and small number of deaths (n=40).

Prenatal care may also benefit women with HIV, as evidenced in study by Hong (2008). Analyses examined associations between maternal HIV infection and infant mortality using data for 2,618 births to women selected for HIV testing as part of the 2004 Malawi Demographic and Health Survey (DHS). The infant mortality rate per 1,000 live births was 46.2 for women with at least one prenatal care visit compared to 126.4 for women who did not receive prenatal care. Having no prenatal care was associated with 2.3 times greater risk of infant mortality compared with at least one prenatal care visit. Proportional hazards regression models were adjusted for HIV status, gender, birth order, birth weight, delivery by a health professional, marital status, household wealth, safe drinking water, toilet facilities, type of cooking fuel, urban/rural residence, geographic region, maternal age, body mass index, working status and years of schooling. In addition to HIV status, birth weight, child's gender, maternal age and urban/rural residence remained significantly associated with infant mortality in adjusted models. Findings were similar in analyses of 3,389 births in the 2003 Ghana DHS (Hong et al., 2007). In adjusted proportional hazards models, having no prenatal care was associated with 1.7 times greater risk of infant mortality; maternal HIV status; birth weight, and type of cooking fuel used in the household remained significantly associated with infant mortality (Hong et al., 2007).

5.2.2 Ecological Studies of Prenatal Care and Infant Mortality

Volpe et al. (2009) used an ecological study design to examine associations between health resources and infant mortality rates in Brazil from 2000 to 2005. Changes in infant mortality rates for 27 states were evaluated against measures of public health expenditure, water supply, prenatal care utilization, cesarean delivery rate, and hospital delivery rate. In multiple regression analysis, a 1% increase in prenatal care coverage was associated with a 0.89 decrease in infant mortality per 1,000 live births, while a 1% increase in the public health expenditure as a percent of gross domestic product was associated with a 0.72 decrease.

Findings from an in-depth case study of Niger suggest similar benefits of prenatal care coverage (Amouzou et al., 2012). The authors examined how recent interventions in Niger, including free health care for all pregnant women and children beginning in 2006, might have contributed to reductions in child mortality (Amouzou et al., 2012). Mortality among children under five years old declined from 226 deaths per 1,000 live births in 1998 to 128 deaths per 1,000 live births in 2009. During the same period, the percentage of women with at least one prenatal care visit increased from 40% to 81%; the percentage of women with at least four prenatal care visits increased from 10% to 26%. Other services increased significantly during the period: vaccinations for tetanus, diphtheria, and measles; supplemental vitamin A for children; and use of insecticide-treated bed nets. However, there were no significant decreases in neonatal mortality. Policy changes, aided by government support, increased access to care by building community health centers in rural areas.

5.2.3 Randomized Controlled Trials of Prenatal Care

Because prenatal care is widely recognized as beneficial, no experimental studies have assessed the impact of prenatal care versus no care. However, researchers have examined the effect of standard models of care with 12 or more visits to a model with fewer recommended visits. Randomized trials (Majoko et al., 2007; Villar et al., 2001) and a meta-analysis of seven randomized controlled trials (Carroli, Villar, et al., 2001) conducted in developing countries compared schedules with four to five prenatal care visits to a standard schedule, of at least 9 visits, and found no difference in risk of fetal or neonatal mortality. Results from these trials suggest that prenatal care can be delivered in fewer focused visits without adversely affecting maternal and infant outcomes. These findings also support the World Health Organization (WHO) recommendations of at least four prenatal care visits for women with normal pregnancies (WHO, 1999).

5.3 Study Objectives and Hypotheses

This study examined the association between having any prenatal care, or having adequate prenatal care, and infant mortality among women in West Africa. The primary hypothesis was that after adjusting for a number of demographic and reproductive characteristics, associations between prenatal care and infant mortality would remain; however, the magnitude of the association would be greatest for women in the wealthiest quintile.

5.4 Conceptual Framework

Andersen's behavioral model of health services use (Andersen & Davidson, 2007b; Andersen, 1995) provides a framework for examining the relationship between use of health services and health outcomes for women in sub-Saharan Africa. The model

proposes a feedback loop in which both contextual and individual characteristics influence health behaviors and subsequent health outcomes. In the vocabulary of the model, these characteristics are grouped into three domains: predisposing, enabling and need. Predisposing characteristics include inherent factors such as gender and age. Enabling factors include resources such as income, poverty, transportation and the availability of health care providers. Finally, the need domain includes measures of perceived and evaluated health.

Figure 5.1 shows the hypothesized relationship between maternal predisposing, enabling, and need characteristics, adequate use of prenatal care, and infant mortality. Women who are wealthier, literate and living in urban areas are expected to have higher rates of adequate prenatal care. Higher wealth, literacy and urban residence are also associated with lower infant mortality. Prenatal care provides an opportunity for interventions that may reduce neonatal mortality (McCurdy et al., 2011). Education received during prenatal care may also influence infant mortality by improving use of childhood immunizations (Choi & Lee, 2006) and by improving future health care seeking behavior (Lincetto et al., 2006).

5.5 Study Design and Methods

5.5.1 Study Design

This study includes women who reported a live birth within three years of participation in the DHS for ten West African Countries. Each woman self-reported on use of prenatal care, and for children who were not alive, age at death.

5.5.2 Setting

The West African region includes some of the poorest countries in sub-Saharan Africa and has poorer maternal health statistics than East and Southern Africa (UNICEF, 2011). West Africa is also home to the regional West African Health Organization (WAHO). The WAHO serves member states of the Economic Community of West African States (ECOWAS) by promoting strategies to address pertinent health issues ("West African Health Organization," n.d.). This study uses data from ten of sixteen countries in West Africa based on the availability of data collected in 2003 or later. Data included in this study are from the most recent DHS for each included country.

5.5.3 Overview of the Demographic and Health Surveys

The DHS is a nationally representative household survey conducted in over 90 developing countries. The DHS seeks to assist governments in collecting data on health and nutrition, with a specific focus on maternal and child health and diseases such as HIV/AIDS and malaria (www.measuredhs.com). Data collection is conducted by local agencies and trained local interviewers. A U.S.-based organization, ICF International (previously Macro International), provides technical assistance, including standardized questionnaires and training manuals. The DHS uses a stratified two-stage cluster design, in which clusters are determined by enumeration areas from census files. The standard DHS survey includes questionnaires for households, women, and men. Data for this study come from the household questionnaire and the women's questionnaire. Topics covered in the women's questionnaire include basic demographics, reproductive history, contraceptive use, prenatal, delivery, and postnatal care, child immunization and nutrition, marriage and sexuality, fertility, employment, HIV/AIDS and issues related to

health care access (ICF International, 2011). The household questionnaire lists household members, and household characteristics and assets (ICF International, 2011). Surveys include country-specific questions and responses as well as standardized questions that allow comparison between countries (Rutstein & Rojas, 2006).

5.5.4 Study Sample

Included countries and survey year were Benin (2006), Burkina Faso (2010), Ghana (2008), Guinea (2006), Liberia (2007), Mali (2006), Nigeria (2008), Niger (2006), Senegal (2010), and Sierra Leone (2008). The response rate ranged from 92.7% for Senegal to 99.0% for Burkina Faso. Across the ten countries, 135,096 women were surveyed. Women were included if they had given birth within three years of the DHS survey (n=62,093). Data on prenatal care use were available only for the most recent birth for each respondent. Mother-child pairs were excluded from the analysis if child was a twin or other multiple (n=1,286) or if mothers had missing data for the following variables: literacy (n=658), receipt of any prenatal care (n=170), number of prenatal care visits (n=2,374) or timing of prenatal care visits (n=281). Additionally, two women were excluded because of missing marital status. The final analytic sample represented 57,322 mother-child pairs.

5.5.5 Measures

The primary outcome measure was infant death based on self-report of an infant death before age one. For each child mentioned during the interview, women were asked whether the child was still alive. For children who had died, women were asked to indicate how old the child was at death. Only responses for the most recent birth (one child per respondent) were analyzed.

The primary exposure variable was adequate prenatal care, measured using the WHO recommendation of having at least four prenatal care visits, beginning in the first trimester, and at least one visit with a skilled provider. Women reported the number of prenatal care visits and the timing of their first prenatal care visit. Women also listed all persons from whom they received prenatal care. Skilled providers included doctors, nurses, midwives and auxiliary midwives.

Individual wealth quintile (1=poorest, 2=poorer, 3=middle, 4=wealthy, 5=wealthiest) and literacy (cannot read vs. can read) were included as covariates. Additional potential confounding variables were examined consistent with Andersen's behavioral model of health service use. Predisposing characteristics examined included maternal age, education, parity (1, 2, 3, 4 or ≥5), marital status (married vs. not married), religion (Christian, Islam, traditional religion, other or no religion) and infant's sex. Enabling characteristics examined included occupation (agricultural, professional, sales, manual or not working) and involvement in decision-making about own health care or large household purchases (yes or no). Need characteristics included body mass index (BMI), cesarean delivery and pregnancy wantedness. BMI was grouped into four categories based on the WHO definitions of underweight (<18.50), normal weight (18.50-24.99), overweight (25.00-29.99) and obese (≥30) (WHO, 2000). Type of provider for delivery (doctor, nurse, midwife, auxiliary midwife, traditional birth attendant, relative/other, no one) was included as a measure of health service use and as a factor that may affect the relationship between prenatal care use and infant mortality.

5.5.6 Ethical Considerations

Approval for this study was obtained from the University of North Carolina at Charlotte Institutional Review Board. MEASURE-DHS approved access to data sources. All study data were deidentified for public dissemination via the MEASURE-DHS website.

5.5.7 Statistical Analysis

Descriptive statistics included means and percentages and were calculated for the entire sample. Bivariate comparisons between groups were conducted using t-tests for continuous variables and chi-square tests for categorical variables. Multivariate proportional hazards regression models estimated the risk of infant death adjusting for confounding variables. Models adjusted for the following predisposing, enabling and need characteristics, which were available for all countries: age, parity, marital status, rural/urban residence, religion, infant's sex, pregnancy wantedness, cesarean delivery, and involvement in decision-making at home. Skilled birth attendance was an additional confounding variable. Sample weights were applied to all analyses. The DHS included normalized weights, which were calculated by dividing each weight by the sum of all weights. The resulting normalized weights therefore sum to the sample size rather than the population size (MEASURE DHS, 2012). Proportions calculated using these weights reflect those in the population. Analyses were conducted using SAS (version 9.2). All tests were two-sided. A significance level of alpha=0.05 was used to indicate statistical significance.

5.6 Results

5.6.1 Sample Characteristics

Table 5.1 shows the distribution of sample characteristics for the overall sample, women whose youngest child did not die before age one and women who did have their youngest child die before age one (infant death). The weighted sample consisted of 56,779 women. The percentage of women who received at least one prenatal visit from any provider was 78.2%, and 23.2% received adequate care. Only 4.4% of women had delivery assistance from a doctor, while 35.5% had delivery assistance from a nurse or midwife; 9.7% had no delivery assistance.

Mothers of infants who died were less likely to receive any prenatal care and less likely to receive adequate care than mothers of infants alive at age one. Mothers of infants who died were also poorer and less educated. Women in the two groups did not differ with regard to involvement in decision-making, marital status or religion.

5.6.2 Wealth and Infant Mortality

As shown in Figure 5.2 there was a significant wealth gradient in unadjusted risk of infant mortality ($p<0.001$). At 11 months, the probability of survival was 94.9% for infants born to women in the poorest quintile and 96.4% for infants of women in the wealthiest quintile. As shown in Figure 5.3, differences in survival persisted among women with adequate prenatal care ($p<0.001$), but were not significant for women with inadequate or no prenatal care ($p=0.053$). However, for all groups except the poorest quintile, risk of infant mortality was higher among women with inadequate or no care, compared to women with adequate care.

5.6.3 Unadjusted Hazard Ratios

Table 5.2 shows unadjusted hazard ratios for associations between the exposure variables, wealth and prenatal care use, and the outcome, infant death. Results indicate that women in the poorest quintile had 53% greater risk of infant mortality (CI 1.33-1.76) compared to women in the wealthiest quintile. Women who received any prenatal care had 32% lower risk of infant death (CI 0.62-0.75) compared to women without prenatal care. Differences were of a smaller magnitude (hazard ratio, HR 0.78, CI 0.71-0.87) for women who received adequate prenatal care compared to women with inadequate or no care.

5.6.4 Multivariate Models for Infant Mortality

The left column of Table 5.3 provides results of multivariate logistic regression models examining associations between having any prenatal care, wealth and infant mortality. Models included age, parity, marital status, religion, involvement in decision-making, occupation, multiple birth, pregnancy wantedness, delivery provider, and rural residence as confounders. Binary variables indicating region of residence (e.g. Northern Liberia) were included as fixed effects. Significant interactions were found between wealth and prenatal care. Thus, results are presented for the effect of prenatal care by wealth quintile. Results showed that risk of infant death was 56% lower for infants of women in the wealthiest quintile who received any prenatal care (CI 0.28-0.69) compared to women in the wealthiest quintile who received no prenatal care. Prenatal care was significantly associated with infant death among women in the four highest quintiles, but not for women in the poorest quintile. An unexpected finding was that women who received delivery assistance from a doctor had 53% greater risk of infant mortality (CI

1.24-1.89) compared to women who saw a nurse or midwife. This finding suggests a greater risk profile among women who seek delivery assistance from a doctor. Younger age and being primiparous were additional factors associated with infant mortality. Women who could not read had 18% greater risk of infant mortality.

The right column of Table 5.3 provides results of proportional hazards regression models examining associations between having adequate prenatal care, wealth and infant mortality. This model was constructed in the same way as previously described for the model with having any prenatal care as the exposure variable. Significant interactions were found between adequate prenatal care and wealth quintiles. Therefore, estimates for adequate prenatal care are reported by wealth quintile. Results indicated that among women in the wealthiest quintile, those with adequate prenatal care had 34% lower risk of infant death (CI 0.51-0.85) compared to women with inadequate or no care. The effect of having adequate prenatal care on infant death was not significant for women in all other wealth quintiles; this result remained the same using different groupings of wealth (data not shown). Women who could not read had 21% higher risk of infant mortality (CI 1.06-1.38) in adjusted models.

5.7 Discussion

This study examined associations between prenatal care use, wealth and infant mortality in a sample of women from ten West African countries. Consistent with the study hypothesis, in adjusted proportional hazards regression models, use of any prenatal care was associated with lower risk of infant mortality. However, differences in risk of infant mortality associated with having adequate care compared to having inadequate or no care, were only significant for women in the wealthiest quintile. The definition for

adequate prenatal care used in this study combined timing of visit (first trimester), number of visits (at least four), and type of provider (doctor, nurse or midwife). Women who received adequate care may be at higher risk, which would prompt them to begin care early and to receive care often during pregnancy. For women in the highest wealth quintile, better use of prenatal care may be related to knowledge or healthy behaviors, in addition to greater access to resources. Results also showed that the magnitude of the effect of prenatal care varied by wealth quintile, and was smaller for poorer women. Poverty increases the risk of additional causes of death, including malnutrition; prenatal care may not notably reduce these risks. Findings from this study contribute to research on the impact of prenatal care use on infant mortality in sub-Saharan Africa by demonstrating that the risk of infant mortality is lower when women receive some prenatal care compared to no prenatal care. Results extend those of previous studies by exploring interactions between wealth and receipt of care. The findings highlight persistent wealth disparities and suggest a need for additional poverty-focused interventions to reduce disparities in maternal and child health.

As with prior studies, receiving prenatal care was associated with lower risk of infant mortality (Hong, 2008; McCurdy et al., 2011; Song & Burgard, 2011). Women receiving prenatal care may benefit from education as well as connections to the health and social service systems, which may help support child development. In its recommendations for prenatal care, the WHO includes newborn care education and provision of psychosocial support (WHO, 1999). Tetanus immunizations provided during pregnancy can also reduce risk of neonatal death (Lozano et al., 2013). Although the association between adequate prenatal care and infant mortality was significant only for

women in the wealthiest quintile, having adequate timing, skilled providers and a minimal quantity of prenatal care may benefit women in other ways. The WHO indicates that skilled providers are better trained to recognize complications and provide needed referrals than unskilled providers (WHO, 2004). In addition, having four visits at regular intervals during pregnancy supports monitoring of risks during each stage of pregnancy (WHO, 1999). Prior research suggests that prenatal care may be more beneficial to normal pregnancies than to complicated pregnancies (Conway & Deb, 2005).

Additional factors remaining significant in multivariate models were literacy, age at childbirth, and parity. Several studies have found associations between maternal education and infant mortality (Buor, 2003; Kiros, 2001; Song & Burgard, 2011). Findings of the present study suggest that maternal literacy is also an important factor. Literacy may influence women's ability to access health services (Berkman et al., 2011; Ciampa et al., 2012; Levandowski et al., 2006). Lower access may contribute to greater risk of death for infants of women who cannot read. Findings of poorer outcomes for young, primiparous women are also supported by previous research (Magadi et al., 2007; Rai et al., 2012). The majority of women in this study were married; thus, poorer outcomes among women in this study may point to clinical factors rather than social ones. Low birth weight is one clinical factor that could contribute to poor outcomes for young women (Finlay, Özaltin, & Canning, 2011).

Findings from this study should be viewed with data limitations in mind. The DHS did not collect information about gestational age; thus, the analysis could not control for effects of preterm birth. Birth weight, included in the DHS, is not collected systematically in most of the countries examined; over 50% of birth weight data were

missing. It is well known that preterm birth (<37 weeks gestation) and low birth weight are associated with greater risk of infant mortality (Callaghan, MacDorman, Rasmussen, Qin, & Lackritz, 2006). If preterm birth and low birth weight were higher among poorer women, this would contribute to higher infant mortality rates. However, preterm birth and low birth weight alone may not explain observed differences in the effect of adequate prenatal care on infant mortality. The measure for adequate care used in this study included skilled care provided by doctors, nurses, or midwives. The DHS includes additional country-specific skilled providers which, when added to analyses, did not change results significantly. It is possible that women who seek and receive prenatal care have other behaviors that contribute to better outcomes. Findings from this study may be generalizable to other sub-Saharan countries. However, applicability to other developing countries may be limited.

5.8 Implications for Policy, Practice and Research

Findings support continued efforts to increase access to prenatal care to provide early medical intervention, clinical monitoring, and education to reduce infant mortality in West Africa and other regions of the sub-Sahara. Services need to be available, accessible, and affordable for women; women should be educated about the usefulness of prenatal care. In recent years, Ghana has increased access to prenatal care by involving community health officers who may or may not have midwifery skills (Ghana Statistical Service (GSS) et al., 2009). Nigeria has implemented a similar program using midwives (Abimbola et al., 2012). While skilled providers are preferred, adding additional providers with less training can increase prenatal care access among women in less advantaged groups.

The greater risk of infant mortality for young, primiparous women highlights the need to increase access to prenatal care among women having their first child. More research examining barriers to care and outreach around family planning may be useful next steps. About 18% of women in the present study reported an unintended pregnancy. While pregnancy intention is a complex measure (Santelli, Lindberg, Orr, Finer, & Speizer, 2009), findings suggest an opportunity to increase knowledge and access to family planning in ways that are culturally sensitive (Phillips et al., 2012; Wadhams, 2010).

Future studies may consider evaluating different levels of prenatal care to determine which combinations of content, timing, and frequency most benefit women in this region. Future analyses comparing outcomes for different types of health care providers can provide policymakers with information needed to develop programs to increase the number of health professionals who provide prenatal services. In the present study, delivery assistance from nurses and midwives was associated with lower risk of infant mortality compared to delivery assistance from doctors. In contrast, the risk of infant mortality with delivery assistance by nurses and midwives was similar to risks with no delivery assistance. In future studies, it would be useful to include measures to indicate higher risk pregnancies (e.g. comorbid conditions, HIV status, preterm labor), as these women may be more likely to use physicians for delivery care. Nurses and midwives may be appropriate for young, healthy women, given limited availability of health professionals.

Prenatal care can help to improve maternal and child outcomes in developing countries. Providing timely access to prenatal care should remain an integral part of strategies to improving maternal and child health outcome in the developing world.

Table 5.1 Characteristics of women with recent birth by infant death[a]

	Weighted N(%)			
	All women with recent birth	No Infant Death	Infant Death	p-value[b]
	N=56,779	N=54,493	N=2,287	
Exposure Variables				
Any prenatal care	44,376 (78.2)	42,750 (78.5)	1,626 (71.1)	<.001
Adequate prenatal care	13,161 (23.2)	12,718 (23.3)	444 (19.4)	<.001
Wealth Quintile				<.001
Poorest	12,666 (22.3)	12,074 (22.2)	592 (25.9)	
Poorer	12,173 (21.4)	11,675 (21.4)	498 (21.8)	
Middle	11,511 (20.3)	11,021 (20.2)	490 (21.4)	
Richer	11,143 (19.6)	10,726 (19.7)	417 (18.2)	
Richest	9,286 (16.4)	8,996 (16.5)	290 (12.7)	
Predisposing Characteristics				
Age at childbirth				<.001
12-17	3,670 (6.5)	3,442 (6.3)	229 (10.0)	
18-34	44,156 (77.8)	42,563 (78.1)	1,593 (69.6)	
35-49	8,954 (15.8)	8,488 (15.6)	466 (20.4)	
Literacy				<.001
Can read	12,400 (21.8)	11,988 (22.0)	412 (18.0)	
Cannot read at all	44,380 (78.2)	42,505 (78.0)	1,874 (82.0)	
Highest level of education				0.002
No education	39,486 (69.5)	37,824 (69.4)	1,662 (72.7)	
Primary	9,620 (16.9)	9,249 (17.0)	371 (16.2)	
Some secondary or higher	7,668 (13.5)	7,414 (13.6)	254 (11.1)	
Missing	5 (<0.1)	5 (<0.1)		
Parity (Birth order)				<.001
1	10,682 (18.8)	10,156 (18.6)	526 (23.0)	
2	10,016 (17.6)	9,661 (17.7)	354 (15.5)	
3	8,710 (15.3)	8,422 (15.5)	288 (12.6)	
4	7,410 (13.1)	7,148 (13.1)	262 (11.5)	

Table 5.1 (continued)

	All women	No Infant Death	Infant Death	p-value[b]
≥5	19,962 (35.2)	19,105 (35.1)	857 (37.5)	
Sex of child				<.001
Female	27,909 (49.2)	26,864 (49.3)	1,044 (45.7)	
Male	28,871 (50.8)	27,628 (50.7)	1,242 (54.3)	
Marital status				0.515
Married	50,747 (89.4)	48,712 (89.4)	2,034 (89.0)	
Not Married	6,033 (10.6)	5,780 (10.6)	252 (11.0)	
Religion				0.652
Christian	15,206 (26.8)	14,620 (26.8)	586 (25.6)	
Islam	36,818 (64.8)	35,315 (64.8)	1,503 (65.7)	
Traditional Religion	2,681 (4.7)	2,569 (4.7)	112 (4.9)	
Other or no religion	2,075 (3.7)	1,989 (3.7)	86 (3.8)	
Enabling Characteristics				
Occupation				0.044
Agricultural	18,246 (32.1)	17,491 (32.1)	755 (33.0)	
Professional/Technical	727 (1.3)	705 (1.3)	21 (0.9)	
Sales, clerical and services	16,291 (28.7)	15,658 (28.7)	633 (27.7)	
Skilled/Unskilled manual	4,102 (7.2)	3,908 (7.2)	194 (8.5)	
Not working	17,138 (30.2)	16,470 (30.2)	669 (29.2)	
Missing	274 (0.5)	259 (0.5)	15 (0.7)	
Involved in decision-making				0.164
No	32,331 (56.9)	31,033 (56.9)	1,298 (56.8)	
Yes	22,078 (38.9)	21,203 (38.9)	876 (38.3)	
Not assessed	2,370 (4.2)	2,257 (4.1)	113 (4.9)	
Need Characteristics				
Cesarean delivery				<.001
No	55,189 (97.2)	53,001 (97.3)	2,188 (95.7)	
Yes	1,449 (2.6)	1,353 (2.5)	96 (4.2)	

Table 5.1 (continued)

	All women with recent birth	No Infant Death	Infant Death	p-value[b]
Missing	141 (0.2)	138 (0.3)	3 (0.1)	
Wanted pregnancy				<.001
Then	46,403 (81.7)	44,473 (81.6)	1,931 (84.4)	
Later	7,717 (13.6)	7,470 (13.7)	247 (10.8)	
Did not want pregnancy	2,506 (4.4)	2,406 (4.4)	100 (4.4)	
Missing	154 (0.3)	145 (0.3)	9 (0.4)	
BMI				0.390
Underweight <18.5	4,896 (8.6)	4,682 (8.6)	214 (9.4)	
Normal weight 18.50-24.99	30,755 (54.2)	29,510 (54.2)	1,245 (54.4)	
Overweight 25.00-29.99	5,390 (9.5)	5,166 (9.5)	224 (9.8)	
Obese ≥30.00	1,764 (3.1)	1,689 (3.1)	75 (3.3)	
Missing	13,974 (24.6)	13,445 (24.7)	529 (23.1)	
Health Care Use				
Delivery assistance				<.001
Doctor	2,518 (4.4)	2,380 (4.4)	138 (6.0)	
Nurse/midwife	20,164 (35.5)	19,491 (35.8)	673 (29.4)	
Auxiliary midwife	5,221 (9.2)	5,034 (9.2)	187 (8.2)	
Traditional birth attendant	14,501 (25.5)	13,864 (25.4)	637 (27.8)	
Relative or other	8,726 (15.4)	8,328 (15.3)	398 (17.4)	
No one	5,524 (9.7)	5,280 (9.7)	245 (10.7)	
Missing	126 (0.2)	116 (0.2)	10 (0.4)	
Contextual Factors				
Lives in rural area				<.001
No	15,784 (27.8)	15,250 (28.0)	534 (23.4)	
Yes	40,995 (72.2)	39,243 (72.0)	1,752 (76.6)	
Country				<.001
Benin	7,843 (13.8)	7,580 (13.9)	262 (11.5)	
Burkina Faso	8,060 (14.2)	7,781 (14.3)	279 (12.2)	

Table 5.1 (continued)

	All women with recent birth	No Infant Death	Infant Death	p-value[b]
Ghana	1,481 (2.6)	1,439 (2.6)	42 (1.9)	
Guinea	3,258 (5.7)	3,106 (5.7)	152 (6.6)	
Liberia	2,528 (4.5)	2,426 (4.5)	101 (4.4)	
Mali	7,172 (12.6)	6,821 (12.5)	351 (15.3)	
Niger	5,136 (9.0)	4,941 (9.1)	195 (8.5)	
Nigeria	12,875 (22.7)	12,283 (22.5)	592 (25.9)	
Senegal	5,824 (10.3)	5,651 (10.4)	173 (7.5)	
Sierra Leone	2,602 (4.6)	2,464 (4.5)	139 (6.1)	

Source: DHS surveys completed between 2005 and 2010 in Benin, Burkina Faso, Ghana, Guinea, Liberia, Mali, Niger, Nigeria, Senegal and Sierra Leone.

[a]Counts and percentages are weighted using DHS-supplied normalized weights, which sum to the total sample size rather than the population size. Proportions reflect those in the population.

[b]Chi-square p-value comparing characteristics of women who experienced infant death and those who did not.

Table 5.2 Unadjusted hazard ratios predicting risk of infant mortality

	Infant mortality	
	HR (95% CI)	p-value
Exposure Variables		
Any Prenatal Care		
No	1.00	
Yes	0.68 (0.62-0.75)	<.001
Adequate Prenatal Care		
No	1.00	
Yes	0.78 (0.71-0.87)	<.001
Wealth Quintiles		
Poorest	1.53 (1.33-1.76)	<.001
Poorer	1.33 (1.15-1.53)	<.001
Middle	1.38 (1.19-1.59)	<.001
Richer	1.21 (1.04-1.40)	0.013
Richest	1.00	

HR, hazard ratio

Table 5.3 Proportional hazards regression models predicting the risk of infant mortality[a]

	Model 1		Model 2	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Any prenatal care vs. no prenatal care by wealth quintile				
Poorest	0.87 (0.72-1.04)	0.115		
Poorer	0.75 (0.61-0.91)	0.004		
Middle	0.70 (0.56-0.86)	<.001		
Richer	0.56 (0.44-0.73)	<.001		
Richest	0.44 (0.28-0.69)	<.001		
Adequate prenatal care vs. inadequate or no care by wealth quintile				
Poorest			1.19 (0.94-1.51)	0.156
Poorer			0.89 (0.68-1.16)	0.385
Middle			0.98 (0.78-1.23)	0.883
Richer			0.85 (0.67-1.06)	0.154
Richest			0.66 (0.51-0.85)	0.001
Predisposing Characteristics				
Age at childbirth		<.001		<.001
12-17	1.32 (1.12-1.56)		1.32 (1.12-1.56)	
18-34	1.00		1.00	
35-49	1.49 (1.32-1.68)		1.49 (1.32-1.69)	
Parity (birth order)		<.001		<.001
1	1.33 (1.15-1.54)		1.34 (1.16-1.55)	
2	1.01 (0.87-1.16)		1.01 (0.88-1.16)	
3	0.94 (0.81-1.09)		0.94 (0.81-1.09)	
4	0.98 (0.84-1.13)		0.98 (0.84-1.13)	
≥5	1.00		1.00	
Literacy		0.014		0.005
Can read	1.00		1.00	
Cannot read at all	1.18 (1.03-1.35)		1.21 (1.06-1.38)	

Table 5.3 (continued)

	Model 1		Model 2	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Current marital status		0.002		0.693
Not Married	0.88 (0.81-0.95)		1.04 (0.86-1.24)	
Married	1.00		1.00	
Sex of child		0.685		0.001
Male				
Female	1.04 (0.87-1.25)		0.87 (0.80-0.95)	
Religion		0.601		0.604
Islam	1.00		1.00	
Christian	1.04 (0.90-1.20)		1.04 (0.90-1.19)	
Other or no religion	1.13 (0.89-1.43)		1.12 (0.88-1.42)	
Traditional Religion	1.15 (0.91-1.45)		1.15 (0.91-1.46)	
Enabling Characteristics				
Respondent's occupation		0.081		0.113
Professional/Technical	1.00		1.00	
Agricultural	1.17 (0.74-1.82)		1.16 (0.74-1.81)	
Sales, clerical and services	1.26 (0.81-1.97)		1.24 (0.80-1.93)	
Skilled/Unskilled manual	1.47 (0.93-2.32)		1.44 (0.91-2.29)	
Not working	1.20 (0.77-1.87)		1.19 (0.76-1.86)	
Missing	1.59 (0.81-3.10)		1.57 (0.80-3.06)	
Respondent involved in decision-making		0.641		0.630
Yes	1.00		1.00	
No	0.98 (0.89-1.08)		0.99 (0.90-1.08)	
Not assessed	1.11 (0.86-1.43)		1.12 (0.87-1.44)	
Need Characteristics				
Cesarean delivery		<.001		<.001
No	1.00		1.00	
Yes	1.78 (1.41-2.26)		1.81 (1.43-2.29)	
Missing	0.65 (0.20-2.11)		0.65 (0.20-2.11)	

Table 5.3 (continued)

	Model 1		Model 2	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Time wanted pregnancy		0.024		0.019
Then	1.00		1.00	
Later	0.83 (0.72-0.95)		0.82 (0.71-0.94)	
No more	0.84 (0.68-1.04)		0.85 (0.69-1.04)	
Missing	1.26 (0.66-2.43)		1.29 (0.67-2.48)	
Health Care Use				
Delivery assistance		<.001		<.001
Nurse/midwife	1.00		1.00	
Doctor	1.53 (1.24-1.89)		1.56 (1.27-1.93)	
Auxiliary midwife	1.01 (0.83-1.22)		1.02 (0.84-1.24)	
Traditional birth attendant	0.94 (0.82-1.08)		1.01 (0.88-1.15)	
Relative or other	1.00 (0.86-1.15)		1.09 (0.94-1.26)	
No one	0.90 (0.75-1.08)		1.02 (0.85-1.21)	
Missing	1.78 (0.95-3.33)		1.95 (1.05-3.64)	
Contextual Factors[b]				
Lives in rural area		0.423		0.296
No	1.00		1.00	
Yes	1.06 (0.92-1.20)		1.07 (0.94-1.22)	

Source: DHS surveys completed between 2005-2010 in Benin, Burkina Faso, Ghana, Guinea, Liberia, Mali, Niger, Nigeria, Senegal and Sierra Leone.

[a]Models apply DHS-supplied normalized weights, which sum to the sample size rather than the population size. Applying the weights produces nationally representative proportions, hazard ratios, and confidence intervals.

[b]In addition to variables shown in table, models adjust for region of residence (e.g. Northern Liberia)

HR, hazard ratio

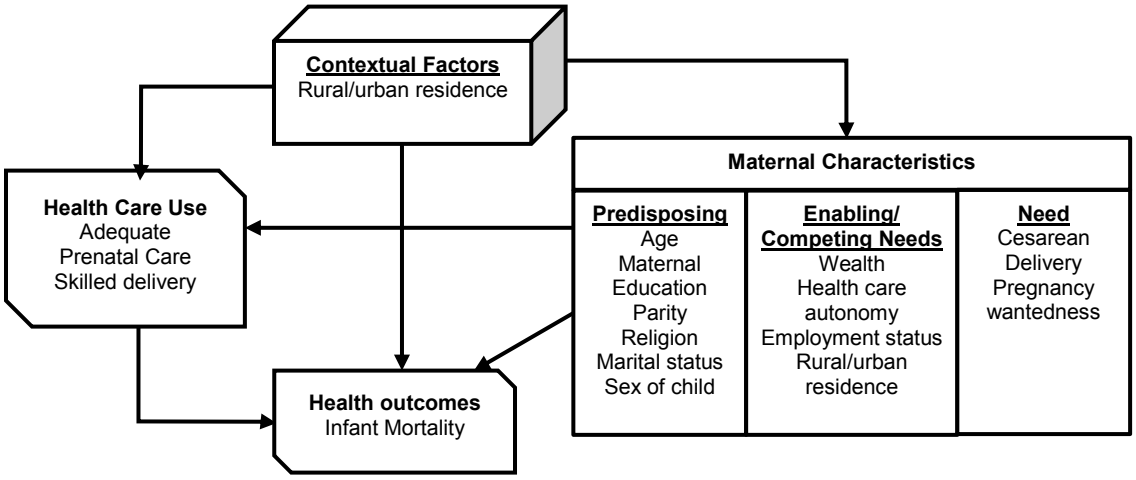

Figure 5.1 Conceptual framework for association between prenatal care and infant mortality, adapted from Andersen and Davidson (2007b)

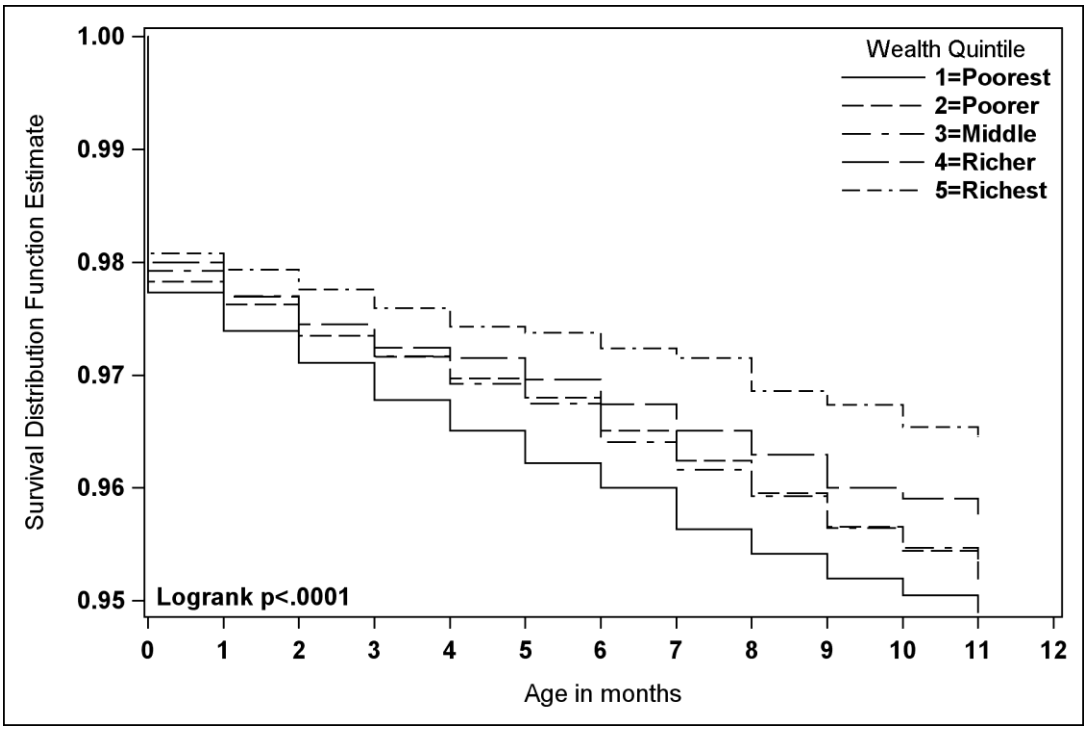

Figure 5.2 Survival probabilities before age 12 months by mother's wealth quintile

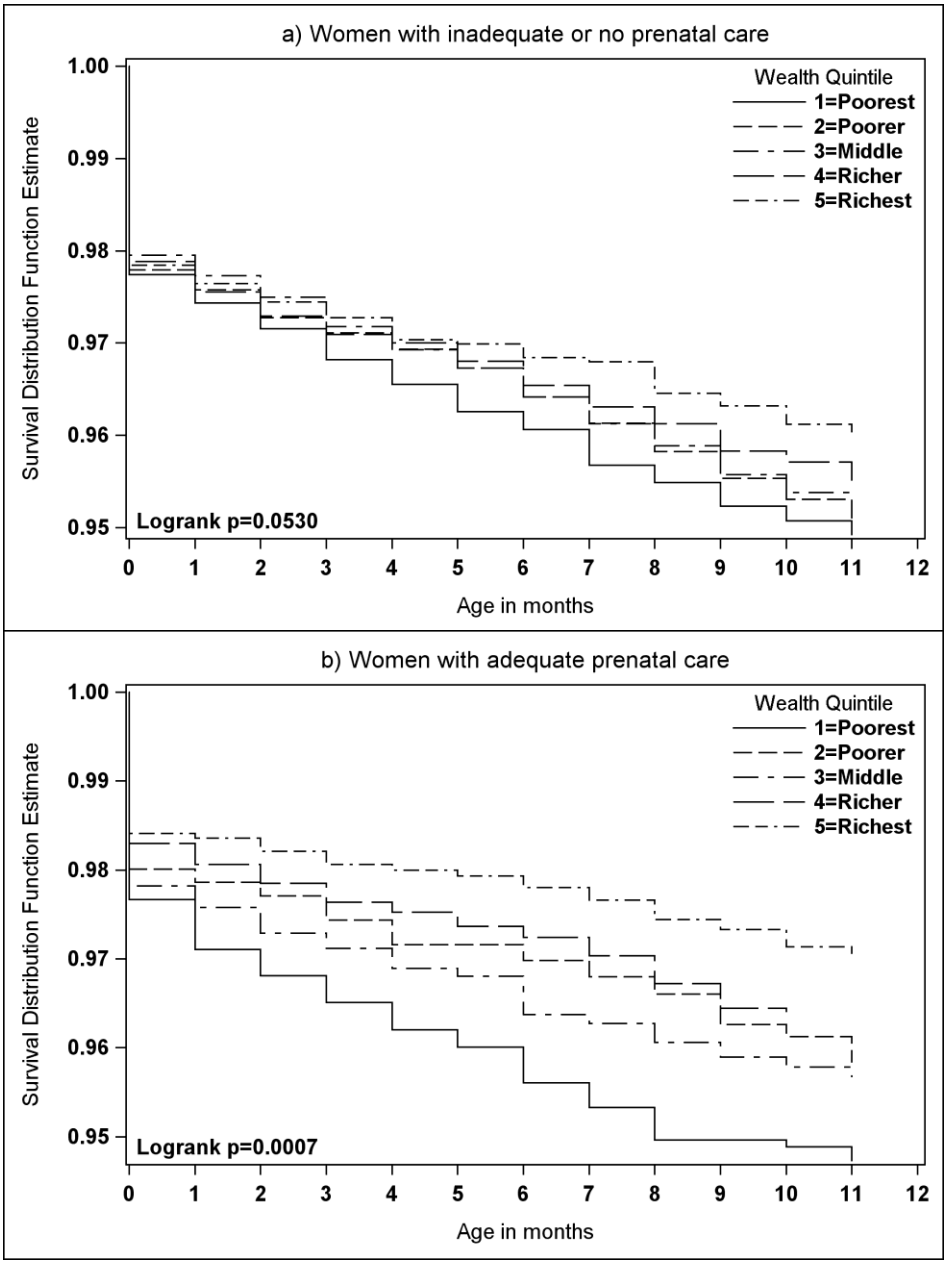

Figure 5.3 Survival probabilities before age 12 months, by mother's wealth quintile and prenatal care use

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