THREE ESSAYS ON THE ECONOMICS OF MATERNAL HEALTH CARE

By

Harminder Kaur Guliani

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AUTHOR: Harminder Guliani,
B.Sc. (Eco. Honors), M.Sc (Eco, Honors)
(GND University, India)

SUPERVISORS: Dr. John Serieux (Supervisor)
Dr. Ardeshir Sepehri (Co-Supervisor)
Dr. John Loxley
Dr. Lisa Avery
Dr. Anne Case

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DECLARATION OF CO-AUTHORSHIP

I hereby declare that the first and second essay of this dissertation (Chapter 2 and 3) incorporates material that is the result of joint research with Dr. John Serieux and Dr. Ardeshir Sepheri. The extent of the co-authorship for these essays is explained below.

Chapter 2: "What impact does contact with the prenatal care system have on women's use of facility delivery? Evidence from low-income countries"

In this chapter, I identified the research question, cleaned the data, contributed to statistical analysis and wrote the first and subsequent drafts of the manuscript. Dr. Sepehri estimated the econometric model, reviewed preliminary and final results, aided in their interpretation, and provided direction for further analysis. Dr. Serieux guided the revisions of the preliminary and final manuscript, provided detailed comment, and modified some text.

Chapter 3: "Determinants of prenatal-care use: evidence from thirty-two low-income countries across Asia, Sub-Saharan Africa and Latin America"

In this chapter, I identified the research question, performed the data cleaning, contributed to statistical design and wrote the first and subsequent drafts of the manuscript. In this chapter, Dr. Sepehri advised on the appropriate econometric methodology, performed statistical analysis and aided in the interpretation of results. Dr. Serieux reviewed the preliminary and final drafts of the manuscript, aided in the interpretation of results, and re-wrote some texts.

I hereby certify that, with above qualifications, this dissertation and the research therein is the product of my own work.

Abstract

This thesis consists of three essays that address various aspects of the economics of maternal health care. The first two essays examine the determinants of utilization of maternal health care services in low-income countries, while the third essay examines the determinants of utilization of prenatal ultrasonography in Canada.

The first essay examines the influence of prenatal attendance (as well as a wide array of observed individual-, household- and community-level characteristics) on a woman's decision to give birth at a health facility or at home for thirty-two low-income countries (across Asia, Sub-Saharan Africa and Latin America). This empirical investigation employs the Demographic and Health Surveys (DHS) data and a two-level random intercept model. The results show that prenatal attendance has a substantial influence on the use of facility delivery in all three geographical regions. Women having four prenatal visits were 7.3 times more likely to deliver at a health facility than those with no prenatal care.

The second essay addresses two related questions: what factors determine a woman's decision to seek prenatal care; and are those the same factors that determine the frequency of care? This investigation also utilizes Demographic and Health Surveys (DHS) data for thirty-two low-income countries (across Asia, Sub-Saharan Africa and Latin America) and applies a two-part and multi-level model to that data. The results suggest that, though a wide range of factors influence both decisions, that influence varies in magnitude across the two decisions, as well as across the three geographical regions.

The third essay examines the influence of various socioeconomic and demographic factors on the frequency of prenatal ultrasounds in Canada, while controlling for maternal risk profiles. This investigation utilizes data from the Maternity Experience Survey (MES) of the Canadian Perinatal Surveillance System and employs a count data regression model (the Poisson distribution) to estimate the effect of various factors on the number of prenatal ultrasounds. The results of this investigation suggest that, even after controlling for maternal risk factors, the type of health-care provider, province of prenatal care, and timings of first ultrasound are the strongest predictors of number of ultrasounds.

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THREE ESSAYS ON THE ECONOMICS OF MATERNAL HEALTH CARE

Table of Contents

List of Tables and Figures

CHAPTER 1

Prenatal Care in Developed and Developing Countries: An Introduction

Prenatal and delivery care are critical both for maternal and newborn health. Many studies, in both developed and developing countries, suggest that prenatal care is an important determinant of improved health outcomes for women and infants and, further, that assistance from a skilled attendant at birth (most closely associated with facility delivery), is necessary to reduce maternal mortality (Bloom *et. al*, 1999; Celik & Hotchkiss, 2000; Campbell & Graham, 2006; Sepehri *et al*, 2008). Prenatal care attendance offers multiple opportunities to reach expectant mothers with information on any risks related to labour and delivery, and can also be a way of promoting delivery with the assistance of a skilled health care provider (Bloom, *et al.*, 1999; Campbell and Graham, 2006; Gage, 2007; WHO, 2003). Timely and adequate prenatal care has also been found to be important for the health of newborns (Halim *et al.*, 2010; Maitra, 2004).

Great efforts have been made during the past two decades to improve access to, and the utilization of, prenatal care in low-income countries. While over three-quarters of pregnant women have at least one prenatal contact with a health professional, only 39% of women benefit from the minimum, WHO recommended, four prenatal visits and over half of women in low-income countries continue to deliver at home without skilled help (WHO, 2010). There also remain substantial disparities in prenatal care attendance and frequency of use, both between and within low-income countries (Gwatkin, *et al.*, 2007; Houweling, *et al.*, 2007). By contrast, in developed countries such as Canada, where these challenges are no longer a major concern, the

use (and potential overuse) of prenatal ultrasounds is a more immediate concern. Through three essays, this dissertation contributes to the literature on maternal health care utilization by making use of more extensive datasets and updated methodologies to obtain more complete answers to questions that had heretofore been asked in rather limited ways and/or not often been asked.

The first two essays attempt to shed some light on the factors that can improve utilization of maternal health services across a large group of low-income countries covering three geographical regions (Asia, sub-Saharan Africa and Latin America). The first essay (Chapter 2) concerns itself with the fact that while much has been written on the determinants of delivery care use in developing countries, comparatively little is known about the influence of prenatal care on a woman's choice of delivery setting. Of the few studies that do exist, they suggest that adequate prenatal contacts increase the likelihood of delivery in a health facility (Allegri et al., 2011; Bloom *et al*; 1999; Gage 2007; Gage and Calaxite 2006; Sepheri *et al*., 2008; Yanagisawa *et al*., 2006). However, most of these studies are country-specific, use small-scale survey data, and focus on a small set of individual and household covariates. Thus, the first essay seeks to extend the range and scope of this literature by examining the relationship between prenatal attendance and a woman's choice of delivery setting using large-scale survey data, for a large number of countries, and accounting for a wide array of observed individual-, household- and community-level characteristics (as well as unobserved community-level factors). This is achieved by using Demographic and Health Survey (DHS) data for thirty-two low-income countries (across the developing regions of Sub-Saharan Africa, Asia and Latin America) and a random intercept logistic model. The results suggest that prenatal attendance has a substantial influence on the use of facility delivery in all three geographical regions, with women having four visits being 7.3 times more likely to deliver at a health facility than those with no prenatal

care. This contrast is most pronounced for Sub-Saharan Africa. The influence of the number of prenatal visits, maternal age and education, parity level, and economic status of the birthing women on the place of delivery is found to vary across the three geographical regions. The results also indicate that obstetrics care is geographically and economically more accessible to urban women with higher incomes and least accessible to rural women with low incomes.

The second essay (Chapter 3) answers two related questions. First, what factors determine a woman's decision to seek prenatal care; and second, do those same factors determine the frequency of care (as demonstrated by the number of prenatal visits). Many studies have examined the determinants of *prenatal care attendance* in low-income countries but few have examined the determinants of the *frequency of prenatal visits*, and whether there are separate processes generating decisions regarding any use of prenatal care (that is, the choice of at least one visit) and the frequency of use (Addai 2000; Alexandre *et al*. 2005; Gage, 2007; Gage and Calixte, 2006; Halim *et al*. 2010; Magadi *et al*. 2003; Magadi *et al*. 2007; Sepehri *et al*. 2008). Moreover, most of the existing studies are country-specific and it is unclear whether the influences of the main determinants of prenatal care utilization vary in magnitude across geographical regions. The primary purpose of the second essay is to fill this gap in the literature. The relevant investigation is based on data from the Demographic and Health Surveys (DHS) of thirty-two low-income countries (across Asia, Sub-Saharan Africa and Latin America) and appropriate two-part and multi-level models. The essay reports that, though both the decision to seek care and the number of prenatal visits are influenced by a range of observed individual-, household- and community-level characteristics, the influence of these determinants vary in magnitude for prenatal care attendance versus the frequency of prenatal visits, as well as across the three geographical regions. Moreover, while there is significant overlap in the variables that

affect the two decisions, some variables appear to play a role in only one of the two decisions. Further, unobserved community-level variables appear to have an impact on the decision to seek care but not on the number of visits. The essay also reports that teenage mothers, unmarried women, and those with unintended pregnancies are less likely to seek prenatal care and have fewer visits. This suggests that safe mother programs need to pay particular attention to these disadvantaged and vulnerable sub-groups of population whose reproductive health issues are often fraught with controversy.

The third essay (Chapter 4) goes beyond concerns about prenatal attendance, the number of visits and delivery care and looks at the use of prenatal ultrasonography, as an essential component of prenatal care provision, in Canada. Ultrasonography has become one of the most critical and integral components of prenatal care in the modern medical era. Prenatal ultrasound technology has achieved almost universal coverage in industrialized countries, as it has gained particular importance in providing information about gestational age of the baby, the presence or absence of abnormal fetuses, multiple pregnancies and fetal growth retardation (Ewigman, 1991; Sari-Kemppainen *et al.,* 1990; Youngblood, 1989). The general recommendation is that a woman with an uncomplicated pregnancy should receive no more than one or two ultrasound examinations during gestation.[1] However, the number of such diagnostic examinations performed during a single pregnancy has markedly increased in recent years, resulting in a rapid increase in the expenditure on imaging services (You et al., 2010). This widespread and repeated use of prenatal ultrasounds has raised concerns about unnecessary testing and potential overutilization of diagnostic imaging, particularly for low-risk pregnancies (Ewigman, 1993; Iglehart, 2006).

[1] The routine use of ultrasound as a screening tool is discouraged by WHO's Safe Motherhood Initiative (WHO, 1995).

The literature on the utilization of prenatal ultrasound is limited, and many studies focus on documenting its trend and its appropriateness. There are some Canadian studies that have documented the evidence of rapid and inappropriate use of prenatal ultrasonography technology in selected provinces (Anderson, 1994; Thompson, 1998; You et al., 2007; You et al, 2010). However, there is no published nationwide study that examines the determinants of the use of prenatal ultrasonography in Canada. The objective of the third essay is to empirically assess the influence of various socioeconomic and demographic factors on the frequency of prenatal ultrasounds in Canada, while controlling for maternal risk profiles, using data from the 2006 Maternity Experience Survey (MES) of the Canadian Perinatal Surveillance System. The results of this investigation suggest that the increase in the number of ultrasounds is not solely explained by maternal risk factors. Even after controlling for those risk factors, the type of health care provider, province of prenatal care, and timings of first ultrasound are the strongest predictor of the number of ultrasounds.

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CHAPTER 2

What impact does contact with the prenatal care system have on women's use of facility delivery? Evidence from low-income countries

Abstract

Prenatal and delivery care are critical both for maternal and newborn health. Although the presence of a skilled attendant during labour and delivery has been shown to lead to a marked reduction in maternal mortality, over half of women in low-income countries continue to deliver at home without skilled help. Using the Demographic and Health Surveys (DHS) data, for thirty-two low income countries (across Asia, sub-Saharan Africa and Latin America), and employing a two-level random intercept model, this essay empirically assesses the influence of prenatal attendance (along with a wide array of observed individual, household and community-level characteristics) on a woman's decision to give birth at a health facility (rather than at home). The results show that prenatal attendance has a substantial influence on the use of facility delivery in all three geographical regions, with women having four visits being 7.3 times more likely to deliver at a health facility than those with no prenatal care visits. This effect is most pronounced for Sub-Saharan Africa. The results also indicate that obstetric care is geographically and economically more accessible to urban women and those from non-poor households than those from rural and/or poor households.

Keywords: health facility delivery; prenatal care; multilevel analysis; low-income countries.

2.1. INTRODUCTION

The reduction of maternal mortality remains one of the most important social and developmental challenges facing governments in many low-income countries. The Fifth Millennium Development Goal calls for a three-quarter reduction in maternal mortality between 1990 and 2015. Though, according to the most recent estimates, there has been a steady decline in maternal deaths globally over the past three decades, the annual maternal death toll still remains high (342,900).[2] Moreover, for every woman who dies, at least 20 others suffer injuries, infection and disability. Nearly all these deaths and injuries take place in low- and middle-income countries and most could be avoided if women had access to qualified medical care during pregnancy, childbirth, and the postpartum period (WHO, 2008). The worst-affected regions are Sub-Saharan Africa and Asia, which together accounts for over 93% of maternal deaths (Hogan *et al*., 2010).

Family planning, prenatal care, skilled birth attendance and emergency obstetrics have been identified as the four most critical interventions in efforts to reduce maternal mortality in developing countries (WHO, 2005). In particular, skilled attendance at delivery is advocated as the "single most important factor in preventing maternal deaths" (WHO, 1999). [3] Yet, many women (57%) in low-income countries deliver at home without skilled help (WHO, 2010). Moreover, there are substantial disparities in the use of obstetric services both between and within countries (Gwatkin, *et al*., 2007; Houweling *et al.*, 2007), with the proportion of women giving birth at health facilities ranging from as low as 12.3% in Ethiopia to as high as 80% in

[2] According to a new analysis, the estimated maternal deaths were 342,900 in 2008, down from 526,300 in 1980 (Hogan *et al*., 2010). These estimates are far lower than the previously reported estimates and they have wide uncertainty intervals.

[3] The presence of a skilled attendant during the labor and delivery, which is when most maternal deaths occur, is shown to lead to a marked reduction in maternal mortality (Campbell & Graham, 2006).

Vietnam.[4] Disparities along economic lines are, in particular, notable in Chad and Ethiopia, where less than 2% of women from the poorest wealth quintiles deliver at health facilities compared to 51 and 45%, respectively, of women from the richest wealth quintiles.

The four most critical interventions for reducing maternal mortality in developing countries, identified above, are not mutually-exclusive. In particular, the process of skilled delivery begins with prenatal care attendance. Prenatal attendance offers multiple opportunities to reach expectant mothers with numerous interventions, including the communication of information on the risk of labour and delivery, as a way of ensuring that women deliver with the assistance of a skilled health care provider (Bloom *et al.*, 1999; Campbell and Graham, 2006; Gage, 2007; Gage and Calixte, 2006;WHO, 2003). Exposure to counselling about pregnancy complications may then "influence women's perceptions about their susceptibility to, and the seriousness of, those complications and act as an impetus to obtaining appropriate delivery care, especially in areas far away from a health facility…."(Gage, 2007). As an entry point into the health system, prenatal attendance (especially in rural settings) can also facilitate women's access to medical care for other needs (Pallikadavath *et al.,* 2004).

While much has been written on the determinants of delivery care use in developing countries, comparatively little is known about the influence of prenatal care attendance on a woman's choice of delivery setting. The few studies that do exist suggest that adequate prenatal contact increases the likelihood of choosing a health facility for delivery (Allegari *et al.,* 2011; Bloom *et al;* 1999; Gage 2007; Gage and Calaxite 2006; Sepheri *et al.,* 2008; Thind *et al.,* 2008; Yanagisawa *et al.,* 2006). However, most of these studies are country-specific, use small-scale survey data, and focus on a small set of individual and household covariates. In this essay, we

[4] Calculated using the latest DHS data for 32 low-income countries.

seek to extend the range and scope of that literature by examining the relationship between prenatal attendance and a woman's choice of delivery setting using large-scale survey data, for a large number of countries, and accounting for a wide array of observed individual-, household- and community-level characteristics (as well as unobserved community-level factors). More specifically, this investigation uses Demographic and Health Survey (DHS) data for thirty-two low-income countries (across the developing regions of Sub-Saharan Africa, Asia and Latin America) and a random intercept logistic model to examine the relationship between prenatal attendance and facility deliveries. The DHS uses standardized questionnaires to collect health and other socioeconomic indicators, facilitating comparisons across countries. A multi-country study, by capturing broad patterns in the utilization of maternal health care services at global and regional levels, can help to inform global, regional and national health strategies (Wang, 2003).

The remainder of this chapter is organized into five sections. Section 2.2 presents a review of the literature. Section 2.3 provides an overview of the data, methodology and variables used. Section 2.4 presents the descriptive and empirical findings. Section 2.5 discusses the implications of results, while section 2.6 concludes the chapter.

2.2. LITERATURE REVIEW

A wide range of published studies have investigated a plethora of potential factors that might determine a women's choice of institutional delivery, or use of skilled attendant at birth, in various low-income settings (Addai, 2000; Anwar *et al.*, 2008; Bloom *et al.*, 1999; Gage, 2007; Gage and Calixite; 2006; Hotchkiss *et al.*, 2005; Kruk *et al.*, 2010; Say and Raine, 2007; Sepehri *et al.*, 2008;, Short and Zhang, 2004; Thind *et al.*, 2008; Yanagisawa *et al.*, 2006). Gabrysch and

Campbell (2009) provide an extensive review of the literature on the determinants of delivery service use in low- and middle-income countries. This study provides an overview of the factors examined, including the hypothesized mechanisms of action for each determinant and their likely confounders. The majority of the studies examined in this review found that maternal education, parity, partner's education, maternal age, marital status, unwanted pregnancy, household living standards, place of residence and socioeconomic status were primary constraints on the use of a health facility for delivery.

However, to date, only a handful of studies in the literature have examined the *impact of prenatal care* on the use of a health facility for delivery in low-income countries. Studies conducted in Burkina Faso (Allegari *et al.,* 2011), Cambodia (Yanagisawa *et al*., 2006), India (Bloom *et al.,* 1999; Thind *et al.,* 2008), Mali (Gage, 2007), and Vietnam (Sepheri *et al.,* 2008), have provided strong evidence of a positive association between having adequate prenatal care and the use of a health facility for delivery - a factor known to decrease maternal mortality (when skilled attendants are present).

Four out of these six studies analysed the impact of number of visits on the use of a health facility for delivery (after controlling for other socio-economic and demographic factors). Using Vietnam's National Household survey data for 2001-2002, Sepheri *et al*., (2008) showed that more prenatal visits increases the likelihood of delivering in a health facility. Based on a multilevel modelling strategy, the results suggest that, compared to women with no prenatal visits, having one prenatal visit increases the likelihood of delivering at a health facility by 51 percent, by as much as 3.2 times for those having between four to six visits and by 10.6 times for those having more than six visits (after adjusting for other individual-, household- and community-level factors). Yanagisawa *et al.* (2006) used population-based survey data to

identify the determinants of the presence of a birth attendant in a rural area of Cambodia. To distinguish between the skilled attendance in a facility and at home and to distinguish change of birth attendants during delivery, three analyses were conducted: place of delivery (facility delivery vs. non-facility), birth attendant during home births (skilled vs. unskilled birth attendant) and change of birth attendant during delivery (changed vs. unchanged), Using logistic regression, they showed that, by adjusting other factors, previous contact with a skilled attendant through antenatal care was a significant, positive, determinant of facility deliveries; and particularly for those women who attended antenatal care four times or more. Similarly, Thind *et al*., (2008) used the latest National Family Health Survey data, to analyze the determinants of delivery location (home, private and public facility) in Maharashtra state (India). They also showed that more than three visits were associated with greater odds of delivering in a public/private facility, compared to home births. A very recent study by Allegri *et al*., (2011) assessed the determinants of antenatal care utilization (defined as having attended at least 3 visits) and skilled assistance at birth (defined as having delivered in a health facility) after the reduction of user fees in rural Burkina Faso. Their result found further support for the argument that having attended at least three antenatal visits was positively associated with delivering in a health facility.

However, two of the six studies that examined the relationship between prenatal visits and facility delivery emphasised the prenatal care content on the use of a health facility for delivery. Bloom *et al.*, (1999) used logistic regression analyses to examine the impact of prenatal care utilization on the likelihood of using safe delivery care in Varanasi, Uttar Pradesh, India. The study introduced a new measure for antenatal care use comprising 20 input components that accounts for timings and visit frequency, as well as content features. Two indicators were used to

model safe delivery care: health professional versus another person, irrespective of delivery site, and home versus a health facility. After controlling for various socio-economic and maternity history factors, the results showed a strong positive association between levels of care obtained during pregnancy and the use of both indicators of safe delivery care. Similarly, Gage (2007), in their analysis of barriers to the utilization of maternal health care in rural Mali, showed that high prenatal care uptake in the neighbourhood and exposure to counselling about pregnancy complications during prenatal care increased the likelihood of institutional delivery.

2.3. DATA AND METHODOLOGY

2.3.1. Data

This paper uses the most recent data from Demographic and Health Surveys (DHS) for thirty two low-income countries from the regions of Asia, Sub-Saharan Africa and Latin America. The DHS years for various countries range from 2001 to 2008.[5] Since the survey years vary by country, only those countries whose per capita income was below the World Bank cut-off point for low-income status during the survey year were selected.[6] The DHS are large-scale household surveys that use a multistage cluster sample design to collect information on nationally representative samples of women of reproductive age. DHS collect, among other things, information on reproductive histories, fertilities, family planning, as well as data on respondents' various socio-economic characteristics such as age, education, gender, marital status, employment status, ethnicity, and religion. The pregnancy and postnatal care section of

[5] Appendix to this chapter provides a list of countries, by survey year and region.

[6] In order to benefit from a large sample for Latin America, we have included Honduras. Honduras' per capita income in 2005, the year of the DHS survey, was slightly above the cutoff point.

the survey collects detailed information on the use of prenatal care, the number of prenatal visits, place of delivery, and other maternal and child health services received by all sampled women aged 15 to 49 years. The overall sample in this study consists of 201,164 women who had their last baby born alive in the five years preceding participation in the survey.

2.3.2. Estimation methodology

Utilization of obstetric services is measured by a broad measure of obstetric care, which takes the value of one if a woman gives birth at a health facility and zero if she gives birth at home. We have chosen to focus on the location of delivery rather than assisted deliveries (which may include home births with professional assistance), to avoid the potential problem of inaccurate reporting of attendant's skill level by respondents. Definitions for birth attendants vary across and within countries, making the distinction between professional (e.g., doctors, nurses, midwives or auxiliary midwives) and non-professional (e.g., traditional birth attendants) rather vague (Abou-Zahr and Wardlaw, 2001). Moreover, in practice, skilled attendance in most developing countries is synonymous with institutional delivery. The proportion of women delivering at home with a skilled attendant present accounts for less than 12% of all home deliveries in developing countries and for as little as 4.4 and 5.8% in Sub-Saharan Africa and Latin America, respectively (Stanton *et al.,* 2006). We have also chosen to group all health facilities into one single group, regardless of their differences, in terms of type of ownership and the level of care provided by each facility. Given the wide variations in the quality and cost of care across health facilities, ideally it would be preferable to analyze women's choice of delivery setting across various types of health facilities. However, this is not possible, given the country specific nature of DHS data on the types of health facilities used for childbirths. The use of private providers for childbirth is far less common in Sub-Saharan Africa (16% of all facility

deliveries) and Latin America (10%) than in Asia (45%). In this context, it is hard to distinguish the effect of facility type from country and region effects.

The likelihood of women seeking obstetric care is likely to be correlated among the community members, since women's choice of childbirth setting is influenced by the unobserved characteristics of the community (Sepehri *et al*., 2008). In this case, the application of standard binary logistic regression models leads to bias (Rabe-Hesketh and Skrondal, 2005). The dependence among the community members' health-seeking behaviour can instead be explicitly modeled using a random-intercept logistic model.

Suppose the likelihood of choosing a health facility for childbirth for the ith individual in the jth cluster or community is given by:

$$\text{logit}\{\Pr(y_{ij}=1 \mid x_{ij}, \zeta_j)\} = \alpha + \beta' x_{ij} + \zeta_j \quad (1)$$

Where α is the constant, β is a vector of regression coefficients corresponding to observed individual-, household- and community-level covariates x_{ij}, and ζ_j is a random intercept. The random intercept is assumed to be normally distributed with a zero mean and variance ψ. The random intercept represents the combined effect of all omitted community level covariates that cause some birthing women within a community to give birth at a health facility.

Assuming that underlying the observed dichotomous response y_{ij}, there is an unobserved or latent continuous response y^*_{ij}, the random intercept logistic regression (1) can alternatively be specified as a linear regression model:

$$y^*_{ij} = \alpha + \beta' x_{ij} + \zeta_j + \varepsilon_{ij}$$

Or equivalently, $$y_{ij}^{*} = (\alpha + \zeta_j) + \beta' x_{ij} + \varepsilon_{ij} \quad (2)$$

$$y_{ij} = \begin{cases} 1 & if\, y_{ij}^{*} > 0 \\ 0 & otherwise \end{cases}$$

Where ε_{ij} is a transitory error term, which varies between individual-household as well as communities, and is assumed to have a standard logistic distribution with a zero mean and variance $\frac{\pi^2}{3}$ (π is the constant 3.1416). The two errors are assumed to be independent from each other, with ζ_j being independent over communities and the ε_{ij} over individual-households and communities. The total residual variance is:

$$\text{Var}(\xi_{ij}) = \text{Var}(\xi_{ij} = \zeta_j + \varepsilon_{ij}) = \psi + \frac{\pi^2}{3}$$

According to the latent-response regression model (2), observations in the same community share the same random term ζ_j and hence they are correlated. The degree of dependence or correlation between observed responses on two birthing women i and i' from the same community can be quantified in terms of the intra-class correlation (ρ) of the latent response y_{ij}^{*} as:

$$\rho = Cor(y_{ij}^{*}, y_{i'j}^{*} / x_{ij}, x_{i'j}) = Cor(\xi_{ij}, \xi_{i'j})$$

$$= \frac{Cov(y_{ij}^{*}, y_{i'j}^{*} / x_{ij}, x_{i'j})}{\sqrt{\text{var}(\xi_{ij})}\sqrt{\text{var}(\xi_{i'j})}}$$

$$= \frac{\psi}{\sqrt{\psi + \frac{\pi^2}{3}}\sqrt{\psi + \frac{\pi^2}{3}}}$$

$$\rho = \frac{\psi}{\psi + \frac{\pi^2}{3}} \tag{3}$$

The higher the degree of interdependence among the observed responses within a community, the higher would be the proportion of the total variance that is between communities, or due to communities.

We begin our analysis by assessing the overall degree of homogeneity in the utilization of obstetric care among women within an enumeration area (the primary sampling unit), by estimating a two-level (individual-household and community) random intercept logistic regression model without including the observed covariates and calculate the intra-community correlation (ρ) as defined in equation (3). The estimated ρ (or total unexplained variation in deliveries at health facilities) is 0.50. Such high value suggests substantial variation across communities in the use of obstetric services for delivery. Therefore, we use a two-level random intercept logistic model to assess the influence of observed individual-, household- and community-level characteristics on a woman's decision regarding the place of delivery.

Finally, the multilevel modeling strategy accommodates the clustered or hierarchical nature of the data and corrects standard errors of the estimated coefficients for intra-community correlation (heteroscedasticity). Community boundaries are defined by enumeration areas, the primary sampling units used by DHS.[7] The endogenity issue between the number of visits and

[7] The number of observations per community (enumerator area) varies across countries. The size of these enumeration areas varies from five to 22.

delivery assistance has been addressed later (see footnote 17). STATA version 9.1 was used for all data analysis.

2.3.3. Study variables

The literature suggests that utilization of obstetric care[8] is influenced by a wide range of observed individual-, household- and community-level variables, as well as unobserved community-level variables, such as perceived benefits of care, as compared to traditional birth attendants, attitudes towards health and health related behaviors, and the prevailing beliefs and practices surrounding birth (Gabrysch and Campbell, 2009; Kruk *et al.,* 2010; Pebley, Goldman, and Rodriguez,1996; Pickett and Pearl, 2001; Say and Raine, 2007).[9] In this essay, we have hypothesised three sets of independent variables that affect choices about the use of a health facility for delivery: (1) individual level factors; (2) household-level factors; and (3) characteristics of the community in which women lives.

The choice of individual and household-level variables, included in this study, and the expected signs of their coefficients, was informed by previous research on the determinants of utilization of maternal health care services in low-income countries (Babalola and Fatusi, 2009; Gabrysch and Campbell, 2009; Kruk *et al.,* 2010; Pickett and Pearl, 2001; Say and Raine, 2007; Sepheri *et al.,* 2008). Table 2.1 provides definitions and summary statistics for the dependent and each type of independent variables included in the analysis.

[8] Obstetric care deals with the care of women during pregnancy, childbirth, and the recuperative period following delivery.

[9] It should be noted here that the perceived benefits of care have both individual and community level component. But it can be presumed that most of the individual level components are captured by individual level characteristics such as education, age, parity, unwanted pregnancy and employment and marital status. Health related behaviour could be considered as an unobserved individual level variable but that attitude is likely to be quite similar within communities because of shared experiences.

Table 2.1. *Definitions and summary statistics*

Variable name	Description	Mean	Std dev.
Dependent variable			
Place of delivery	1= if delivers at a health facility, 0 otherwise	0.472	0.499
Individual-level independent variables			
Number of prenatal visits			
0 (reference category)	1=if no prenatal attendance, 0 otherwise	0.186	0.389
1	1=if one prenatal contact, 0 otherwise	0.055	0.227
2	1=if two prenatal contacts, 0 otherwise	0.112	0.315
3	1=if three prenatal contacts , 0 otherwise	0.184	0.387
4	1=if four prenatal contacts , 0 otherwise	0.141	0.348
5-12	1=if 5-12 prenatal contacts, 0 otherwise	0.314	0.464
13+	1=if thirteen and more prenatal contacts, 0 otherwise	0.008	0.091
Maternal education			
No education (reference category)	1=if no education, 0 otherwise	0.443	0.497
Incomplete primary	1=if incomplete primary education, 0 otherwise	0.230	0.421
Primary	1=if completed primary education, 0 otherwise	0.093	0.291
Incomplete secondary	1=if incomplete secondary education, 0 otherwise	0.170	0.376
Secondary	1=if completed secondary education, 0 otherwise	0.033	0.178
Higher education	1=if post-secondary education, 0 otherwise	0.031	0.173
Maternal age at last live birth			
15-19 years (reference category)	1=if woman is in this age group, 0 otherwise	0.077	0.266
20-29 years	1=if woman is in this age group, 0 otherwise	0.257	0.437
30-34 years	1=if woman is in this age group, 0 otherwise	0.270	0.444
35-49 years	1=if woman is in this age group, 0 otherwise	0.397	0.489
Parity			
1 (reference category)	1=if first parity, 0 otherwise	0.225	0.418
2	1=if second parity, 0 otherwise	0.209	0.406
3	1=if third parity, 0 otherwise	0.155	0.362
4	1=if fourth parity, 0 otherwise	0.119	0.324
5+	1=if five and above parity, 0 otherwise	0.292	0.455
Marital status	1= if currently/formerly married, 0 otherwise	0.971	0.168
Unwanted pregnancy	1=if pregnancy is unwanted, 0 otherwise	0.127	0.333
Woman's employment status	1=if currently working, 0 otherwise	0.538	0.499
Household-level independent variables			
Household wealth quintile			
Quintile 1 (reference category)	1=if household wealth quintile is 1 (poorest), 0 otherwise	0.213	0.410
Quintile 2	1=if household wealth quintile is 2, 0 otherwise	0.200	0.400
Quintile 3	1=if household wealth quintile is 3, 0 otherwise	0.200	0.400
Quintile 4	1=if household wealth quintile is 4, 0 otherwise	0.195	0.396
Quintile 5	1=if household wealth quintile is 5 (richest), 0 otherwise	0.192	0.394
Household size	Number of individuals residing in the household	7.075	4.134
Community-level independent variables			
Urban residence	1=if household reside in urban area, 0 otherwise	0.319	0.466
Poor region	1= if household resides in a poor region, 0 otherwise	0.142	0.349

We have included: the number of prenatal care visits, maternal age at last live birth, marital status, maternal educational attainment and employment status, unwanted pregnancy, and the parity level as the individual-level factors. Frequency of prenatal care visits is a measure of the propensity to use the health system. Frequent contact with the health workers during prenatal care may not only increases mothers' familiarity and confidence in the health system, but also expose them to early detection of obstetric complications. Both of these factors may influence the decision to use a health facility for delivery (Gage, 2007; Gabrysch and Campbell, 2009; Stephenson *et al.,* 2006; Kurk *et al.,* 2010; Yanagisawa *et al.,* 2006). Therefore, to assess the influence of prenatal attendance and its adequacy on women's choice of delivery setting, the number of visits in this study has been divided into seven categories, ranging from one visit to thirteen and more visits (with no visits as the reference category). The number of prenatal visits may also act as a proxy for the amount and quality of care since fewer visits may place a limit on the amount and quality of care that expectant mothers can receive (Magadi *et al.,* 2000).

The level of maternal education is measured by six categories – no education (reference category), incomplete primary education, primary education, incomplete secondary education, secondary education, and higher education. This presentation of education provides a useful estimate of the incremental effect of education on facility delivery use. The literature suggests multiple pathways through which a mother's education level can positively impact health behavior, including increased autonomy and decision making power, greater control over resources, greater ability in accessing and processing new information, and being more efficient in the production of health (Cleland and van Ginneken, 1988; Elo, 1992; Gabrysch and Campbell, 2009; Grossman, 1975; Levine *et al.*, 2004; Ragupathy, 1996). To capture the effects of age, women were classified into five age-groups in the reproductive age period (15-49) (see

table 2.1). Maternal age at delivery is not only an important demographic factor, but also reflects older women's greater experience in using health services, more control over household decision making and higher biological risks (Gabrysch and Campbell, 2009; Glei, *et al.,* 2003; Reynolds, *et al.,* 2006). Older woman are thus expected to use health care services more often. On the other hand, younger woman are more modernized and hence may more likely to use modern health services (Navaneetham and Dharmalingam, 2002). Thus, according to the literature, the effect of age is ambiguous.

Similarly, to capture the influence of parity on facility delivery use, parity is classified into four categories (see Table 2.1). These parity categories reflect the greater health risks associated with the first and grand multiparity (having five and more children) and, as such, imply the greater need for service (Bai, *et al.,* 2002). On the other hand, birthing women with a higher birth order may also find it difficult to deliver at health facilities due to the lack of adequate childcare support and birth attendants' negative comments (Elo 1992; Gage and Calixte, 2006; Short and Zhang, 2004) and due to the important role of accumulated past experiences, such as the knowledge and confidence gained from previous births (Elo 1992; Raghupathy, 1996; Short and Zhang, 2004). Marital status is measured as currently/formerly married versus never married (the reference category).[10] Marital status may reflect female autonomy and access to financial resources (Gabrysch and Campbell, 2009). Single expectant mothers are often poor and stigmatized, since pregnancies bring immense social cost for

[10] The number of observations on 'formerly-married' women was small, especially for Asia. Thus, we chose to aggregate 'formerly- married' with 'currently-married' categories. Combining these two categories is, however, likely to conceal important differences by marital status due to the presence of a partner. We estimated the model for the entire sample using separate dummies for currently-married, formerly-married and never-married, with currently-married being a reference category. The estimated coefficient of the formerly-married dummy was not statistically significant, suggesting that it was appropriate to aggregate formerly-married with currently-married categories.

unmarried expectant mothers in low-income economies, where families do not support out-of-wedlock births, and hence less likely to use maternal health services (Duong *et al.,* 2004).Unwanted pregnancy is represented by a dummy variable which takes the value of one if the pregnancy is unwanted. Women with an unwanted pregnancy are presumed to attach less value to the expected child, and thus expected to use less service (Magadi *et al.,* 2000). Maternal employment status is represented by a dummy variable, which takes the value of one if the woman is currently working and zero if not. On the one hand, women's work status promotes the use of a health facility by providing better access to information, increasing female mobility and overcoming financial barriers, but, on the other hand, it may reflect resource constraints for poor women, and thus associated with a reduced demand for services (Addai, 2000; Desai and Jain, 1994; Gabrysch and Campbell, 2009; Hogan *et al.,* 1999). Two other potential individual-level variables, partner's educational attainment and employment, are excluded from the model due to lack of data.

The household-level variables include household economic status and household size. Household economic status is measured by wealth quintiles using the DHS household wealth index.[11] This index was constructed as the weighted sum of household's ownership of durable consumer items, such as television, bicycles, car and truck; household use of water source and sanitation facilities; indicators of housing quality such as materials used for housing construction for floor and the walls; and other characteristics that reflect economic status (Filmer and Pritchett, 2001).[12]

[11] Since DHS data sets do not provide information on household income and expenditures, household economic status is measured by wealth quintiles using the DHS household wealth index.

[12] The general methodology used to calculate Wealth index is given in Filmer and Pritchett (2001). The specific approach used in the DHS is described in Rutstein and Johnson (2004).

DHS wealth is categorized into five wealth quintiles to distinguish poor from not too poor.[13] There are multiple pathways through which a woman's socio-economic status (ability to pay) is expected to be positively associated with the utilization of maternal health services in general. Greater household wealth may not only reduce financial barriers to care (Bonu et al., 2009; Hotchkiss et al., 2005; Prarta et al., 2004), but also equip women with more modern and receptive attitudes toward modern health care services (Naveentham and Dharmalingam, 2002; Stephenson *et al.,* 2002). The low utilization among poor households may reflect the high cost of access, the aversion to investment in obstetrics care due to low perceived benefits, perception of poor quality of care, or due to greater confidence in traditional birth attendants (Borghi et al., 2006b; Glei et al., 2003). The poor are expected to use not only less care, but also tend to be deficient in terms of the required number of visits and care content (Sepheri *et al.,* 2008).

The community-level variables reflect differences in economic and social constraints of certain ethnic groups and other communities, including differences in health beliefs and practice surrounding birth that are likely to have an important impact on the use of maternal health services (Pebley *et al.,* 1996). Overall, very few researchers have investigated community-level effects on the use of a health facility delivery. Those that do have used a variety of different community-level variables, such as distance to a health facility, place of residence, poverty rate, practice patterns of others in their areas of residence, and proximity to people with secondary or higher education (Gage and Calaxite, 2006; Gage 2007; Sepheri *et al.,* 2008). These studies have found strong evidence that these community-level factors have some influence on the use of

[13] The wealth quintiles are constructed for each country (using the same methodology) and are given with the DHS data sets. We have identified this variable from each country and merged them, like other variables, into our final pooled file. We have not made any changes to this variable and have used it, as provided, for our analysis. Because countries are not identical in tastes, culture etc. it is likely that there was some measurement error induced by the assumption of similar wealth indicators across countries. However, there is little reason to believe that this was substantive enough to undermine relatively robust results.

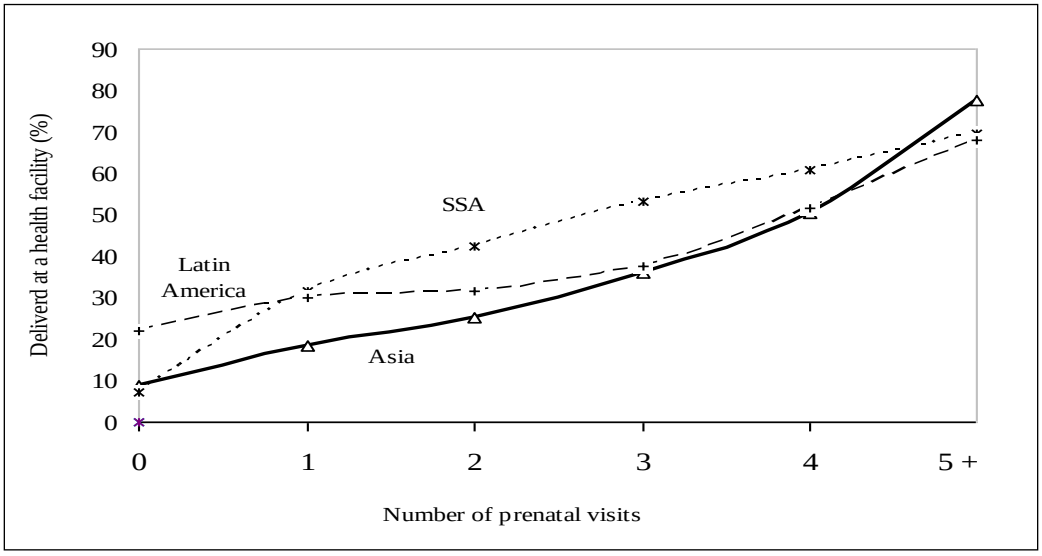
facility delivery. The community-level variables included in this study are the place of residence (urban/rural areas) and a regional poverty indicator. Place of residence highlights the differences in the availability and accessibility of services in urban and rural areas. The prevalence of traditional beliefs and practices, existence of extreme poverty and less availability of services and infrastructure in rural areas hampers service use (Gabrysch and Campbell, 2009; Say and Raine, 2007). A country's region is classified as poor if the share of the poor and near-poor households (the lowest two wealth quintiles) in the total population of the region exceeds the national share by one standard deviation. The poor-region dummy may act not only as a proxy for the state of the region's physical infrastructure and health service environment, but also for ethnicity. Ethnicity is closely linked to place of residence with ethnic minority groups typically accounting for a disproportionately high share of a country's poor and remote areas (Glei *et al.,* 2003). Other potential community-level variables are physical infrastructure and health service environment indicators, such as the state of roads, availability of transport, and the density of health facilities and providers. These are not included in the analysis due to lack of data. DHS provide data on problems posed by transportation and distance to the nearest health facilities when respondents are seeking outpatient care for themselves. However, these data are available for 25 countries. We have used these data to assess the robustness of our results. To measure the effect of country-specific factors on a woman's choice of delivery setting, 31 country dummies are included in the model.

2.4. RESULTS

2.4.1. Descriptive statistics

Figure 2.1 displays the association between the average number of prenatal visits and the use of facility delivery care.

Figure 2.1: The number of prenatal visits and the use of facility delivery care



Three general patterns are evident. First, in the case of Latin America, women with no prenatal visits are more likely to deliver at a health facility than their counterparts in the other two regions. Second, in the case of Sub-Saharan Africa, the likelihood of giving birth at a health facility rises steadily with an increase in the number of prenatal visits, but at a declining rate, with the first prenatal contact increasing the likelihood of delivery at a health facility by 24.2 percentage points, while the subsequent contacts increase the likelihood of giving birth at a health facility by only between 8 to 11 percentage points. By contrast, in the cases of Asia and Latin America, the likelihood of giving birth at a health facility increases modestly with the number of prenatal visits at a declining rate, initially, and then at an increasing rate after two

visits in Asia and three visits in Latin America. Third, over half of the birthing women with four prenatal visits delivered at health facilities in all three regions. Moreover, among those with five and more prenatal visits, 69-78% delivered at health facilities.

Table 2.2 reports the facility delivery use by wealth quintile, the level of maternal education and the place of residence.

Table 2.2. *The percentage of women giving birth in a health facility by wealth quintile, maternal level of education and the place of residence*

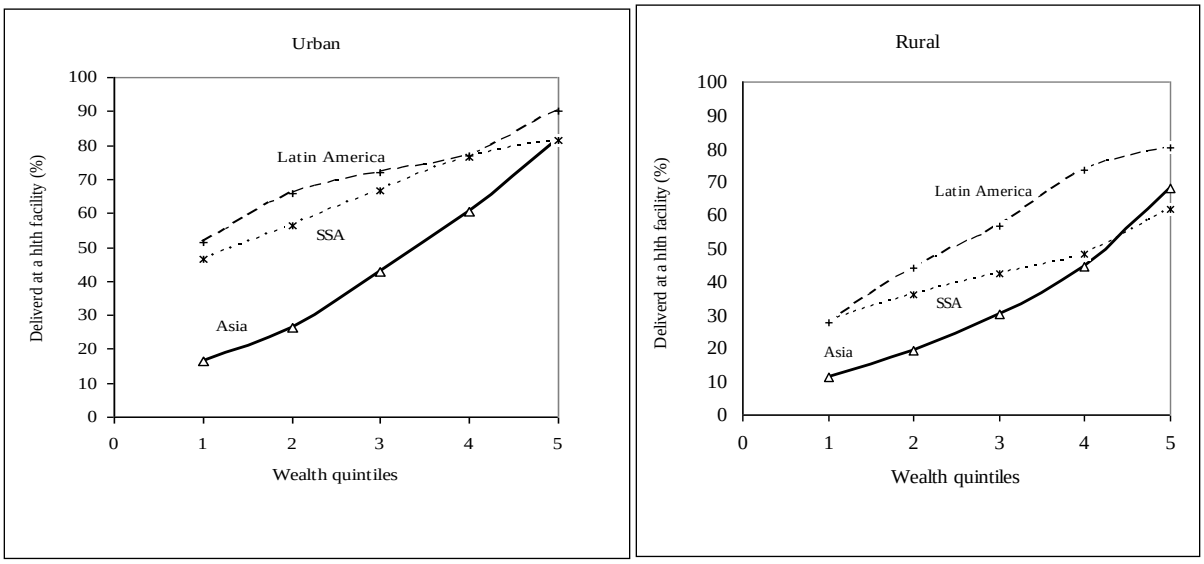
	All countries	Asia	Sub-Saharan Africa	Latin America
Average	47.4	40.3	49.6	55.4
By wealth quintile				
Poor and near-poor[a]	29.0	16.1	33.2	37.1
Middle quintile	44.2	33.7	46.3	64.5
Rich and near-rich[b]	68.4	65.7	68.3	81.9
By the maternal education				
No schooling	31.9	18.8	35.5	32.5
Primary	45.0	25.7	49.4	53.1
Secondary	59.2	50.0	67.1	71.8
Higher	78.2	75.4	80.5	92.4
By place of residence				
Urban	71.7	63.1	75.5	78.1
Rural	35.8	27.9	38.5	41.1

[a] The bottom two wealth quintiles.
[b] The top two wealth quintiles.

The percentage of women giving birth at health facilities varies from as low as 40.3% in Asia to as high as 55.4% in Latin America. These averages mask wide variations in facility delivery use in terms of the economic status, the level of maternal education and the place of residence. Women from the near-rich and rich households (the top two wealth quintiles) are, on average, 2.4 times more likely to deliver at a health facility than their counterparts from the poor

and near-poor households (the bottom two wealth quintiles). For Asia, at a ratio of 4:1, this difference in the place of delivery between these two groups is more pronounced than in other regions. While 32% of women with no schooling delivered at health facilities, on average, 45% and 59% of women with the primary and secondary education gave birth at health facilities, respectively. The incremental effect of primary education on the place of delivery is less pronounced for Asia than it is for the other two geographical regions. The likelihood of delivering at a health facility also varies by the place of residence, with those in the urban areas being twice as likely to deliver at a health facility as those in the rural areas, 71.7% versus 35.8%. The rural-urban gap is most pronounced for Asia. These averages, however, hide wide variations within the urban and rural areas in terms of women's economic status. Figure 2.2 displays the facility delivery use by the place of residence and wealth quintile.

Figure 2.2: The facility delivery use by the place of residence and wealth quintile.



Four points are worth noting. First, the urban wealth gradient is steeper than the rural wealth gradient for Asia and Sub-Saharan Africa. By contrast, the rural wealth gradient is steeper than the urban wealth gradient for Latin America. Second, Asia's urban and rural areas have the

steepest wealth gradients, with both rich urban and rural women being five to six times more likely to deliver at a health facility than their poor counterparts. Third, regional differentiation with respect to the place of delivery declines steadily as the wealth index increases. Fourth, the place of residence appears to be far less significant for Asia's poor and near-poor birthing women than their counterparts in the other two regions. Only 11.4 and 16.5% of Asia's birthing women from the rural and urban poor households, and 19.4 and 26.5% of rural and urban near-poor households, respectively, gave birth at health facilities.

2.4.2. Estimation Results

The regression results for all countries combined, as well as for the three geographical regions, are presented in Table 2.3. The likelihood ratio test clearly rejects the null hypothesis that the standard deviation of the random intercept term is zero, and hence favours the random intercept logistic model over the ordinary logistic model. The intra-community correlation (ρ) and the estimated values of the variance (ψ) of the random intercept term are also shown in the table. The high value of the intra-community correlation term (ρ) for all countries and the three geographical regions, even after controlling for all observed individual-, household- and community-level covariates, suggests that there are some unobserved covariates in the primary sampling units that affect a woman's choice of delivery setting. To facilitate interpretation, the estimated coefficients are converted into odds ratios. The coefficient estimates of 31 country-specific dummies are not reported in Table 2.3.[14]

Regarding the results for all countries combined, all explanatory variables have their expected signs and most are statistically significant at the 1% level, with the exception of marital

[14] The country specific effects are not reported here as they did not show a clear pattern. Not only, does the direction of country specific coefficients vary the magnitude changes with any change in the reference category.

status, employment status, unwanted pregnancy and household size. As expected, prenatal visits were shown to be the leading predictors of the place of delivery, even after controlling for individual-, household- and community-specific characteristics. The results indicate that the odds of giving birth at a health facility vary considerably with the number of prenatal visits. Compared to women with no prenatal visits, having one prenatal visit almost doubles the odds of delivering at a health facility; increases it by more than seven times for those having four prenatal visits; and by as much as 11 times for those having between five to twelve visits. The influence of prenatal visits on the place of delivery is greatest in Sub-Saharan Africa, with one prenatal visit increasing the chance of delivering at a health facility by 3.4 times and three prenatal visits by almost 9 times. By contrast, the incremental influence of the number of prenatal visits on the place of delivery is far smaller in Asia and Latin America, where the first prenatal contact increases the odds of giving birth at a health facility by 80% and three prenatal visits by 2.3 times.

With respect to other individual-level characteristics, education is the strongest predictor of facility delivery care use. Overall, respondents with primary education are 56% more likely to give birth at a health facility than those with no education (the reference category). The influence of maternal education on the choice of delivery setting becomes even more pronounced beyond primary education levels. Women with secondary education and post-secondary education are, respectively, 1.9 and 3.5 times more likely to give birth in a health facility than those with no education. While the incremental influence of primary and secondary education on the place of delivery is similar across the three geographical locations, having post-secondary education increases the odds of giving birth at a health facility by as much as 3.5 times in Asia compared to 2.4 and 2.7 times in Sub-Saharan Africa and Latin America, respectively.

Table 2.3 Regression results for the place of delivery

	All countries	Asia	Sub-Saharan Africa	Latin America
	Odds Ratio (Std. error)	Odds Ratio (Std. error)	Odds Ratio (Std. error)	Odds Ratio (Std. error)
Fixed Part				
Individual characteristics				
No. of Visits				
1	2.8416*	1.8267*	4.3535*	1.7541*
	(0.1059)	(0.1086)	(0.2228)	(0.2639)
2	4.1956*	2.3186*	7.0681*	2.3304*
	(0.1286)	(0.1147)	(0.3002)	(0.2766)
3	6.2281*	3.4528*	9.9636*	3.1591*
	(0.1766)	(0.1678)	(0.3874)	(0.3204)
4	8.3101*	5.3387*	12.6158*	3.7848*
	(0.2465)	(0.2928)	(0.5042)	(0.3694)
5-12	12.0379*	10.5121*	16.7557*	4.8850*
	(0.3376)	(0.5037)	(0.6580)	(0.3867)
≥13	20.0906*	26.8689*	20.1930*	6.2550*
	(1.8280)	(4.3973)	(2.4543)	(2.1543)
Maternal education				
Incomplete Primary	1.3064*	1.3276*	1.3441*	1.0993
	(0.0253)	(0.0603)	(0.0312)	(0.0708)
Primary	1.5596*	1.3558*	1.5916*	1.6242*
	(0.0404)	(0.0694)	(0.0530)	(0.1265)
Incomplete Secondary	1.9640*	1.8650*	1.8885*	2.4933*
	(0.0456)	(0.0698)	(0.0617)	(0.2220)
Secondary	2.8764*	2.5530*	3.0275*	2.8225*
	(0.1331)	(0.1705)	(0.2227)	(0.4678)
Higher	4.4797*	4.5288*	3.3506*	3.7317*
	(0.2590)	(0.3434)	(0.3562)	(0.8968)
Age at last birth				
20-24	1.0973*	1.1323**	1.0853**	0.9615
	(0.0310)	(0.0628)	(0.0391)	(0.0801)
25-29	1.4208*	1.5266*	1.3220*	1.4092*
	(0.0449)	(0.0920)	(0.0541)	(0.1340)
30-34	1.6839*	1.9512*	1.5053*	1.6836*
	(0.0597)	(0.1320)	(0.0688)	(0.1821)
≥35	1.7990*	2.3709*	1.5085*	2.2688*
	(0.0676)	(0.1775)	(0.0723)	(0.2589)
Parity of last live birth				
2	0.5110*	0.4770*	0.5509*	0.4630*
	(0.0113)	(0.0176)	(0.0167)	(0.0325)
3	0.3970*	0.3192*	0.4674*	0.3596*
	(0.0102)	(0.0145)	(0.0161)	(0.0300)
4	0.3329*	0.2671*	0.4001*	0.2502*
	(0.0099)	(0.0149)	(0.0153)	(0.0243)

*1% Significant level; ** 5% Significant level; *** 10% level

Table 2.3 (continued)

	All countries	Asia	Sub-Saharan Africa	Latin America
	Odds Ratio (Std. error)	Odds Ratio (Std. error)	Odds Ratio (Std. error)	Odds Ratio (Std. error)
≥ 5	0.2880*	0.2360*	0.3487*	0.2079*
	(0.0088)	(0.0142)	(0.0136)	(0.0210)
Marital Status	1.0346	0.8981	1.0257	0.9628
	(0.0434)	(0.3713)	(0.0467)	(0.1181)
Employment Status	0.9920	0.8928*	1.0361***	0.9389
	(0.0163)	(0.0279)	(0.0219)	(0.0464)
Unwanted Pregnancy	0.9900	1.0090	1.0175	1.0062
	(0.0217)	(0.0441)	(0.0298)	(0.0535)
Household-level Variables				
Wealth Quintile				
quintile 2 (near poor)	1.3238*	1.3544*	1.2734*	1.6205*
	(0.0293)	(0.0672)	(0.0344)	(0.0985)
quintile 3 (middle)	1.6751*	1.8067*	1.5236*	3.1227*
	(0.0401)	(0.0934)	(0.0441)	(0.2641)
quintile 4 (near rich)	2.3309*	2.4958*	2.1081*	4.7911*
	(0.0621)	(0.1387)	(0.0684)	(0.5136)
quintile 5 (richest)	4.2316*	4.6745*	3.6408*	9.0199*
	(0.1416)	(0.3036)	(0.1544)	(1.2563)
Household Size	0.9994	0.9959	1.0005	1.0023
	(0.0019)	(0.0041)	(0.0023)	(0.0081)
Community-level Variables				
Urban* quintiles 1-2	2.7315*	2.1198*	3.0097*	3.3207*
	(0.1295)	(0.1702)	(0.2019)	(0.3991
Urban* quintiles 3-4-5	3.1879*	2.3050*	3.8392*	2.4028*
	0.0943	(0.1105)	(0.1588)	(0.2301)
Poor regions	0.6492*	0.6116*	0.6796*	0.8086**
	(0.0232)	(0.0364)	(0.0342)	(0.0684)
Random Part				
ρ^a	0.2832	0.2739	0.2885	0.1873
ψ^b	1.2998	1.2410	1.3340	0.7581
LR test statistic [c]	12325.98*	2557.68*	8632.24*	447.91*
level 1 units	196838	58391	121170	17277
level 2 units	17539	6187	9369	1983

*1% Significant level; ** 5% Significant level; *** 10% level

[a] Intracluster correlation.

[b] Variance of the random intercept term.

[c] Comparing random intercept logistic model against ordinary logit model.

The likelihood of giving birth also varies positively with maternal age; with adolescents being the most disadvantaged age group. Two general patterns are evident. First, the age gradient is steeper for Asia and Latin America than it is for Sub-Saharan Africa. In Asia, birthing women

aged 30-34 and 35 years and older are, respectively, 95% and 137% more likely to give birth at a health facility than adolescents aged 15-19 (the reference category), whereas in Sub-Saharan Africa women in the same age groups are 51% more likely to do so. Second, in Latin America, the odds of giving birth at a health facility by birthing women in their early 20s are not significantly different from those for adolescents. The estimated results for birth order dummies suggest that use of the facility delivery drops monotonically with an increase in the birth order. The negative influence of birth order on the place of delivery is greater for Latin America and Asia than it is for Sub-Saharan Africa. In Latin America, compared to the birthing women of first parity (the reference category), women of the second parity are 54% less likely to give birth at a health facility, and women of fifth and higher parity are by as much as 79%. Marital status does not have a statistically significant effect for any of the three geographical regions. The influence of employment on the place of delivery is rather mixed. While women's employment status has little effect on the place of delivery in the three regions combined, it has a negative and significant effect on the place of delivery in Asia, and a positive and significant effect in Sub-Saharan Africa.

With respect to the household-level variables, the odds of giving birth at a health facility increases monotonically with household economic status. Birthing women from the top two wealth quintiles of households are, respectively, 1.3 and 3.2 times more likely to deliver at a health facility than those from the lowest wealth quintile (the reference category). The wealth gradient is more pronounced in Latin America, where women from the top two wealth quintiles of households are, respectively, 3.8 and eight times more likely to deliver at a health facility than those from the poorest wealth quintile. This is an interesting contrast with the unconditional relationship, presented in Figure 2.2 above, which showed a steeper wealth gradient for Asia.

The difference likely derives from the fact that the simple, unconditional, relationship reflects both income and education effects. Overall and across regions, household size is not a significant predictor of the place of delivery. As expected, urban women are found to be more likely to deliver in a health facility than rural women.

To assess the effect of the place of residence on the place of delivery at various levels of wealth, an interaction term combining urban and wealth quintile was added to the list of explanatory variables. The results indicate that urban women, regardless of wealth level, are more likely to deliver in a health facility than rural women, and that the urban-rural gap in the use of facility delivery care becomes larger as wealth increases but not by a great amount – suggesting that location dominates wealth, in terms of influence on choice of facility deliveries. Urban women from the top three wealth quintiles of households are 2.2 times more likely to deliver at a health facility than rural women, while urban women from the bottom two wealth quintiles are only 1.7 times more likely to do so.[15] The results for both Asia and Sub-Saharan African indicate a similar pattern of utilization. However, the urban-rural differences are more pronounced for Sub-Saharan Africa, where urban women from the bottom two wealth quintiles and from the top three wealth quintiles of households are, respectively, twice and 2.8 times more likely to deliver at a health facility than rural women.[16] By contrast, in the case of Latin America, the location and wealth effects are contradictory. The urban poor are more different, in their choice of facility delivery, from rural women than the urban rich. Lastly, as expected, residents of the poor regions are 35% less likely to deliver in a health facility than the residents of the non-

[15] Testing for equality of the coefficients on the interaction terms between wealth quintiles and urban suggested that certain interaction terms could be aggregated as shown in Table 2.3.

[16] Tests of the equality of the coefficients on the two interaction terms was not rejected for Asia, but was rejected for Sub-Saharan Africa.

poor regions (the reference category). The influence of regional poverty on delivery is less pronounced in Latin America, where the residents of the poor regions are only 19% less likely to give birth at a health facility than those from the non-poor regions.

2.5. DISCUSSION

As anticipated, the results of this investigation support the presumption that a woman's decision regarding the place of childbirth is significantly associated with the number of prenatal care visits, and several observed individual-, household- and community-level characteristics, as well as by unobserved community-level characteristics. Moreover, though the strength and magnitude of the effect of the number of prenatal visits on the place of delivery has been found to vary across the three geographical regions, the patterns are generally consistent.

This result is consistent with the findings from country- and region-specific studies, that prenatal attendance does appreciably influence the use of facility delivery across all the global regions examined (see for example, Bloom *et al*., 1999; Gage 2007; Sepehri *et al*., 2008; Thind *et al*., 2008). Moreover, the association becomes stronger for women with greater prenatal care visits, from 1.8 times for women with one prenatal visit to 7.3 times for those with four visits (WHO's recommended minimum number of visits). The influence of prenatal contacts on the place of delivery is found to be more pronounced in Sub-Saharan Africa than in Asia and Latin America. The significance of prenatal contact and its increasing incremental effect on the delivery location likely reflects the role that prenatal care has in terms of informing women of the potential benefits of delivering at a health facility (Bloom *et al*., 1999; Gabrysch and Campbell 2009; Gage, 2007; Stephenson *et al.,* 2006; WHO, 2003). An alternate explanation is

that these results may highlight the selectivity effect, whereby the observable and unobservable characteristics, such as the availability and access to prenatal and facility delivery, a previous history of pregnancy and delivery related complications that predispose birthing women to seek prenatal care, make them more likely to give birth at a health facility (Gabrysch and Campbell, 2009; Stephenson *et al*., 2006). In this case, the frequency of prenatal visits in the delivery assistance equation would be potentially endogenous and ignoring non-random institutional deliveries would lead to invalid inference on the number of prenatal visits. However, tests for the exogeneity of the frequency of prenatal visits indicate no evidence of a significant selectivity effect.[17] We also re-estimated the delivery model using additional information on problems posed by transportation and distance to the nearest health facilities for a subset of countries for which the data are available. The estimated parameters of the number of prenatal visits were found to be robust to the inclusion of these additional variables.[18] The selectivity effect can thus

[17] The hypothesis of exogeneity of the number of prenatal visits can be defined as the absence of correlation between the error terms in the delivery assistance and the frequency of visits equations (Green, 2003). We estimated a series of recursive bivariate probit models to test for the potential correlation between error terms in delivery assistance and the frequency of visits equations. These types of models are known as seemingly unrelated bivariate probit models in which the two equations have different specifications, but are not independent as they are computed on the same set of subjects. In effect, every time we ran this model, we have two dependent variables. For instance, institutional delivery and visit one, institutional delivery and visit two and so on. The independent variables include all the explanatory variables included in this study with the exception of number of visits in delivery equation. The reported likelihood-ratio tests suggest that the two errors terms are not significantly correlated, thus institutional deliveries and the frequency of prenatal visits do not be appear to be jointly determined. It should also be noted here that there are other new and, perhaps, more powerful tests, such as Instrumental variables (IV), and the use of panel data and individual fixed effects, to check for exogeneity in the number of visits. But these tests were not feasible in this particular case. The use of panel data and fixed-effects estimation cannot be applied in a purely cross-sectional framework and, though IV estimation is theoretically possible, because both the number of visits and delivery assistance are generally influenced by the same set of variables, it is rather hard to come up with valid instruments.

[18] Availability and accessibility of health services is certainly a crucial dimension of the use of health services. Thus, on one hand, we do have an omitted variable in our analysis, but on the other hand, the robustness of our results shows that it is not a source of significant omitted variable bias. Moreover, facility availability could be a source of endogenity between error terms and frequency of visits. But, again, the robustness of the parameters clearly shows that facility availability was not the issue. The results for those 25 countries were not presented as it was only for a subset of countries and the model was re-run for a check on robustness only. We struggled with the issue of whether to stick to the 25 country sample for the study or go for the larger sample and, in the end went for the greater coverage. Once we choose the larger sample we felt it would be too confusing to be quoting the results for two samples (with different explanatory variables) in one study.

be excluded as a likely explanation of the estimation results. Our results on the influence of other individual-level characteristics, including maternal education and age, and parity level, are generally in line with those reported for low-income countries (Anwar *et al*., 2008; Bloom *et al*., 1999; Elo,1992; Gabrysch and Campbell, 2009; Hotchkiss, *et al.,* 2005; Pebley *et al*., 1996; Raghupathy, 1996; Sepheri *et al.,* 2008). The incremental effect of maternal education, age and parity on the use of delivery services is found to vary across three geographical regions.[19] These variations across regions in the choice of delivery setting may reflect regional variations in overall levels of development, modes of delivery of services, degree of dispersion of populations and cultural norms and practices surrounding birth. Private provision of health care services is more developed in Asia than in the other two regions. The importance of private care in Asia may explain the more pronounced education and maternal age effect on the choice of delivery place. Both age and education may allow women to better assess the cost and benefits of using health facility for delivery.

Finally, the finding that a woman's employment status has little effect on her choice of delivery setting in Latin America, but a negative effect in Asia and a positive effect in Sub-Saharan Africa, points to potential multiple pathways through which a woman's working status can influence the use of facility delivery. Seeking employment outside the home may encourage women's use of health facilities for childbirth facilities by providing them with an increased range of movement, better access to information, and more resources (Gabrysch and Campbell, 2009; Hogan *et al.*, 1999). However, employment may not necessarily be associated with greater use of obstetric care if: (i) women have little control over their earnings; (ii) employment is

[19] Since the model does not control for the partner's education, the estimated coefficients of maternal education dummies are likely to be biased upward. Re-estimating the model for a subset of the sample for which data on partner's education is available suggests that the size of bias is rather small (between 4-14%).

largely poverty-induced and reflect resource constraints; and (iii) employment is seasonal and poorly-remunerated (Addai, 2000; Desai and Jain, 1994; Gabrysch and Campbell, 2009). Data on women's occupation is available only for a sub-set of the countries under consideration. According to these data, far fewer respondents in Asia than in Sub-Saharan Africa reported currently-working (36 versus 65%) and those who worked outside the home in Asia were disproportionately from poor and near-poor households, and they were mainly engaged in agriculture as hired workers (38%) or self-employed (22%). By contrast, less than 4% of the currently-working women in Sub-Saharan Africa worked as hired agricultural workers, while almost 55% reported being engaged in agriculture as self-employed. Moreover, far fewer women in Asia work in sales than in Sub-Saharan Africa (9 versus 21.5%). In contrast to Asia and Sub-Saharan Africa, far fewer women in Latin America work in agriculture, either as self-employed (8%) or as employees (9%), with almost half of the sample population being engaged in sales and unskilled manual jobs. These patterns of employment would seem to support the view that work is much more of a response to poverty in Asia than it is in Sub-Saharan Africa, thus leading to contrasting effects indicated by the estimation results.

Besides individual-level factors, women's choice of delivery setting is also influenced by a number of observed household- and community-level characteristics. The findings that the utilization of delivery care varies across wealth quintiles point to financial barriers, including both direct and indirect costs of accessing obstetrics care. Expected costs of institutional delivery have been found to have a negative effect, both for poorer and better-off households, with the women in poor households being considerably more price-responsive than those in better-off households (Hotchkiss *et al.*, 2005). A number of low-income countries have already waived or substantially reduced user fees for maternal care services, resulting in higher utilization and

lower wealth inequities (Allegri *et al*., 2011; Penfold *et al.,* 2007). However, in many low-income countries the cost of delivery at a health facility is substantial, even in places where maternal health care services are nominally provided free of charge (Bonu *et al*., 2009; Borghi *et al*., 2008; Borghi *et al*., 2006a; Kruk, *et al.*, 2009; Perkins *et al.*, 2009; Prata *et al*., 2004). In addition to the official and unofficial provider fees and the costs of medications and supplies, households often face significant additional costs, including transportation, lodging and the time spent away from productive activity.

Our results on place of residence and interaction with household wealth quintiles suggest that urban women are more likely to use facility delivery care than rural women, and that the urban-rural gap increases with household wealth in Sub-Saharan Africa, while it decreases in Latin America. Urban centers provide a wide variety of public and private obstetrics care with varying quality to those who can afford them. Moreover, rural women may also have alternative delivery venues, such as traditional birth attendants and community midwives, that are likely to be more financially affordable and culturally acceptable (Glei *et al*., 2003). In their analysis of demand for public health facility deliveries in Morocco, rural women were found not only to be more price-sensitive than their urban counterparts, but price-elasticity was slightly greater than one, indicating that user fee increases would lead to a more than proportional reduction in the use of public health facility deliveries (Hotchkiss *et al*., 2005). The wealth-related urban-rural gaps may also reflect greater barriers to access, including distance and transportation, faced by the rural women in Sub-Saharan Africa. Similarly, the findings that women living in poor regions of a country are less likely to deliver in a health facility may reflect many supply and demand side barriers such as undersupply of facilities and providers, especially females, in these regions, poor quality of obstetric services, and lack of access to transportation. Sub-Saharan Africa is the

poorest of the three regions and, not surprisingly, the urban-rural divide is strongest in that region.[20] By contrast, the weaker effect of geographic attributes (in the form of urban residence and the level of regional poverty) in Latin America may reflect the higher level of development of the region and greater overall access to facilities in general.

These findings have important policy implications for the utilization of obstetrics care in low-income countries. The significance of prenatal attendance on women's decisions to give birth at health facilities in all three geographical regions suggests policy efforts aimed at increasing the coverage of facility delivery in low-income countries should strengthen demand and quality of prenatal care so that birthing women get at least four visits from a competent provider (as suggested by WHO guidelines). In particular, more emphasize should be given to the education and communication content of prenatal care that empower birthing women and their families to make an informed decision regarding the place of birth. Given the low quality of educational components of the existing prenatal programs in many low-income countries (Gabrysch and Cambell, 2009; Nikiema *et al.*, 2010), the effectiveness of these programs could be improved by ensuring that the provision of quality and client-centered counseling and advice earns the trust of expectant mothers and encourages them to obtain adequate prenatal care. The large incremental effects of the number of prenatal visits on the use of facility delivery, especially in Sub-Saharan Africa, also suggest that timely and adequate prenatal visits are essential for improving the coverage of delivery service use.

[20] One might argue that the differences in HIV prevalence between countries in East and Southern Africa and the rest of the sample could be driving our results. However, out of 23 sub-Saharan African countries that we have in our sample, only five of them are high HIV-prevalence countries (namely Lesotho,Malawi, Mozambique, Zambia and Zimbabwe) and only three are mid-to-high HIV-prevalence countries (Kenya, Tanzania and Uganda). Therefore, it is highly unlikely that they are driving the results because they are both a numerical and heterogeneous minority.

Some caveats are in order. While the quality of DHS data is quite high for low-income countries, common data limitations remain. The data on the utilization of maternal services are subject to recall errors and the wealth index, as a measurement of household socio-economic status, has been criticized for being too urban in the construction of the household wealth index (Rutstein, 2008), and is also problematic for cross country analysis. Moreover, the study does not adequately control for the availability and quality of obstetrics care. Since DHS, like other population based surveys, make no claim to ascertaining provider skill, all medical staff attending birth qualifies as skilled birth attendants, even if they have little training in the skills needed to manage normal pregnancies and identify and manage the referral of complications (Harvey *et al*., 2007). In many resource-poor settings, both the shortage and competency of health care providers is one important barrier and a birthing woman may not necessarily receive competent care, even if she delivers at a formal health facility (Harvey *et al*., 2007; Koblinsky *et al*., 2006; Nikiema *et al*., 2010; Ross and Begala, 2005). The problem is further compounded by the lack of a supportive infrastructure, including the lack of drugs and equipment, ineffective supervision, low morals, and poor attitudes towards patients (Koblinsky et al., 2006; Ross and Begala, 2005). That being said, it remains true that, for low-income countries as a group, facility delivery is significantly more likely to be associated with care by a skilled attendant than is a home birth.

2.6. CONCLUSION

Using the Demographic Health Surveys data from 32 low-income countries across Asia, sub-Saharan Africa and Latin America, and an appropriate modeling framework, this paper demonstrated that number of prenatal visits had a significant impact on women's decision to use

a health facility for delivery across all regions. This indicates a need for concerted effort in motivating women to utilize antenatal services. The importance of prenatal care is more pronounced for low-income countries, given the high maternal mortality and morbidity in these economies.

Additionally, at the individual and household level, health promotion strategies that increase awareness, empowerment and the financial status of women can help to increase the frequency of facility births, given the strong impact of maternal age, education and household socioeconomic status on the use of a health facility of delivery. At the community level, there is a need for introducing appropriate financing systems so as to cover not only the direct, but also the indirect, costs of access to health services by the poorest segments of the population since these factors likely play a role in their lesser use of facility delivery.

APPENDIX 2

Table A.2.1. List of low-income countries, by survey year and region

Asia	Ethiopia 2005
Bangladesh 2007	Ghana 2008
Cambodia 2005	Guinea 2005
India 2005-06	Kenya 2003
Nepal 2006	Lesotho 2004
Vietnam 2002	Liberia 2007
Pakistan 2006-07	Madagascar 2003-04
	Malawi 2004
Latin America	Mali 2006
Haiti 2005-06	Mozambique 2003
Honduras 2005-06	Niger 2006
Nicaragua 2001	Rwanda 2005
	Senegal 2005
Sub-Saharan Africa	Sierra Leone 2008
Benin 2006	Tanzania 2007-08
Burkina Faso 2003	Uganda 2006
Cameroon 2004	Zambia 2007
Chad 2004	Zimbabwe 2005-06
Congo, Dem. Rep 2007	

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CHAPTER 3

Determinants of prenatal care use: evidence from thirty-two low-income countries across Asia, Sub-Saharan Africa and Latin America

Abstract

While much has been written on the determinants of prenatal care attendance in low-income countries, comparatively little is known about the determinants of the frequency of prenatal visits in general and whether there are separate processes generating the decisions to use prenatal care and the frequency of use. Using the Demographic and Health Surveys (DHS) data for thirty-two low-income countries (across Asia, Sub-Saharan Africa and Latin America) and an appropriate two-part and multi-level model, this essay empirically assesses the influence of a wide array of observed individual-, household- and community-level characteristics on a woman's decision to use prenatal care and the frequency of that use (while controlling for unobserved community-level factors). The results suggest that, though both the decision to seek care and the number of prenatal visits are influenced by a range of observed individual-, household- and community-level characteristics, the influence of these determinants vary, in terms magnitude of their effect, between prenatal care attendance and the frequency of prenatal visits. The magnitudes of those influences also vary across the three geographical regions (for both dependent variables). Moreover, unobserved community-level variables appear to have an impact on the decision to seek care but not on the number of visits. Finally, the findings that teenage mothers, unmarried women, and those with unintended pregnancies are less likely to seek prenatal care and have fewer visits suggest that safe mother programs need to pay particular attention to these disadvantaged and vulnerable sub-groups of the population.

Keywords: prenatal care; multilevel analysis; two-part model; low-income countries

3.1 INTRODUCTION

Great efforts have been made during the past two decades to improve access to, and the utilization of, prenatal care in low-income countries. While over three-quarters of pregnant women seek at least one prenatal contact with a health professional, only 39% of women benefit from the minimum WHO-recommended four prenatal visits (WHO, 2010). There also remain substantial disparities in prenatal care attendance and the frequency of use, both between and within low-income countries (Gwatkin, *et al.,* 2007; Houweling, *et al.,* 2007). While the benefits of routine prenatal care are still debated, some elements of prenatal care have clearly been shown to reduce complications and improve birth outcomes (Carroli *et al.,* 1988; Fiscella, 1995; McDonagh, 1996; Rooney, 1992). Prenatal care attendance offers multiple opportunities to reach expectant mothers with information on any risks related to labour and delivery, and as a way of promoting deliver with the assistance of a skilled health care provider (Bloom, *et al.,* 1999; Campbell and Graham, 2006; Gage, 2007; WHO, 2003). Timely and adequate prenatal care has also been found to be important for the health of newborns (Halim *et al.,* 2010; Maitra, 2004). In addition, prenatal care can be an entry point for the prevention of HIV transmission from mother to children. Prenatal care attendance can also, especially in rural settings, facilitate women's access to medical care for future needs (Pallikadavath, *et al.* 2004).

While much has been written on the determinants of *prenatal care attendance* in low-income countries, comparatively little is known about the determinants of the *frequency of prenatal visits* in general, and whether there are separate processes generating decisions regarding any use of prenatal care and the frequency of use in particular (Addai, 2000; Alexandre *et al.,* 2005; Gage, 2007; Gage and Calixte, 2006; Habibov and Fan, 2008; Halim *et al.,* 2010; Magadi *et al.,* 2000; Magadi *et al.,* 2003; Magadi *et al.,* 2007; Sepehri *et al.,* 2008). Moreover,

most of the existing studies are country-specific and it is unclear whether the influence of the main determinants of prenatal care utilization varies in magnitude across geographical regions. The primary purpose of this essay is to address those shortcomings in the literature. Using Demographic and Health Surveys (DHS) data for thirty-two low-income countries across Asia, Sub-Saharan Africa and Latin America, this essay empirically assesses the influence of a wide array of observed individual-, household- and community-level characteristics on a woman's decision to seek prenatal care *and* the frequency of use (while controlling for unobserved community-level factors). Cross-county studies have their own usefulness in terms of capturing broad patterns and trends in utilization of maternal health care services at the global level that could be used as an input into formulating overall policy strategies (Wang, 2003).

The remainder of this chapter is organized into five sections. Section 3.2 presents a review of the literature. Section 3.3 provides an overview of the data, methodology and variables used. Section 3.4 presents the descriptive and empirical findings. Section 3.5 discusses the implications of results, while section 3.6 concludes the chapter.

3.2 LITERATURE REVIEW

A wide range of empirical studies have examined the utilization of maternal health services in low-income countries. Six of these studies examined the factors associated with the use of prenatal care attendants (Babalola and Fatusi, 2009; Pallikadavath *et al.,* 2004; Pebley *et al.,* 1996; Reynolds *et al.,* 2006; Short and Zhang, 2004; Trinh *et al*., 2007). In general, this literature suggests an important role for individual, household factors, as well as factors operating at the community level, in determining the utilization of prenatal care services. These

studies consistently reported a positive association between age, education, socioeconomic status, marital status and place of residence on the use of prenatal services.

Another set of six of these studies tried to identify the determinants of the frequency and timings of visits (Addai, 2000; Gage, 2007; Gage and Calaxite; 2006; Magadi *et al.,* 2000; Magadi *et al.,* 2003; Magadi *et al.,* 2007). Magadi *et al.* (2000), in their analysis of frequency and timings of prenatal care for Kenya, showed that high socioeconomic status, low parity, and planned pregnancies were associated with frequent use of antenatal visits and early first visits. Substantial distance to nearest health care facility was found to be an obstacle to receiving adequate prenatal care. Similarly, Gage and Calaxite (2006) highlighted the lack of availability of services and poor road conditions as significant factors in reducing the frequency and timeliness of receipt of prenatal care in rural Haiti. Gage (2007) also emphasised that, whereas the shortage of health facilities was a barrier to receipt of prenatal care in the first trimester, transportation barriers were more important for four or more prenatal visits. Addai (2000) estimated not only the factors associated with the use of a doctor for prenatal care, but also the determinants of the choice of four or more antenatal check-ups. Using the logistic regression models, the results provided some useful insights into the significance of cultural, social and demographic, and accessibility variables in shaping the use of prenatal services in rural Ghana.

In a large scale study, Magadi *et al.* (2003) also looked at the frequency and timings of antenatal care among the urban poor, other urban residents and rural women across 23 sub-Saharan African economies. The results indicate that while, on average, the urban poor receive better antenatal care than the rural poor, the urban poor are much worse off than the urban non-poor. The urban poor are more likely, than the non-poor, to initiate antenatal care late in pregnancy and make fewer visits to a health facility during pregnancy. In another cross country analysis,

Magadi *et al.*, (2007) showed that (across a group of Sub-Saharan African countries) teenagers were more likely to initiate antenatal care late and receive inadequate visits (less than four) during pregnancy compared to older women, even after taking into account important factors such as parity, premarital births, educational attainment and rural/urban residence.

However, there are only four studies in the literature that have tried to separately analyze the two decisions that ultimately determine the level of prenatal care - the decision to seek care and the frequency of use - in low-income countries. Studies by Habibov and Fan (2008) on Tajikistan, Sepheri *et al.* (2008), on Vietnam, Alexander *et al.* (2005), on Haiti, and Halim *et al.*(2010) on Nepal have empirically examined whether the patterns are similar or different for *any use* of prenatal care compared to *the frequency of use*. In all of these studies, the decision to use any care and the number of prenatal visits was analyzed using a two-part model. The multivariate analysis used a binary logistic regression model to predict and explain the probability of seeking prenatal care, while negative binomial models were used to predict and explain the frequency of visits by the subgroup of women who sought prenatal care. While the majority of these studies found that maternal education, parity, partner's education, maternal age, marital status, unwanted pregnancy, household living standards, place of residence and socioeconomic status were primary constraints in the use of maternal health services, their effect varied over the two decision making processes. For instance, Habibov and Fan (2008) showed that certain variables such as poverty and perceptions of low quality of health care service were the strongest predictors of the use of prenatal health services; these variables did not affect the second stage decision – the frequency of use. Similarly, Sepehri *et al.* (2008) have shown that influence of certain variables, such as incremental effect of maternal education, marital status, are greater on the use of any prenatal care than on the number of visits. Their results also

showed that, while place of residence has no influence on the decision to seek prenatal care in Vietnam, it has a positive influence on middle- and high-income women's decisions on the number of prenatal visits. The findings on the determinants of utilization of prenatal care services in urban and rural Haiti by Alexander *et al.* (2005) also suggest that, whereas mother's and partners' education levels were the strongest predictors of prenatal care use in rural areas, longer travel times and greater distances to dispensaries in rural areas were substantial barriers to repeated prenatal visits among women who sought prenatal care. However, Halim *et al.* (2010) showed that educational attainment and access to the media, in addition to cultural, geographic and demographic controls, influence both the use of antenatal care and the frequency of antenatal visits in 1996 and in 2001 in Nepal.

3.3 DATA AND METHODOLOGY

3.3.1 Data

This paper uses the most recent data from Demographic and Health Surveys (DHS) for thirty-two low-income countries from the regions of Asia, Sub-Saharan Africa and Latin America. The DHS years for various countries range from 2001 to 2008.[21] Since the survey years vary by country, only those countries whose per capita income was below the World Bank cut-off point for low-income status during the survey year were selected.[22] The DHS are large-scale household surveys that use a multistage cluster sample design to collect information on nationally representative samples of women of reproductive age. DHS collect, among other things, information on reproductive histories, fertilities, family planning, as well as data on

[21] Appendix to this chapter provides a list of countries, by survey year and region.

[22] In order to benefit from a large sample for Latin America, we have included Honduras. Honduras' per capita income in 2005, the year of the DHS survey, was slightly above the cutoff point.

respondents' various socio-economic characteristics such as age, education, gender, marital status, employment status, ethnicity, and religion. The pregnancy and postnatal care section of the survey collects detailed information on the use of prenatal care, the number of prenatal visits, place of delivery, and other maternal and child health services received by all sampled women aged 15 to 49 years. The overall sample in this study consists of 200,417 women who had their last baby born alive in the five years preceding participation in the survey.

3.3.2 Estimation Method

The utilization of prenatal care can be disaggregated onto two broad measures of access: (1) the use of prenatal care, which takes the value of one if an individual, seeks prenatal care (during the pregnancy of her last baby born alive) and zero if an individual does not seek prenatal care, and (2) the number of prenatal visits. The number of prenatal visits may also act as a proxy for the amount and quality of care, with fewer numbers of visits limiting the amount and quality of care that an expectant mother can receive (Erbaydar 2003; Magadi *et al.* 2000; Trinh *et al.* 2007). It is important to analyse weather the factors underlying the two decision-making processes are similar or different because of the distinct nature and approach to health care utilization. The decision to seek care is generally initiated by mother, but the frequency of use is decided jointly by both health care provider and expectant mother. While the health care provider may decide the number of visits, an expectant mother can decide to abide by it or not. Moreover, in the developing world, the poor continue to use not only less care, but also tend to be inadequate in terms of required number of visits and care content (Sepehri *et al.,* 2008). Therefore, this disaggregation allows us to more clearly identify the factors that motivate what is, essentially, a two-part decision.

A woman's decision on the utilization of prenatal care is best modeled using a hurdle or two-part model (TPM), as initial contact and frequency decision needs to be treated as 'different stochastic processes' (Pohlmeier and Ulrich, 1995). [23] The first part models the probability that the hurdle is crossed; the second part is a truncated count data model. The idea behind the hurdle model is that a binomial probability model governs the realization of the first zero/non-zero outcome, while, in the second stage, a truncated distribution describes a range of positive outcomes. The data generating process for the second stage might be significantly different from the first stage. In the context of our analysis, the first part specifies the decision to seek prenatal care (the 'hurdle' specification) and the second part determines the extent of utilization among those birthing women who had at least one visit ('level' specification).

Underlying the TPM is the assumption that separate processes may govern the decisions to use the service and the frequency of use. Factors that determine women's decision to use prenatal care services may differ from those that determine its frequency. The TPM is often interpreted in a principal-agent type framework in which the physician (agent) partly determines utilization on behalf of patient (principal), once initial contact has been made (Zweifel, 1981). Particularly, the decision to seek prenatal care is assumed to be initiated by the expectant mother, while the number of visits would be decided jointly by the expectant mother and the health care provider. A TPM is also considered to be conceptually more appropriate for modeling health care utilization where the number of visits made by an expectant mother during her pregnancy meets the underlying "single illness spell" assumption of the TPM (Pohlmeier and Ulrich, 1995).

[23] A two-stage model with count variables has been widely employed in the empirical analysis of health care utilization. Pohlmeier and Ulrich (1995), Deb and Trivedi (1997), Lahiri and Xing (2004), Alexender *et al.,* (2005) and Sepheri *et al.* (2008) have used two-stage approaches for analyzing the demand for various types of health care utilization.

In the first stage, our dependent variable is binary and, therefore, the probability of seeking care can be modeled using a binary logistic regression. In the second stage, our dependent variable is a count variable reflecting the number of times birthing women visit health care services. Although a truncated Poisson model is usually employed for count-dependent variables, it often suffers from over-dispersion (Long and Freese, 2006). We have, therefore, employed an alternative approach, a truncated negative binomial model, to estimate the frequency of visits. In our hurdle specification, the first part of the likelihood function is the binary process defined over the total sample and the second product is the likelihood of a truncated at zero negative binomial models, defined over the sample of woman who decided to seek care.

To the extent that a women's decisions to seek prenatal care and the frequency of its use is influenced by the unobserved characteristics of the community, the likelihood of women seeking prenatal care is likely to be correlated among community members. In this case, the application of standard binary logistic regression models leads to bias (Rabe-Hesketh and Skrondal, 2005). The dependence among the community members' health-seeking behaviour can instead be explicitly modeled using a random-intercept logistic model.

Suppose the likelihood of accessing prenatal services for the i^{th} individual in the j^{th} cluster or community is given by:

$$\text{logit}\{\Pr(y_{ij}=1 \mid x_{ij}, \zeta_j)\} = \alpha + \beta' x_{ij} + \zeta_j \quad (1)$$

Where α is the constant or intercept, β is a vector of regression coefficients corresponding to observed individual-, household- and community-level covariates x_{ij}, and ζ_j is a random intercept. The random intercept represents the combined effect of all omitted community-level

covariates that is involved in the decision to seek prenatal care for a significant number of women in the community. The random intercept is assumed to be normally distributed with a zero mean and variance ψ .

Assuming that the observed dichotomous response y_{ij}, represents an unobserved or latent continuous response y^*_{ij}, the random intercept logistic regression (1) can alternatively be specified as a linear regression model:

$$y^*_{ij} = \alpha + \beta' x_{ij} + \zeta_j + \varepsilon_{ij}$$

Or equivalently,

$$y^*_{ij} = (\alpha + \zeta_j) + \beta' x_{ij} + \varepsilon_{ij} \qquad (2)$$

$$y_{ij} = \begin{cases} 1 & if \quad y^*_{ij} > 0 \\ 0 & otherwise \end{cases}$$

Where ε_{ij} is a transitory error term, which varies between individual households as well as communities, and is assumed to have a standard logistic distribution with a zero mean and variance $\frac{\pi^2}{3}$ (π is the constant 3.1416). The two errors are assumed to be independent from each other with ζ_j being independent over communities and the ε_{ij} over individual households and communities. The total residual variance is:

$$\text{Var}(\xi_{ij}) = \text{Var}(\xi_{ij} = \zeta_j + \varepsilon_{ij}) = \psi + \frac{\pi^2}{3}$$

According to the latent-response regression model (2), observations in the same community share the same random term ζ_j , and hence they are correlated. The degree of dependence or correlation between observed responses, with respect to two birthing women i and

k from the same community, can be quantified in terms of the intra-class correlation (ρ) of the latent response y_{ij}^* as:

$$\rho = Cor(y_{ij}^*, y_{kj}^* / x_{ij}, x_{kj}) = Cor(\xi_{ij}, \xi_{kj})$$

$$= \frac{Cov(y_{ij}^*, y_{kj}^* / x_{ij}, x_{kj})}{\sqrt{\text{var}(\xi_{ij})}\sqrt{\text{var}(\xi_{kj})}}$$

$$= \frac{\psi}{\sqrt{\psi + \frac{\pi^2}{3}}\sqrt{\psi + \frac{\pi^2}{3}}}$$

$$\rho = \frac{\psi}{\psi + \frac{\pi^2}{3}} \quad (3)$$

The higher the degree of interdependence among the observed responses within a community the higher would be the proportion of the total variance that is between communities, or due to communities.

We begin our analysis by assessing the overall degree of homogeneity in the utilization of prenatal care among women within an enumeration area (the primary sampling unit),[24] we estimate a two-level (individual, household and community) random intercept logistic regression model for the decision to seek care and a two-level random intercept Poisson regression model for the frequency of prenatal care use, without including the observed covariates and calculate the intra-community correlation (ρ). The estimated ρ is 0.45 for seeking prenatal care and 0.07 for the frequency of prenatal use. The later correlation becomes very small once the model controls for all observed individual-, household- and community-level characteristics. We thus

[24] Community boundaries are defined by enumeration areas, the primary sampling units used by DHS.

control for unobserved community-level only in modeling the decision to access prenatal care (through the use of the random intercept framework).

The negative binomial distribution, used to model the second decision, is derived as a gamma mixture of Poisson random variables. In the context of our analysis, we are interested in modeling the probability of *y* number of visits by i^{th} women in a single pregnancy. The negative binomial density function can thus be defined as:

$$f[y_i|x_i] = \frac{\Gamma[y_i + \alpha^{-1}]}{y_i!\ \Gamma\alpha^{-1}}\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu_i}\right)^{\alpha^{-1}}\left(\frac{\mu_i}{\alpha^{-1}+\mu_i}\right)^{y_i}$$

Where $\Gamma(.)$ is gamma distribution function, $\mu_i = e^{x_i\beta'}$ is the intensity parameter to be estimated, β is a vector of regression coefficients corresponding to covariates x_i and α is a dispersion parameter and $\alpha \geq 0$. The distribution has a conditional mean of: $E(y_i \mid x_i) = \mu_i$ and conditional variance $\mu_i + \alpha\mu_i^2$. The Poisson distribution is a special case of the negative binomial distribution where $\alpha=0$ (Cameron and Trivedi, 1986). A test of the appropriateness of the Poisson distribution can be carried out by testing the hypothesis that $\alpha=0$. We have checked for the problem of over-dispersion in our data set. The estimated measure of dispersion (alpha) in the negative binomial model is small but positive for all countries as well as Asia and sub Saharan Africa. However, we have used the Poisson Model for Latin America instead of the negative binomial model, because the likelihood function did not converge.[25]

[25] A likely reason for that failure to converge is the more homogenous and urbanized societies of Latin America. Beyond the greater level of urbanization, an active NGO presence in the provision and support of prenatal care, and a longer history of public sector provision of such services, are likely explanatory factors.

The use of multilevel modeling strategy for any use of prenatal care accommodates the clustered or hierarchical nature of the DHS data and corrects standard errors of the estimated coefficients for intra-community correlation (heteroscedasticity). Standard errors of the estimated coefficients are also corrected for intra-community correlation (heteroscedasticity) in the estimation of the frequency of prenatal use. STATA version 9.1 was used for all data analysis.

3.3.3 Study variables

The theoretical and empirical literature suggest that the utilization of maternal health care services is influenced by a wide range of observed individual-, household- and community-level variables, as well as unobserved community-level variables, such as the perceived benefits of care, attitudes towards health and health-related behaviours, and the prevailing health beliefs and practice surrounding pregnancy and birth (Becker *et al.*, 1993; Gage and Calixte, 2006; Pebley *et al.*,1996; Pickett and Pearl, 2001; Say and Raine, 2007; Short and Zhang, 2004).[26] In this essay, we have hypothesised three sets of independent variables that affect choices about the decision to seek care and its frequency: individual level factors; household-level factors; and community-level factors. Table 3.1 below provides definitions and summary statistics for the dependent and each type of independent variables used in the estimation of the two-part model (TPM).

[26] It should be noted here that the perceived benefits of care have both individual and community level component. But it can be presumed that most of the individual level components are captured by individual level characteristics such as education, age, parity, unwanted pregnancy and employment and marital status. Health related behaviour could be considered as an unobserved individual level variable but that attitude is likely to be quite similar within communities because of shared experiences.

Table 3.1. Definitions and summary statistics

Variable name	Description	Mean	Std dev.
Dependent variable			
Sought any prenatal care	1= if seek care from any health professional, 0 otherwise	0.817	0.386
Number of visits	A count variable indicating the frequency of visits	3.605	2.881
Individual-level independent variables			
Maternal education			
No education (reference category)	1=if no education, 0 otherwise	0.443	0.497
Less than primary	1=if incomplete primary education, 0 otherwise	0.230	0.421
Primary	1=if completed primary education, 0 otherwise	0.093	0.291
Less than secondary	1=if incomplete secondary education, 0 otherwise	0.170	0.376
Secondary	1=if completed secondary education, 0 otherwise	0.033	0.178
Higher education	1=if post-secondary education, 0 otherwise	0.031	0.173
Maternal age at last live birth			
15-19 years (reference category)	1=if woman is in this age group, 0 otherwise	0.077	0.266
20-29 years	1=if woman is in this age group, 0 otherwise	0.257	0.437
30-34 years	1=if woman is in this age group, 0 otherwise	0.270	0.444
35-49 years	1=if woman is in this age group, 0 otherwise	0.397	0.489
Parity			
1 (reference category)	1=if first parity, 0 otherwise	0.225	0.418
2	1=if second parity, 0 otherwise	0.209	0.406
3	1=if third parity, 0 otherwise	0.155	0.362
4	1=if fourth parity, 0 otherwise	0.119	0.324
5+	1=if five and above parity, 0 otherwise	0.292	0.455
Marital status	1= if currently/formerly married, 0 otherwise	0.971	0.168
Unwanted pregnancy	1=if pregnancy is unwanted, 0 otherwise	0.127	0.333
Woman's employment status	1=if currently working, 0 otherwise	0.538	0.499
Household-level independent variables			
Household wealth quintile			
Quintile 1 (reference category)	1=if household wealth quintile is 1 (poorest), 0 otherwise	0.213	0.410
Quintile 2	1=if household wealth quintile is 2, 0 otherwise	0.200	0.400
Quintile 3	1=if household wealth quintile is 3, 0 otherwise	0.200	0.400
Quintile 4	1=if household wealth quintile is 4, 0 otherwise	0.195	0.396
Quintile 5	1=if household wealth quintile is 5 (richest), 0 otherwise	0.192	0.394
Household size	Number of individuals residing in the household	7.075	4.134
Community-level independent variables			
Urban residence	1=if household reside in urban area, 0 otherwise	0.319	0.466
Poor region	1= if household resides in a poor region, 0 otherwise	0.142	0.349

We have included: maternal educational attainment, maternal age at last live birth, marital status, employment status, unwanted pregnancy, and the parity level as the individual-

level factors. The level of maternal education is measured by six categories – no education (reference category), incomplete primary education, primary education, incomplete secondary education, secondary education, and higher education. This presentation of education provides a useful estimate of the incremental effect of education on decision to seek care and its frequency. The literature suggests multiple pathways through which a mother's education level can be expected to positively impact health behaviour including: increased autonomy and decision-making power, greater control over resources, greater ability in accessing and processing new information, and being more efficient in the production of health (Cleland and van Ginneken, 1998; Elo, 1992; Gabrysch and Campbell, 2009; Grossman, 1975; Levin et al., 2004; Ragupathy, 1996). To capture the effects of age, women were classified into five age-groups in the reproductive age period (15-49) (see Table 3.1). Maternal age is not only an important demographic factor, but also reflects older women's greater experience in using health services, more control over household decision making and higher biological risks (Gabrysch and Campbell 2009; Glei *et al.*, 2003; Short and Zhang, 2004). Older women are thus expected to use health care services more often. However, younger woman may be more modernized and thus more likely to use modern health services (Navaneetham and Dharmalingam, 2002) – making the expected net age effect uncertain.

Similarly, to capture the influence of parity on use and frequency of prenatal care, parity is classified into four categories (Table 3.1). These parity categories reflect the greater health risks associated with the first and grand multiparity (having five and more children) and, as such, imply the greater need for service (Bai, *et al.*, 2002). On the other hand, birthing women with a higher birth order may also find it difficult in accessing prenatal services due to the lack of adequate child care support; and birth attendants' negative comments (Elo, 1992; Gage and

Calixte, 2006; Raghupathy, 1996; Short and Zhang, 2004); and due to the knowledge and confidence gained from past experiences (Elo, 1992; Raghupathy, 1996; Short and Zhang, 2004). Marital status is measured as currently/formerly married versus never married (the reference category).[27] Marital status may reflect female autonomy and access to financial resources (Gabrysch and Campbell, 2009). Single expectant mothers are often poor and stigmatized, since pregnancies outside of marriage bring immense social cost in low income economies where families do not support out- of-wedlock births, and are thus less likely to use maternal health services (Duong *et al.,* 2004). Unwanted pregnancy is represented by a dummy variable which takes the value of one if the pregnancy is unwanted. Women with unwanted pregnancy presume to attach less value to the expected child and may delay prenatal care use as they go through a period of denial or as they contemplate an abortion (Magadi *et al.,* 2000; Weller *et al.,* 1987). Maternal employment status is represented by a dummy variable which takes the value of one if the woman is currently working and zero if not. Whereas, on the one hand, women's work status promotes the use of health services by providing better access to information, increasing female mobility and overcoming financial barriers; on the other hand, it may reflect the presence of significant resource constraints for poor women, and hence may be associated with reduced demand for health care services (Addai, 2000; Desai and Jain, 1994; Gabrysch and Campbell, 2009; Hogan *et al.,* 1999). Two other potential individual-level variables, partner's educational

[27] The number of observations on 'formerly-married' women was small, especially for Asia. Thus, we chose to aggregate formerly-married' with 'currently-married' categories. Combining these two categories is, however, likely to conceal important differences by marital status due to the presence of a partner. We estimated the model for the entire sample using separate dummies for currently-married, formerly-married and never-married, with currently-married being a reference category. The estimated coefficient of the formerly-married dummy was not statistically significant - suggesting that it was appropriate to aggregate formerly-married with currently-married categories.

attainment and employment are excluded from the model due to lack of data – information on partner's education and employment is only available for the ever-married women.

The household-level variables include household economic status and household size. Household economic status is measured by wealth quintiles using the DHS household wealth index.[28] This index was constructed as the weighted sum of household's ownership of durable consumer items, such as television, bicycles, car and truck; household use of water source and sanitation facilities; indicators of housing quality such as materials used for housing construction for floors and walls; and other characteristics that reflect economic status (Filmer and Pritchett, 2001).[29] DHS wealth indices were then categorized into five wealth quintiles to distinguish poor from not too poor and rich from well-off but not-rich.[30] There are multiple pathways through which women's socio-economic status (ability to pay) was expected to be positively associated with the utilization of maternal health services in general. Greater household wealth may not only reduce financial barriers to care (Bonu *et al*., 2009; Hotchkiss *et a*l., 2005; Prarta *et al*., 2004), but also equip women with more modern and receptive attitudes towards modern health care services (Naveentham and Dharmalingam, 2002). The low utilization among poor households may reflect the high cost of access, the aversion to investment in obstetrics care due to low perceived benefits, perception of poor quality of care, and the higher work burden of the

[28] Since DHS data sets do not provide information on household income and expenditures, household economic status is measured by wealth quintiles using the DHS household wealth index.

[29] The general methodology used to calculate wealth index is given in Filmer and Pritchett (2001). The specific approach used in the DHS is described in Rutstein and Johnson (2004).

[30] As mentioned in footnote 13, the wealth quintiles are constructed for each country (using the same methodology) and are given with the DHS data sets. We have identified this variable from each country and merged them, like other variables, into our final pooled file. We have not made any changes to this variable and have used it, as provided, for our analysis. Because countries are not identical in tastes, culture etc. it is likely that there was some measurement error induced by the assumption of similar wealth indicators across countries. However, there is little reason to believe that this was substantive enough to undermine relatively robust results.

poor, in terms of both paid and unpaid work (Borghi *et al.,* 2006; Duong *et al.,* 2004; Glei *et al.,* 2003; Hotchkiss *et al.,* 2005). The poor are expected to use not only less care, but also tends to be deficient in terms of the required number of visits and care content (Sepheri *et al.,* 2008).

Community-level variables reflect differences in economic and social constraints of certain ethnic groups and differences in health beliefs and practice surrounding birth that are likely have an important impact on the use of maternal health services (Pebley *et al.,* 1996). Overall, very few researchers have investigated community-level effects in the use of a prenatal care. Those that did used a variety of different community-level variables, such as distance to a health facility, place of residence, poverty rate, practice patterns of others in their areas of residence, and proximity to people with secondary or higher education (Babalola and Fatusi, 2009; Gage and Calaxite, 2006; Gage, 2007; Sepheri *et al.,* 2008). These studies found strong evidence of these community-level factors on the use of maternal health services. The community-level variables included in this study are the place of residence (urban/rural areas) and a regional poverty indicator. Place of residence highlights the differences in the availability and accessibility of services among urban and rural areas. Living in urban centers may potentially increase awareness and exposure to a wide range of health providers providing varying quality of care to those who can afford them. The prevalence of traditional beliefs and practices, existence of extreme poverty, the less availability of services and limited infrastructure in rural areas hamper service use (Gabrysch and Campbell, 2009; Say and Raine, 2007). A country's region is classified as poor if the share of the poor and near-poor households (the lowest two wealth quintiles) in the total population of the region exceeds the national average by one standard deviation. Poorest regions reflect remoteness, poor road and health infrastructure, limited access to information, and strong adherence to traditional values (Pebley *et al.* 1996).

The poor-region dummy may act not only as a proxy for the state of region's physical infrastructure and health service environment, but also as a proxy for ethnicity. Ethnicity is closely linked to place of residence with ethnic minority groups typically accounting for a disproportionately high share of a country's poor and residents of remote areas (Glei *et al.*, 2003). Other potential community-level variables, such as physical infrastructure and health service environment indicators (such as the state of roads, availability of transport, and the density of health facilities and providers) are excluded from the analysis due to the lack of data. DHS provide data on problems posed by transportation and distance to the nearest health facilities, when respondents are seeking outpatient care for themselves. However, these data are available for 25 countries. We have used these data to assess the robustness of our results. To measure the effect of country-specific factors on a woman's choice of delivery setting, 31 country dummies are included in the model.

3.4 RESULTS

3.4.1 *Descriptive statistics*

Table 3.2 reports prenatal care attendance and the number of prenatal visits by wealth quintile, level of maternal education, and place of residence. The percentage of birthing women seeking prenatal care varies from 76.5% in Asia to 88.5% in Latin America. Among those who sought prenatal care, the average number of visits varied from 4.2 in Sub-Saharan Africa to 5.6 in Latin America.

Table 3.2. Prenatal care attendance and number of visits by wealth quintile, level of maternal education and the place of residence

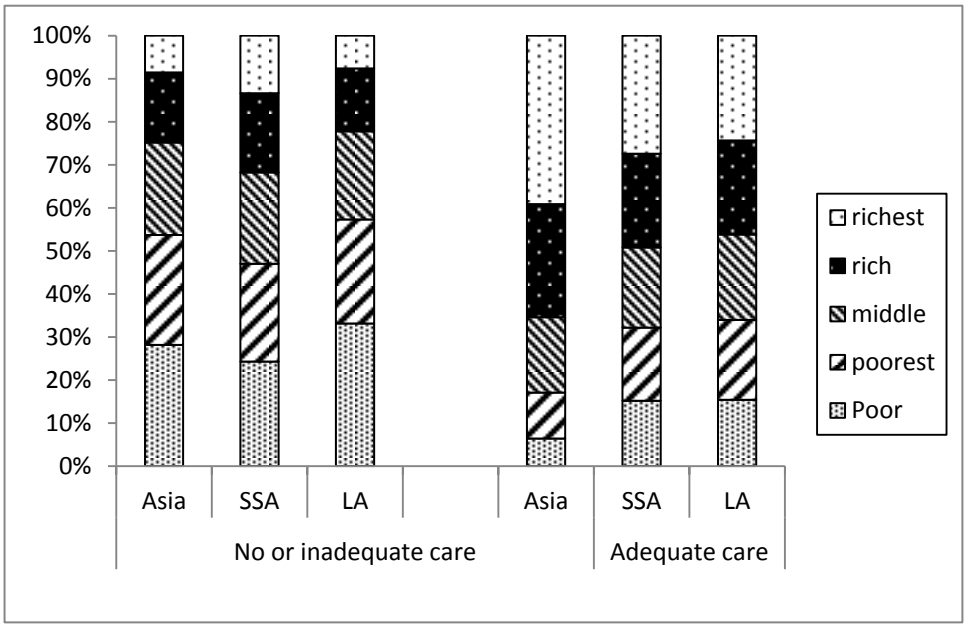
	Prenatal attendance (%)				Number of visits			
	All countries	Asia	Sub-Saharan Africa	Latin America	All countries	Asia	Sub-Saharan Africa	Latin America
Average	81.7	76.5	83.2	88.5	4.4	4.5	4.2	5.6
By wealth quintile								
Poor [a]	68.8	54.6	72.8	85.0	3.7	2.7	3.8	4.9
Middle	81.9	76.4	83.3	90.8	3.4	3.0	3.3	5.1
Rich [b]	94.7	95.3	94.1	97.0	5.5	6.3	5.0	7.1
By the level of maternal Education								
No schooling	69.4	60.7	72.5	73.3	3.7	3.2	3.8	4.6
Primary	92.1	81.9	95.4	93.6	4.6	4.0	4.4	6.0
Secondary	96.6	95.1	98.1	97.8	6.0	6.0	5.5	7.1
Higher	98.7	98.5	99.4	98.8	7.1	7.3	6.3	7.8
By the place of residence								
Urban	91.6	87.7	93.5	92.7	5.2	5.5	4.8	6.2
Rural	77.1	70.5	78.9	85.8	4.0	3.8	3.9	5.2

[a] The bottom two wealth quintile
[b] The upper two wealth quintile

These averages mask wide variations in the utilization of prenatal care within and across the three regions in terms of economic status, level of maternal education, and place of residence. These disparities are more marked (i) for the number of prenatal visits than the use of any prenatal care; and (ii) in Asia than in other two regions. In the case of Asia, birthing women from the richest wealth quintile are 1.7 times more likely to seek prenatal care and have 2.3 times more visits than those from the poorest wealth quintile. The education gradient is also more pronounced in Asia (than in the other two regions) where 95.1% and 98.5% of women with the secondary and post-secondary education, respectively, sought prenatal care compared to 60.7% for those with no education. Those with secondary and post-secondary education also had, on average, respectively, of six and 7.3 visits, versus 3.2 for those with no education.

Economic disparities in the utilization of prenatal care, both within and across the three geographical regions, also suggest that the poor are less likely to use adequate prenatal care if they seek any care at all.[31] Figure 3.1 below displays the use and adequacy of prenatal care across wealth quintiles.

Figure 3.1: The use and adequacy of prenatal care across wealth quintiles



The most disadvantaged groups are the poor and near-poor in Asia, where more than 80% of women from the lowest two wealth quintiles had either no prenatal care or had inadequate care. By contrast, only 26% of women from the richest wealth quintile had either no prenatal care or had inadequate care. The adequacy of use of prenatal care also varies positively with household wealth quintile in the other two regions, though it is not as pronounced as it is in Asia.

[31] Adequate, in this case, is defined as being at or above the WHO-recommended minimum of four visits.

3.4.2 Estimation Results

The regression results obtained from the TPM for all countries combined, as well as for the three geographical regions are presented in Table 3.3. The likelihood ratio (LR) test clearly rejects the null hypothesis that the standard deviation of the random intercept term is zero, and hence favours a random intercept logistic model over an ordinary logistic model. The intra-community correlation (ρ) and the estimated values of the variance (ψ) of the random intercept term are also shown in the table. The high value of intra-community correlation (ρ) for all countries and the three geographical regions, even after controlling for all observed individual-, household- and community-level covariates, suggests that there are some unobserved covariates in the primary sampling units that affect women's decisions to seek prenatal care. Regarding the second part of the TPM, the estimated measure of dispersion (alpha) is positive and small, and the LR test clearly rejects the truncated Poisson model in favour of the truncated negative binomial model for all countries combined, Asia and Sub-Saharan Africa.

To facilitate interpretation, the estimated coefficients of the logistic model (the first part of the TPM) are converted to odds ratios. For the truncated negative binomial model (the second part of the TPM), the estimated coefficient of a dummy variable is approximately the proportionate increase in the expected number of visits due to the dummy variable equalling unity, rather than zero (Cameron *et al.* 1988). The coefficients of explanatory variables, other than dummies, can similarly be interpreted. The coefficient estimates of 31 country-specific dummies are not reported in Table 3.3.

Table 3.3. Regression results for Prenatal care attendance and number of visits.

	Prenatal attendance				Number of visits (Negative Binomial)			
	All Countries	Asia	Sub-Saharan Africa	Latin America	All countries	Asia	Sub-Saharan Africa	Latin^ America
	Odds Ratio (Std. Error)	Odds Ratio (Std. Error)	Odds Ratio (Std. Error)	Odds Ratio (Std. Error)	Coeff. Est. (Std. Error)	Coeff. Est. (Std. Error)	Coeff. Est. (Std. Error)	Coeff. Est. (Std. Error)
Fixed Part								
Individual Characteristics								
Maternal Education								
Incomplete Primary	1.6692*	1.5019*	1.6972*	1.8148*	0.0933*	0.1140*	0.0615*	0.0589*
	(0.0379)	(0.0600)	(0.0520)	(0.1215)	(0.0041)	(0.0127)	(0.0048)	(0.0115)
Primary	2.0994*	1.9055*	2.0488*	2.7008*	0.1139*	0.1277*	0.0824*	0.0973*
	(0.0737)	(0.0997)	(0.1127)	(0.2670)	(0.0053)	(0.0145)	(0.0064)	(0.0128)
Incomplete Secondary	2.9794*	2.7143*	2.7955*	4.0269*	0.1888*	0.2443*	0.1293*	0.1339*
	(0.0928)	(0.1120)	(0.1506)	(0.4924)	(0.0049)	(0.0099)	(0.0063)	(0.0138)
Secondary	4.0860*	4.1679*	3.1184*	5.1597*	0.2498*	0.3086*	0.1752*	0.1461*
	(0.3039)	(0.4042)	(0.4185)	(1.2127)	(0.0079)	(0.0140)	(0.0119)	(0.0167)
Higher	7.2803*	7.8175*	3.8899*	7.6592*	0.3719*	0.3785*	0.2627*	0.2192*
	(0.7711)	(1.0154)	(0.8321)	(2.9266)	(0.0080)	(0.0131)	(0.0137)	(0.0204)
Age at last Birth								
20-24	1.1927*	1.2207*	1.1066**	1.2359**	0.0790*	0.0976*	0.0586*	0.0594*
	(0.0403)	(0.0685)	(0.0511)	(0.1344)	(0.0060)	(0.0156)	(0.0072)	(0.0127)
25-29	1.3679*	1.3852*	1.2266*	1.6401*	0.1509*	0.1861*	0.1056*	0.1372*
	(0.0516)	(0.0851)	(0.0641)	(0.2047)	(0.0065)	(0.0163)	(0.0080)	(0.0139)
≥ 30	1.4203*	1.4045*	1.2503*	2.0682*	0.2056*	0.2447*	0.1598*	0.1631*
	(0.0578)	(0.0930)	(0.0706)	(0.2808)	(0.0071)	(0.0173)	(0.0088)	(0.0152)
Parity of last live birth								
2	0.6905*	0.6651*	0.7343*	0.6393*	-0.0666*	-0.1056*	-0.0376*	-0.0488*
	(0.0194)	(0.0280)	(0.0300)	(0.0630)	(0.0042)	(0.0077)	(0.0056)	(0.0092)
3	0.5673*	0.4905*	0.6641*	0.5544*	-0.1271*	-0.2141*	-0.0705*	-0.0580*
	(0.0179)	(0.0233)	(0.0301)	(0.0637)	(0.0051)	(0.0105)	(0.0064)	(0.0112)

*1% Significant level; ** 5% Significant level; *** 10% Significant level

^For Latin America we have used Poisson model as compared to negative binomial since the likelihood function did not converge.

Table 3.3 (Continued)

	Prenatal attendance				Number of visits (Negative binomial)			
	All Countries	Asia	Sub-Saharan Africa	Latin America	All Countries	Asia	Sub-Saharan Africa	Latin^ America
	Odds Ratio (Std. Error)	Odds Ratio (Std. Error)	Odds Ratio (Std. Error)	Odds Ratio (Std. Error)	Coeff. Est. (Std. Error)	Coeff. Est. (Std. Error)	Coeff. Est. (Std. Error)	Coeff. Est. (Std. Error)
4	0.5165*	0.4173*	0.6411*	0.4551*	-0.1621*	-0.2982*	-0.0932*	-0.0895*
	(0.0181)	(0.0225)	(0.0318)	(0.0577)	(0.0059)	(0.0141)	(0.0073)	(0.0136)
≥ 5	0.4120*	0.3038*	0.5214*	0.3436*	-0.1811*	-0.3802*	-0.1245*	-0.1044*
	(0.0145)	(0.0170)	(0.0256)	(0.0448)	(0.0059)	(0.0154)	(0.0073)	(0.0141)
Marital Status	2.4903*	2.2929**	2.1445*	3.1406*	0.1204*	0.4573*	0.0758*	0.1259*
	(0.1486)	(0.9694)	(0.1467)	(0.4292)	(0.0085)	(0.1269)	(0.0094)	(0.0190)
Unwanted Pregnancy	0.7561*	0.9005*	0.6857*	0.7470*	-0.0409*	-0.0344*	-0.0270*	-0.0464*
	(0.0185)	(0.0333)	(0.0273)	(0.0464)	(0.0047)	(0.0122)	(0.0062)	(0.0082)
Employment Status	1.0877*	0.9634	1.2396*	1.0569	0.0046	-0.0010	0.0251*	0.0152**
	(0.0210)	(0.0290)	(0.0340)	(0.0643)	(0.0030)	(0.0072)	(0.0038)	(0.0067)
Household Level variables								
Wealth Quintile								
quintile 2 (near poor)	1.3291*	1.3816*	1.2796*	1.5051*	0.0339*	0.1008*	0.0314*	0.0440*
	(0.0297)	(0.0506)	(0.0391)	(0.1111)	(0.0048)	(0.0140)	(0.0057)	(0.0096)
quintile 3 (middle)	1.7016*	1.8654*	1.5951*	1.7380*	0.0795*	0.2281*	0.0581*	0.0968*
	(0.0426)	(0.0767)	(0.0535)	(0.1727)	(0.0049)	(0.0139)	(0.0057)	(0.0116)
quintile 4 (near rich)	2.3680*	2.8780*	2.0900*	2.2138*	0.1352*	0.3493*	0.0909*	0.1394*
	(0.0777)	(0.1601)	(0.0882)	(0.4538)	(0.0056)	(0.0150)	(0.0064)	(0.0163)
quintile 5 (richest)	4.2489*	5.7482*	3.3563*	5.3780*	0.2781*	0.5261*	0.1878*	0.2166*
	(0.2511)	(0.5538)	(0.2594)	(2.9281)	(0.0078)	(0.0166)	(0.0095)	(0.0248)
Household Size	0.9966	0.9830*	1.0001	1.0046	-0.0037*	-0.0078*	-0.0028*	-0.0071*
	(0.0022)	(0.0040)	(0.0028)	(0.0103)	(0.0004)	(0.0010)	(0.0004)	(0.0012)
Community-level variables								
Urban* quintiles 1-3	1.4473*	1.4736*	1.7490*	0.8524	0.0343*	0.0987*	0.0201*	0.0236**
	(0.0617)	(0.0897)	(0.1244)	(0.0920)	(0.0057)	(0.0131)	(0.0076)	(0.0108)

*1% Significant level; ** 5% Significant level; *** 10% Significant level

^For Latin America we have used Poisson model as compared to negative binomial since the likelihood function did not converge.

Table 3.3 (Continued)

	Prenatal attendance				Number of visits (Negative binomial)			
	All Countries	Asia	Sub-Saharan Africa	Latin America	All Countries	Asia	Sub-Saharan Africa	Latin^ America
	Odds Ratio (Std. Error)	Odds Ratio (Std. Error)	Odds Ratio (Std. Error)	Odds Ratio (Std. Error)	Coeff. Est. (Std. Error)	Coeff. Est. (Std. Error)	Coeff. Est. (Std. Error)	Coeff. Est. (Std. Error)
Urban* quintile 4	1.8097*	1.6097*	2.4803*	0.8096	0.0570*	0.0795*	0.0661*	0.0085
	(0.0921)	(0.1246)	(0.1891)	(0.1774)	(0.0060)	(0.0126)	(0.0073)	(0.0158)
Urban* quintile 5	2.2553*	1.6140*	3.4863*	0.5838	0.0323*	0.0382*	0.0907*	0.0233
	(0.1605)	(0.1834)	(0.3348)	(0.3274)	(0.0073)	(0.0119)	(0.0091)	(0.0240)
Poor regions	0.5426*	0.5659*	0.3890*	1.4093*	-0.0530*	-0.1600*	-0.0104***	-0.0069
	(0.0220)	(0.0338)	(0.0244)	(0.1423)	(0.0044)	(0.0090)	(0.0059)	(0.0090)
Random Part								
ρ^a	0.3320	0.3085	0.3586	0.2029				
ψ^b	1.6353	1.4678	1.8395	0.8375				
LR test statistic [c]	12659.04	4004.20	8000.78	311.16				
level 1 units	200417	58877	124172	17368				
level 2 units	17542	6187	9372	1983				
Lnalpha					-3.3862	-2.1035	-4.7675	
LR test statistic [d]					1916.5	4378.23	90.5	
Sample size					160276	44579	100420	15277

*1% Significant level; ** 5% Significant level; *** 10% Significant level

[a] Intracluster correlation.

[b] Variance of the random intercept term.

[c] Comparing random intercept logistic model against ordinary Logit model.

[d] Comparing zero truncated negative binomial model against zero truncated Poisson model.

^ For Latin America we have used Poisson model as compared to negative binomial since the likelihood function did not converge.

(a) All-country sample

Regarding the results for all countries combined, all explanatory variables have their expected signs and they are statistically significant at the 1% level, with the exception of household size with respect to the decision to seek care and employment status with respect to the frequency of visits. The likelihood of prenatal care attendance and the frequency of use are both strongly influenced by the level of maternal education. The influence of education is more pronounced for seeking prenatal care than the number of visits. Compared to those with no education, women with completed primary school are 1.1 times more likely to seek prenatal care, and those with secondary and post-secondary education are three and 6.3 times more likely to seek care, respectively. By contrast, women with secondary and post-secondary education have only 25 and 37% more visits, respectively, than those with no education.

Prenatal care attendance and the frequency of use also vary positively with maternal age, with adolescents being the most disadvantaged age group. On the other hand, women with a higher number of previous childbirths are less likely to use any prenatal care and have fewer visits. Married women are almost one and one-half times more likely to seek prenatal care than the unmarried women (the reference category) and are also more likely to have more prenatal visits. Birthing women are less likely to seek any prenatal care and have fewer visits for unwanted pregnancies, compared to pregnancies that are wanted (the reference category).

Household and observed community-level variables have quite similar effects on the decision to seek care and the number of visits. The likelihood of seeking any prenatal care and the number of prenatal contacts increases monotonically with household wealth. Birthing women from the fourth and fifth wealth quintiles of households are, respectively, 1.4 and 3.2 times more

likely to seek prenatal care than those from the lowest wealth quintiles (the reference category). To assess the effect of the place of residence on prenatal care attendance and the frequency of contacts at various levels of wealth, an interaction in terms combining urban and wealth quintile was added to the list of explanatory variables.[32] The urban-rural difference in seeking care becomes larger as we climb the wealth gradient. As might be expected, residents of the poorest regions are 46% less likely to seek any prenatal care and have fewer visits when they seek care than the residents of the non-poor regions (the reference category).

(b) Regional Differences

There are noticeable differences in the effect of several variables across regions (for both the decision to seek care and the number of visits). The incremental influence of primary and secondary education on the use of prenatal care is more pronounced in Latin America than in the other two regions. In that region, primary and secondary education increases the odds of seeking prenatal care by 1.7 and 4.2 times respectively. With respect to the number of prenatal visits, however, the influence of education is most pronounced in Asia, where those with secondary and post-secondary education had 30 and 38% more visits than those with no education. The influence of maternal age has a similar regional pattern. In Latin America, birthing women in the 25-29 and 30-plus age groups are 64 and 107%, respectively, more likely to seek prenatal care than teenage mothers (aged 15 to 19). But the incremental influence of maternal age on the number of prenatal visits is largest in Asia, where older birthing women, aged 25-29 and 30-plus years, have 19 and 25 percent, respectively, more visits than teenage mothers.

[32] Testing for equality of the coefficients on the interaction terms between wealth quintiles and urban suggested that certain interaction terms could be aggregated, as shown in Table 3.3.

The negative influence of birth order, on both the decision to seek prenatal care and the number of visits, is weaker in Sub-Saharan Africa than it is in Latin America and Asia. By contrast, the influence of the desirability of a pregnancy on prenatal use is greater in Sub-Saharan Africa than in the other two regions. In Sub-Saharan Africa, women with unwanted pregnancies are 31% less likely to use any prenatal care than those with wanted pregnancies. The effect of both birth order and the desirability of pregnancy on the decision to seek care are also stronger than the effect on the number of visits. The influence of employment on the use of prenatal care is not consistent across regions. While women's employment status has a positive and significant effect on the number of visits in Sub-Saharan Africa and Latin America, it has a negative effect in Asia. However, employment has a significant effect on the decision to seek care only for Sub-Saharan Africa. For that region, employed women are 24% more likely to seek prenatal care and have 3% more visits than those with no outside employment.

In terms of household level attributes, the wealth gradient is more pronounced in Asia than in the other two regions (a confirmation of the result for the simple data analysis). In Asia, women from the top two wealth quintiles of households are 1.9 and 4.7 times, respectively, more likely to seek prenatal care and have 35 and 53% more visits than those from the poorest wealth quintile. Three general patterns are evident from the interaction terms (the combined effects of the place of residence and wealth quintiles) across regions. First, in both Asia and Sub-Saharan Africa urban women are more likely to seek prenatal care and have more prenatal contacts than the rural average, regardless of income level. Second, urban-rural differences in the use of any prenatal care vary across wealth quintiles in Sub-Saharan Africa, where the higher odds of seeking any prenatal care by urban women, compared to their rural average varies from 75% for those from the lowest three wealth quintiles to close to 150 and 250% for those from the top

fourth and fifth wealth quintiles, respectively. Third, urban-rural differentials in repeated visits vary across wealth quintiles in all three geographical regions. While the urban-rural differences in repeated visits become smaller as we climb the wealth gradient in Asia, they become larger in Sub-Saharan Africa and have no clear pattern in Latin America.

The influence of regional poverty on any use of prenatal care is more negative in Sub-Saharan Africa than in Asia but, surprisingly, it is positive in Latin America. However, the results of Latin America are driven by a small number of regional outliers with a relatively high rate of prenatal care attendance and poverty, and hence the results should be interpreted with caution. With respect to the number of visits, the relationship is only significant for Asia.

3.5 DISCUSSION

The results of this investigation indicate that, though both the decision to seek care and the number of prenatal visits are influenced by a range of observed individual-, household- and community-level characteristics, both the set of relevant variables and the magnitude of the effects vary across the two decisions. In the first instance, unobserved community-level variables have been shown to have an effect on the decision to seek care but not on the number of visits. Secondly, several variables that affect the decision to seek care (notably regional poverty, parity, marital status and desirability of pregnancy) appear to have no influence on the number of visits. Thirdly, even when the same variable appears to influence both decisions, the magnitude of its effect is quite different across the two decisions.

The results of this paper are consistent with the general findings of earlier studies. The likelihood of seeking any prenatal care and the frequency of its use are both strongly influenced

by the level of maternal education and maternal age (Addai, 2000; Alexandre *et al.*, 2005; Celik and Hotchkiss, 2000; Gage, 2007; Gage and Calixte, 2006; Halim *et al.,* 2010; Magadi *et al.,* 2003; Magadi *et al.,* 2007; Pebley *et al.,* 1996; Sepehri *et al.,* 2008; Short and Zhang, 2004). However, the influence of education is more pronounced for seeking prenatal care than the number of visits.[33] Similarly, women are also less likely to access prenatal services and use these services more sparingly as birth order increases. The influence of both marital status and the desirability of pregnancy are also stronger on seeking prenatal care than on frequency of visits, suggesting that, once the decision is made to seek care, a married woman's behaviour is much closer to the norm. Consistent with previous research, household wealth is an important predictor of both prenatal care attendance and the repeated visits, which point to financial barriers, including both direct and indirect costs of accessing prenatal care (Gage 2007; Gage and Calixte 2006; Say and Raine 2007; Sepehri *et al.*, 2008). Although facility fees are less a barrier to seeking prenatal care compared to delivery care (Prata *et al.* 2004), households often face significant costs in accessing prenatal care, including travel costs, and the time spent away from productive activity (Borghi *et al.*, 2006; Ensor and Ronoh, 2005; Kowalewski *et al.,* 2002).[34] Our results on place of residence and interaction with household wealth quintiles may reflect greater physical barriers, especially transportation, faced by rural women in general and the rural poor and near-poor in particular (Gage, 2007; Gage and Calixte, 2006: Sepehri *et al.,* 2008). However, lack of stable and regular sources of income and pressures to work long hours in ad hoc trading

[33] Since the model does not control for the partner's education, the estimated coefficients of maternal education dummies are likely to be biased upward. Re-estimating the model for a subset of the sample, for which data on partner's education is available, suggests that the size of bias is rather small for the frequency of visits (between 1-5%) and between 11-36% for the prenatal care attendance.

[34] Waiting time costs are found to be substantial in a poor region of Tanzania, accounting for 97% of the total costs borne by maternity users at the hospital. The average waiting time for the consultation was found to vary from 73 minutes at hospital, to 65 minutes at health centers and to 28 minutes at dispensaries (Kowalewski *et al.* 2002).

jobs to meet basic household needs often leave the urban poor and near-poor with little time to seek care, even when care is provided free of charge (Magadi *et al.,* 2003 ; Sarin, 1997). Moreover, weaker family support networks in urban areas, compared with the rural areas, also leaves many urban-poor women without support of the extended family in providing childcare (Magadi *et al.* 2003).

However, the findings that the responsiveness of both the decision to seek care and the frequency of visits to certain individual-, household- and community-attributes varies across regions may reflect regional variations in overall levels of development, modes of delivery of services, degree of dispersion of populations and cultural norms and practices surrounding birth. Sub-Saharan Africa is the poorest of the three regions and, not surprisingly, the urban-rural divide is strongest in that region. By contrast, the weaker effect of geographic attributes (in the form of urban residence and the level of regional poverty) in Latin America may reflect the higher level of development of the region and greater overall access to facilities in general. Moreover, many non-governmental organizations have targeted Latin America's poorer nations to promote the use of prenatal care by implementing and expanding maternal health programs, particularly in those areas with a poor health infrastructure or suffering from extreme poverty (Gage and Calixte, 2006). Private provision of health care services is more developed in Asia than in the other two regions. Almost 45% of the women who sought prenatal care in Asia used private facilities, as compared to 16% in Sub-Saharan Africa and 10% in Latin America. The importance of private care in Asia may explain the greater wealth effect on both the decision to seek care and the number of visits, as well as the more pronounced education and maternal age effect on the number of visits. In the latter case, both age and education may allow women to better assess the cost and benefits of additional visits. Also, the stronger influence of marital

status on the decision to seek care in Asia may be reflective of a greater cultural bias against premarital births in that region (Duong *et al.* 2004).

Finally, the findings that a woman's employment status has little effect on her use of prenatal care in Asia and Latin America, while it has a positive effect in Sub-Saharan Africa, points to the potential for multiple pathways through which a woman's working status can influence the use of prenatal care. Seeking employment outside the home may encourage women to seek more care by providing them with an increased range of movement, better access to information, more resources, as well as greater confidence and ability to plan for the future (Gabrysch and Campbell, 2009; Hogan *et al.,* 1999). However, employment may not necessarily be associated with greater use of maternity care if: (i) women have little control over their earnings; (ii) employment is largely poverty-induced and reflect resource constraints; and (iii) employment is seasonal and poorly-remunerated (Addai, 2000; Desai and Jain, 1994; Gabrysch and Campbell, 2009; Miles-Doan and Brewster, 1998). Moreover, to the extent to which participation in income-generating work increases women's combined paid and unpaid work load, they may have little time available for seeking prenatal care in general and for repeated visits in particular. Data on women's occupation is available only for a sub-set of the countries under consideration. According to these data, far fewer respondents in Asia than in Sub-Saharan Africa reported currently working (36 versus 65%) and those who worked outside the home in Asia were disproportionately from poor and near-poor households, and they were mainly engaged in agriculture as hired workers (38%) or self-employed (22%). By contrast, less than 4% of the currently working women in Sub-Saharan Africa worked as hired agricultural workers, while almost 55% reported being engaged in agriculture as self-employed. Moreover, far fewer women in Asia work in sales than in Sub-Saharan Africa (9 versus 21.5%). In contrast to Asia

and Sub-Saharan Africa, far fewer women in Latin America work in agriculture, either as self-employed (8%) or as employees (9%), with almost half of the sample population being engaged in sales and unskilled manual jobs. These patterns of employment would seem to support the view that work is much more of a response to poverty in Asia than it is in Sub-Saharan Africa, thus leading to the contrasting effects indicated by the estimation results.

These findings have important policy implications for the utilization of prenatal care in low-income countries. The strong influence of household wealth, education and regional poverty on prenatal care use suggests that safe motherhood programs need to explore effective ways of increasing service utilization among poor and less educated birthing women, as well as those living in the poorest regions of a country. Similarly, the existence of large urban-rural disparities in the use of any prenatal care and repeated visits emphasizes the importance of developing appropriate maternal health care delivery systems in rural areas to ensure greater and timely access to quality maternal health services (Bhutta *et al.,* 2008). Interventions that can be delivered by primary health care, in community settings that allow female fieldworkers (from the community) to identify pregnant women for antenatal care, have proved important in increasing the utilization of antenatal care in some resource-poor settings (Griffiths and Stephenson, 2001).

Over the longer term, the objectives of safe motherhood programs can be linked with those of social and economic development programs such as poverty reduction, enhancing the status of women, and increasing primary and secondary school enrolment rate among girls. The finding that teenage mothers and unmarried women, and those with unintended pregnancies, are less likely to seek prenatal care and have fewer visits suggests that particular attention needs to be paid to the disadvantaged and vulnerable sub-groups of the population whose reproductive health issues are often fraught with controversy (Bernstein, 2005; Magadi *et al.*, 2007). Since

teenage birthing mothers are more likely to experience premarital and unintended births than older birthing women, coupled with their more precarious socio-economic positions, they are a sub-group of particular concern (Gage, 1998; Magadi *et al.*, 2000; Magadi *et al.*, 2007; Marston and Cleland, 2003). Finally, the importance of unobserved community-level factors on women's decisions to use any prenatal care suggests the need to contextualize policy efforts aimed at increasing the use of prenatal care in low-income countries. Clearly, additional research, especially qualitative, remains to be done to understand the unseen community-level determinants of utilization of prenatal care and how any barriers that may exist can be reduced in socially- and culturally-appropriate ways.

Some caveats are in order. While the quality of DHS data is quite high for low-income countries, common data limitations remain. The data on the utilization of maternal services are subject to recall errors and the wealth index, as a measurement of household socio-economic status, is criticized for being too urban in the construction of the household wealth index (Rutstein, 2008), and is also problematic for cross country analysis. Moreover, the study does not adequately control for the availability and quality of prenatal care services. In many resource-poor settings, both the shortage and competency of health care providers is one important barrier and a birthing woman may not necessarily receive competent antenatal care, even if she uses a formal health facility (Jahn *et al.*, 2000; Nikiema *et al.*, 2010; Pallikadavath *et al.*, 2004; Ross and Begala, 2005).[35] The problem is further compounded by the lack of a supportive infrastructure, including the lack of drugs and equipment, ineffective supervision, lack of information or proper counselling to pregnant women on pregnancy complications or any other

[35] It should be noted that, despite the potential absence of skilled care during a facility delivery, that still remains significantly less likely than for in home deliveries.

danger signs, low morals, poor attitudes towards patients, and an uncoordinated care process when more than one type of provider is contacted (Jahn *et al.,* 2000; Koenig *et al.,* 2007; Ross and Begala, 2005). Using enumeration areas as proxies for communities may conceal a category of much greater complexity. However, enumeration areas are considered to be a more accurate representation of the community environment for some settings than the sampling strata (Gage and Calixte, 2006). Finally, the study relied on cross-sectional data, and hence the results may be subject to some selectivity and endogeneity bias – though, given the strength of most of the results, such bias is unlikely to have made a substantive difference.[36]

3.6 CONCLUSION

Using the Demographic Health Surveys data from 32 low-income countries across Asia, sub-Saharan Africa and Latin America, and an appropriate modeling framework, this paper sought to determine the factors involved in the decision to seek care and the number of prenatal visits for a group of thirty-two low-income countries across three developing regions. A two-stage modelling approach was used to separately assess the decision to seek care and the frequency of use. Our findings indicate that, though there is some overlap, different sets of explanatory variables are related to the decision to utilize health care and the further decision on how frequently to utilize it. Those variables that are important in both decisions do not appear to have the same importance in the two decisions. Thus, whether or not to use health services and the decision regarding the frequency of use appear to be based on separate, sequential, decision–

[36] Selectivity and endogenity biases may include some predisposing factors such as complications during the previous pregnancy, previous exposure to maternal health care services and availability of such services in the community. These factors may influence a woman's decision to seek care as well as the number of prenatal visits.

making processes. The empirical evidence presented in this chapter demonstrated, as well, that the decision to seek care and the frequency of care continues to remain low among the poor, the very young and the unmarried, and hence concerted efforts are needed to motivate women in those categories to utilize antenatal services.

APPENDIX 3

Table A.3.1. List of low-income countries, by survey year and region

Asia	Ethiopia 2005
Bangladesh 2007	Ghana 2008
Cambodia 2005	Guinea 2005
India 2005-06	Kenya 2003
Nepal 2006	Lesotho 2004
Vietnam 2002	Liberia 2007
Pakistan 2006-07	Madagascar 2003-04
	Malawi 2004
Latin America	Mali 2006
Haiti 2005-06	Mozambique 2003
Honduras 2005-06	Niger 2006
Nicaragua 2001	Rwanda 2005
	Senegal 2005
Sub-Saharan Africa	Sierra Leone 2008
Benin 2006	Tanzania 2007-08
Burkina Faso 2003	Uganda 2006
Cameroon 2004	Zambia 2007
Chad 2004	Zimbabwe 2005-06
Congo, Dem. Rep 2007	

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Chapter 4

Determinants of the use of prenatal ultrasounds: Evidence from Canada

Abstract

Using the Maternity Experience Survey (MES) of the Canadian Perinatal Surveillance System, and employing a count data regression model, this essay examines the influence of various socioeconomic and demographic factors on the frequency of prenatal ultrasounds in Canada, while controlling for maternal risk profiles. The results of this investigation suggest that the increase in the number of ultrasounds is not solely explained by maternal risk. Even after controlling for these risk factors, the type of health care provider, province of prenatal care, and the timing of the first ultrasound were the strongest predictors of the number of ultrasounds. Birthing women who received their care in Ontario were likely to have more ultrasounds than the women who received their prenatal care from other provinces/territories. Similarly, obstetricians/gynecologists were likely to recommend more ultrasounds than midwives, nurse practitioners and family physicians. Ultrasounds in the first trimester were strongly associated with a higher total number of ultrasounds during the pregnancy. Thus, there is a case to be made for more closely examining those underlying factors, if efforts are to be made to reduce the use of ultrasounds in circumstances where there is no documented benefit.

Keywords: prenatal care; ultrasonography; Poisson regression; Canada

4.1 INTRODUCTION

Ultrasonography has become one of the most critical and integral components of prenatal care in the modern medical era. Routine obstetrical ultrasound screening of the fetus is used for early detection of congenital and placental abnormalities, multiple gestation pregnancies, fetal growth disorders, and to assess gestational age (Ewigman, 1991; Sari-Kemppainen *et al.,* 1990; Youngblood, 1989). Indisputably, this has provided, at least in theory, an opportunity for the current generation providers to detect problems that might not otherwise have been apparent; leading to improvements in clinical outcomes through fetal interventions, anomaly counseling, postnatal management, and pregnancy termination (Clayton and Brock, 2010). However, routine ultrasound is not generally recommended and the use of ultrasound as a part of routine prenatal care has been controversial. A recent review of prenatal care in the United States suggests that the routine ultrasound screening is unlikely to be more beneficial or cost effective than targeted screening of women with specific risk factors (Filly and Crane, 2002; Raynor, 2003).[37] Evidence suggests no beneficial effect of prenatal diagnostic imaging in terms of important clinical outcomes, such as perinatal morbidity and mortality among fetuses of low risk pregnant women (Ewigman, 1993; Sari-Kemppainen *et al.,* 1990; Thompson *et al.,* 1998).[38] Whereas no fetal or maternal abnormality has been linked to the use of prenatal ultrasound, there is some suggestive evidence that there may be biological effects on the fetus in the form of, intrauterine growth restriction, delayed speech, non-right handedness and a range of other risks presumed to be related to frequent diagnostic imaging (Bly and Hof, 2005; Campbell, 1993; Newnham *et al*.,

[37] Maternal risk is identified by demographic features, patient's obstetric history and complications in current pregnancy that is threatening to mother and/ or fetus (Goodwin *et al.,* 1969; Coopland *et al.,* 1977).

[38] It would tend to reduce mortality only in cases where women choose to terminate pregnancy upon indication of fetal abnormality (Saari-Kemppainen *et al.,*1990)

1993; Salvesen *et al.*, 1999). Moreover, the use of prenatal ultrasonography among low-risk pregnancies can lead to unintended harmful consequences, such as increased anxiety from early and false-positive diagnoses of fetal abnormalities (Berwick and Weinstein, 1985).

The widespread use of prenatal ultrasound has raised concern about unnecessary testing and potential overutilization of diagnostic imaging, particularly among low-risk pregnancies (Ewigman, 1993; Iglehart, 2006). The total annual operational costs for diagnostic imaging in Canada is now more than $2.2 billion, with prenatal ultrasonography being one of the most rapidly proliferating imaging test (You *et al.*, 2010). [39] Given the high cost of diagnostic imaging tests, there is a need for health-care professionals and policy makers to have some appreciation of the factors that determine the frequency of prenatal ultrasounds in order to properly assess the extent to which the current frequency of use is justified vis-a-vis its costs.

There are some Canadian studies that have documented the evidence of rapid and inappropriate use of prenatal ultrasonography technology in a selected number of provinces – Anderson (1994) for Ontario and British Colombia, Thompson *et al.*, (1998) for Western Labrador, and You *et al.*, (2007, 2010) for Ontario. There is, however, no published nationwide study that examines the determinants of the frequency of use of prenatal ultrasonography in Canada. This essay seeks to fill this gap in the literature by examining the effect a wide range of socioeconomic and demographic factors, and the type of prenatal care provider, on the number of prenatal ultrasounds in Canada, while controlling for maternal risk factors. The econometric study presented here is the first of its kind using 2006 Canadian Maternity Experiences survey - a

[39] In 2005–2006, Canadian hospitals reported an estimated $2.2 billion for the operation of diagnostic imaging services; this is up from the $2.0 billion reported in 2004–2005 (CIHI, 2007). As such, prenatal ultrasound imaging may account for only a small proportion of total cost, but that may be occurring with many other imaging tests and that additional cost needs to be emphasized (You *et al.*, 2010).

rich data set that allows us to control for a wider set of maternal socioeconomic factors, as well as the type of provider and maternal risk factors than earlier studies.

The remainder of this chapter proceeds as follows: Section 4.2 provides a review of the existing literature on the use of prenatal ultrasounds; Section 4.3 outlines the data and methodology used; the findings and analysis are presented in Section 4.4; and, finally, Section 4.5 discusses the results, while section 4.6 concludes the study.

4.2 LITERATURE REVIEW

Routine ultrasound examination has become a universal feature of prenatal care in developed countries and in those developing countries with developed health services (Garcia *et al.,* 2002). However, the literature on the utilization of prenatal ultrasound is limited, and many studies focus on documenting its trend and its appropriateness. According to Anderson (1994), the number of prenatal ultrasounds more than doubled in both Ontario and British Colombia between 1981 and 1990, and total expenditure for prenatal ultrasound increased 304 percent in Ontario and 133 percent in British Colombia over the same period. The average number of prenatal ultrasound examinations per delivery also increased from 1.06 to 2.18 in Ontario and from 0.88 to 1.75 in British Colombia. Further, in British Colombia, about 80 percent of women who delivered had at least one prenatal ultrasound examination during pregnancy and six percent had more than four. Overall, the increase in the use of ultrasound was found to be primarily driven by increases in rates of utilization in all age groups and not by increases in the proportion of older pregnant women.

Another regional study by Thompson *et al*. (1998) also examined the frequency of prenatal ultrasonography and its appropriateness in Western Labrador in 1994. Their descriptive findings suggest no significant differences in the number of ultrasounds between low-risk and high-risk pregnancies and between uncomplicated deliveries and instrumental or operative deliveries. Their findings also indicated that there was a substantial overuse of prenatal ultrasound examination in Western Labrador, where, on average, 2.16 ultrasounds were performed per delivery and more than half (53 percent) of the examinations were classified as inappropriate, according to the existing guidelines. Moreover, the study did not find any relation between the number of prenatal ultrasound examinations and maternal or neonatal outcome.

However, the average number of prenatal ultrasounds conceals a wide variation in the use of ultrasound across birthing women. According to the Maternity Experience Survey (2006), while women reported, on average, 3.1 ultrasounds during pregnancy, 15.8 percent had one, 31.1 percent had two and about 30 percent had more than four. The average number of ultrasounds also varied widely across providers and by the place of residence of respondents (PHAC, 2006). A recent study by You *et al.*, (2010) used repeated cross-sectional population based data on all women, with a singleton obstetric delivery from 1996 to 2006 in Ontario, and examined the extent to which the observed rapid increase in the use of ultrasounds reflects changes in maternal risk, while controlling for maternal age, income, rural versus urban place of residence, and a range of maternal risk factors. The results suggest a substantial increase in the use of prenatal ultrasound and the magnitude of the increase in rates was similar for women with low-risk pregnancies and those with high risk pregnancies in the second or third trimester. As the rising utilization could not be explained solely by increases in maternal age, changes in maternal risk

profiles or increases in uptake of first trimester scanning for nuchal translucency, the authors, therefore, suggested the importance of nonclinical factors that may lead to an increase in usage.

4.3 DATA AND METHODS

4.3.1 Data

This study utilizes the Maternity Experience survey (MES) data set conducted by Statistics Canada in 2006 and sponsored by Public Health Agency of Canada. The MES study is a nationwide survey that assessed pregnancy, delivery and postnatal experiences of mothers and their children. Participants eligible for the study were women aged 15 years and above, who had singleton live births between the period of February 15, 2006 and May 15, 2006 in the ten provinces of Canada and between November 1, 2005 and February 1, 2006 in the Territories of Canada and who lived with their baby at the time of data collection. A stratified random sample of 8,542 women was selected, without replacement, from the May 2006 Canadian Census. The stratification was primarily by province or territory. An estimated 8,244 were deemed eligible for the survey. The number of women who responded fully to the survey questions (conducted by telephone) was 6,421. Non-response to the survey was mainly from inability to establish telephone contact. The majority of the (telephone) interviews were conducted between the 5th and 9th month after delivery.

4.3.2 Methodology

The survey output of primary interest is the number of prenatal ultrasounds during pregnancy. [40] Since the output of primary interest is a non-negative integer, a discrete probability distribution provides a natural basis for modeling the frequency of prenatal ultrasound examination. The Poisson regression model is thus a natural starting point for analysis.[41] The Poisson regression model is derived from Poisson distribution, whose probability mass function can be defined as:

$$Pr[y_i|x_i] = \frac{e^{-\mu_i}\ {\mu_i}^{y_i}}{y_i!},$$

In the context of our analysis, we are interested in modeling the probability of *y* number of ultrasounds by i^{th} women in a single pregnancy, μ is the intensity parameter to be estimated, and x_i is the vector of covariates. It can be shown that the conditional mean is given by $E[y_i|x_i] = \mu_i$ and $\text{var}[y_i|x_i] = \mu_i$, a well-known equidispersion property of the Poisson model. With exogenous regressors, the usual Poisson specification is: $\mu_i = \exp(x_i\,\beta)$, where $x_i$is the vectors of explanatory variables and β is the vector of parameters to be estimated. The density function is therefore:

$$\Pr[y_i|x_i\beta)] = \frac{\mathrm{e}^{-\exp(\mathrm{x}_i\beta)}\qquad \exp(x_i\,\beta)^{y_i},}{\mathrm{y}_i!}$$

[40] It should be noted here that the number of ultrasounds included in the data are the ones referred by physicians and performed in a public health facility only. There are private diagnostic imaging centres available in various provinces but we cannot include the effect of these additional procedures. However, since these ultrasounds are often performed for their entertainment values (such as to have keepsake videos/pictures), the net effect would likely be to further magnify the effect of non-risk factors on the total number of ultrasounds performed per pregnancy.

[41] We have also run our regression with the Negative Binomial model to account for overdispersion. The value of α turned out to be very small. The Poisson distribution is a special case of the negative binomial distribution where α=0 (Cameron & Trivedi, 1986).

Since the MES sample was not a simple random sample, weighted estimates of prevalence and variances were required to take into consideration the sample design and rates of non-response (Statistics Canada, 2006). The number of ultrasounds was estimated through population weights and examined across various socio-economic, demographic, types of prenatal care provider and maternal risk factors. Population weights estimate the representativeness of each respondent in the sample based on the relevant strata. It also takes non-responses into consideration (Statistics Canada, 2006). Reported percentages in this study are based on 5376 respondents giving birth during the survey target period.[42]

To account for the complex sampling design, bootstrapping was performed to calculate standard errors (Rao & Wu, 1988; Rao *et al.*, 1992). Population weights and bootstrap weights were all created by Statistics Canada and provided with the MES data file. All analyses, including bootstrapping, were conducted using the statistical software STATA (version 12.0).

4.3.3 Study variables

A wide range of independent variables were investigated as potential predictors of the number of ultrasounds during pregnancy. These independent variables are grouped as: a) maternal risk profile; b) socioeconomic and demographic factors; c) type of prenatal care provider; d) reproductive history; and e) timings of first prenatal visit. Table A.4.1 (Appendix 4) describes and presents the summary statistics of dependent and independent variables used in the study.

Potential maternal risk factors are presented by eight indicators: If women have: (i) any health problems before and during pregnancy defined by any new medical conditions; (ii) any

[42] Women who reported prenatal care from outside Canada have been excluded from the analysis (but that sub-group covered less than thirty observations).

health problems that required taking medication for more than 2 weeks, having special care, or extra tests; (iii) hospital stay for supervision before birth or delivery; (iv) use medications or technology to get pregnant; (v) any complications during labor or birth; then it is considered a risky pregnancy. Further, women's body mass index before pregnancy was used to capture the impact of weight on the number of ultrasounds. It was categorized into four groups: underweight, normal weight (the reference category), overweight and obese. A pregnancy was considered to be risky if the woman was obese or overweight. Type of birth was grouped into three categories: Cesarean, vaginal (reference category) and induced delivery with forceps or vacuum. Similarly, term of delivery, (preterm, full-term (the reference category) and post-term) was used to capture the relationship between preterm delivery and the use of ultrasounds. Gestational week of pregnancy when a woman had her first ultrasound was grouped into three main categories: less than 10 weeks of pregnancy, 11-19 weeks of pregnancy (the reference category) and greater than 20 weeks of pregnancy. These categories were meant to capture the effect of timings of ultrasound on its frequency.[43]

Socio-economic and demographic factors included in this study are maternal age at selected birth, province/territory where prenatal care was sought, urban/rural place of residence, maternal education, total household income and residency status of the woman. Maternal age is classified into five broad categories: ages 15-19, 20-24, 25-29 (the reference category), 30-34, 35-39 and 40 years and older. Dummy variables were created to represent the provinces and the territories (as a group), with Ontario as the reference category. Place of residence was sorted into three groups, rural, semi-urban (the reference category) and urban. Maternal education was

[43] Guidelines generally recommend two ultrasound examinations be performed in a pregnancy without complications — one in the first trimester (between 10-12 weeks' gestation), for measurement of nuchal translucency to screen for aneuploidy, and one in the second trimester (between 18- 22 weeks' gestation) to screen for fetal anomalies as a standard of care (PHI, 1992; Summers *et al*., 2007).

grouped into four broad categories: less than high school, high school graduate, post-secondary diploma (reference category), and the university graduates. Annual household income was categorized into four groups: less than $30,000, $30,000 to $59,999, $60,000 to less than $99,999 (the reference category) and $100,000 and more. Residency status, defined by declared place of birth in the 2006 census, was grouped into three broad categories: Canadians, aboriginals and immigrants. The Canadians included all individuals born in Canada but not aboriginal. All permanent residents born outside Canada were classified as immigrants. The aboriginals' category included all those born in Canada and identifying themselves as belonging to one of the following three categories: First nations, metis and Inuit.[44]

Type of prenatal care provider was categorized into five main groups: obstetricians/gynaecologists (the reference category), family doctor/general practitioners, midwives, nurses and others. Timing of the first prenatal care visit was grouped into three trimesters, with the first trimester being the reference category. Reproductive history was represented by parity and history of complications in a prior pregnancy associated with stillbirth, miscarriage, and tubal or ectopic pregnancy.

4.4 RESULTS

4.4.2 Descriptive analysis

Table 4.1 below reports the average number of prenatal ultrasound by province, type of health-care provider and by timing of the first prenatal ultrasound. On average, the birthing women received 2.9 ultrasounds for a single pregnancy. There were also wide variations in the number of ultrasound across provinces/territories, type of health-care provider, and place of

[44] There were a few cases where immigrants also responded to be an aboriginal. But since the focus is on Canadian Aboriginals, those cases were recorded as immigrants.

residence. Women who received most of their prenatal care in Ontario and Nova Scotia had, on average, the highest number of ultrasounds, 3.12 and 2.99, respectively. By contrast, women who received most of their prenatal care in Manitoba or Territories (Northwest Territories, Yukon and Nunavut) had on average 2.3 and 2 ultrasounds, respectively.

Table 4.1. Average number of ultrasounds by provincial prenatal care, type of health care provider and timings of first ultrasound.

	Number of ultrasounds
Average	2.90
By Province of prenatal care	
Newfoundland	2.93
Prince Edward Island	2.25
Nova scotia	2.99
New Brunswick	2.81
Quebec	2.86
Ontario	3.12
Manitoba	2.21
Saskatchewan	2.69
Alberta	2.85
British Colombia	2.62
Territories[1]	2.06
By type of health care provider	
Obstetrician /Gynaecologists / or both	3.09
Family Doctor/GP/Doctor unspecified	2.68
Midwife	2.40
Nurse	2.43
Other	3.35
By week of pregnancy for first ultrasound	
<=10	3.77
11 to 19	2.65
>=20	1.96

Similarly, women who visited Obstetricians and/or Gynecologists for their prenatal care received, on average, the highest number of ultrasounds (3.09), compared to 2.4 ultrasounds for those whose prenatal care providers were midwives and/or nurse practitioners. Wide variations were also noticeable in the number of ultrasounds by the week of pregnancy when a woman had

her first ultrasound. Women who had their first ultrasounds before the tenth week of gestation, received, on average, more ultrasounds (3.77), compared to those who receive the first ultrasounds between 11 and 19 weeks of pregnancy (2.65 only) and more than 20 weeks of pregnancy (1.96).

4.4.3 Econometric analysis

The regression results for the number of ultrasounds are presented in Table 4.2. The results show that all explanatory variables have the expected signs, with the sole exception of aboriginal status and most of them are statistically significant at the 1% level.

With respect to maternal risk characteristics, birthing women who had health problems before and during pregnancy and received extra tests or medications are, respectively, 11 and 13% more likely to have frequent ultrasounds than those who did not have such problems (the reference category). Women who had a hospital admission before labor or birth were 18% more likely to have a higher number of ultrasounds. However, women who used medical technology to get pregnant and had complicated labor or birth were, only 7% and 3% respectively, more likely to have a higher number of ultrasounds. Compared to a normal weight woman, an obese woman was 7% more likely to have a higher number of ultrasounds. Similarly, compared to vaginal birth, women who had a Cesarean were 6% more likely to have a higher number of ultrasounds.[45] Women who had a post-term baby (>41 weeks) were 15% more likely to have a higher number of ultrasounds than if the baby was full-term (the reference category). Women who had their first ultrasound in less than ten weeks of pregnancy were also 30% more likely to have a higher number of ultrasounds compared to those who received their first ultrasound in the

[45] It should be noted that Cesarean here includes both for medical and non-medical reasons.

11th to 19th weeks of pregnancy. By contrast, women who had their first ultrasound after more than 20 weeks of pregnancy were 24% less likely to have more ultrasounds.

Table 4.2 : Regression results for the number of ultrasounds

	Coefficient Estimate	Bootstrap Standard error
Maternal Risk profile		
Health problems Before pregnancy	0.1051*	0.0174
Health problems During pregnancy	0.1316*	0.0148
Overnight Hospital Stay before labor/birth	0.1756*	0.0192
Technical pregnancy	0.0688*	0.0259
Complications during labor/ birth	0.0304*	0.0184
Body mass index before pregnancy		
Under Weight	0.0367	0.0278
Overweight	0.0040	0.0163
Obese	0.0652*	0.0188
Type of birth		
Caesarean	0.0581*	0.0143
Forceps or vacuum	0.0255	0.0211
Term of delivery		
Pre term	0.0067	0.0371
Post term	0.1004*	0.0331
Week of pregnancy when had first ultrasound		
<=10	0.2958*	0.0139
>=20	-0.2412*	0.0323
Socio- Economic and Demographic factors		
Maternal age at selected birth		
15-19	0.0005	0.0469
20-24	-0.0321	0.0227
30-34	0.0356**	0.0162
35-39	0.0432**	0.0204
>=40	0.1310*	0.0374
Province of Prenatal care		
Newfoundland	-0.0123	0.0319
Prince Edward Island	-0.2431*	0.0363
Nova Scotia	-0.0219	0.0287
New Brunswick	-0.0213	0.0315
Quebec	-0.0510*	0.0176
Manitoba	-0.2358*	0.0344
Saskatchewan	-0.0888*	0.0285
Alberta	-0.0696*	0.0221
British Colombia	-0.1462*	0.0230
Territories[i]	-0.1957*	0.0364

[i] Includes Yukon, Nunavut and North west Territories

*significant at 1% level; ** significant at 5% level; ***significant at 10% level

Table 4.2(Continued)

	Coefficient Estimate	Bootstrap Standard error
Area of Residence		
Rural	-0.0133	0.0185
Urban	0.0684*	0.0155
Maternal education		
Less than high school	-0.0174	0.0319
High school graduate	-0.0061	0.0189
University graduate	0.0181	0.0157
Household income		
<30,000	0.0332	0.0221
30,000-59,000	0.0091	0.0167
>100,000	0.0162	0.0181
Residency status		
Aboriginals	0.0516	0.0327
Immigrants	0.0186	0.0177
Type of prenatal care provider		
Doctor	-0.0908*	0.0140
Midwife	-0.1961*	0.0309
Nurse	-0.1300***	0.0768
Other	0.0306	0.1030
Trimester of Prenatal care		
Second and third trimester	-0.1013**	0.0435
Reproductive history		
Parity		
2	-0.0523*	0.0150
3	-0.0797*	0.0220
4	- 0.0693***	0.0415
>=5	-0.1518*	0.0581
Any Miscarriage, tubal pregnancy or still birth	0.0618*	0.0130
Constant	0.8935	0.0239

*significant at 1% level; ** significant at 5% level; ***significant at 10% level

Among the socio-economic and demographic factors, maternal age, the province of prenatal care, and the place of residence are the strongest predictors of the number of ultrasounds, even after controlling for maternal risk factors. The number of ultrasounds varied positively with maternal age, with birthing women aged 40 years and older being 13 times more likely to have a higher number of ultrasounds than those aged 25-29 (the reference category), whereas women in the 30-34 and 35-39 age groups were only 4 % more likely to do so. The

province/territories, where a woman receives most of her prenatal care, was shown to have an important impact on the frequency of ultrasounds. In general, all provinces or territories had fewer ultrasounds than Ontario (the reference category). Women who received their prenatal care in Manitoba and Prince Edward Island were 24% more likely to have fewer ultrasounds than those in Ontario. Similarly, birthing women in British Colombia and the Territories were, respectively, 15% and 20% more likely to have a smaller number of ultrasounds than those in Ontario. As expected, urban women were found to be 7% more likely to have a higher number of ultrasounds than semi-urban women (the reference category). Living in rural areas had a negligible and statistically insignificant impact on the number of ultrasounds. Surprisingly, there was no statistically significant difference between the number of ultrasounds received by aboriginal and non-aboriginal Canadians.

The type of prenatal care provider turned out to be the strongest predictor of the number of ultrasounds. Women who received most of their care from midwives and nurses were 20% and 13% likely to have fewer ultrasounds than those who received most of their care from Obstetricians or Gynaecologists' (the reference category).[46] Regarding the reproductive history covariates, women with a higher number of child births had fewer ultrasounds. An increase in the parity number (birth order) reduced the number of ultrasounds by 5 to 15% for a higher order birth, compared to the birthing women of first parity (the reference category). Similarly, women who had a history of stillbirth, tubal or ectopic pregnancies, or miscarriage were 6% more likely to have more ultrasounds than women who did not. With respect to timings of prenatal care, women who received prenatal care in the second and third trimesters were 10% more likely to

[46] Initially, we have created separate dummies for each type of provider. However, testing for the equality of coefficients on provider indicates that certain types of providers can be aggregated.

have more ultrasounds than those who received care early in the first trimester (the reference category).[47]

4.5 DISCUSSION

Using the Maternity Experience Survey (MES) of the Canadian Perinatal surveillance System, this paper empirically assesses the influence of various socio-economic and demographic factors, type of prenatal care provider, timing of prenatal care, reproductive history and maternal risk factors on the frequency of prenatal ultrasonography in Canada. The results of the study suggest that the use of prenatal ultrasonography in Canada is influenced by a multitude of factors that include type of provider, province of prenatal care, socioeconomic and demographic factors, in addition to pregnancy risk factors.

Most of the potential maternal risk factors we have included in our analysis, such as health problems during or before pregnancy, obesity, complications during pregnancy, type of birth, and term of delivery, are important factors in determining the frequency of ultrasounds and the results are highly significant. These findings are consistent with the growing body of evidence that support the targeted screening of women with specific risk factors so that necessary health interventions can be taken to improve maternal outcomes (Ewigman *et al.,* 1993; Siddique *et al.,* 2009). However, the results of this investigation also suggest that an older woman had a higher chance of receiving a high number of ultrasounds than a woman of a lower age group.

[47] Testing for the equality of coefficients on second and third trimesters indicates that they can be aggregated.

This may reflect a higher potential risk by this age group, since higher maternal age is generally associated with higher rates of preterm birth, fetal growth restriction, perinatal mortality, neonatal morbidity and maternal mortality (Cleary- Goldman *et al.,* 2005; Newburn-Cook and Onyskiw, 2005), but it unlikely to be the only explanation. The investigation results also suggest that, even after controlling for maternal risk factors, women who had their first ultrasound early in their pregnancy (<=10 weeks) were 30% more likely to receive a higher number of ultrasounds, than women who had their first ultrasound between 11- 19 weeks. Even though we allowed for a more generous time frame for the first ultrasound (less than 10 weeks compared to the general recommendation of between 10-12 weeks), our results are strong and statistically significant. This is the likely outcome of two factors. First, since all pregnant women are typically obliged to have an ultrasound in the second trimester, even though they have had an ultrasound in the first trimester, this essentially assures two or more ultrasounds for that pregnancy (as well as calling into question the wisdom of early ultrasounds that cannot provide full information because fetus is not fully developed until the second term). Second, this may also reflect self-selection, as women who are overanxious (or overcurious) about the pregnancy may push their doctor for early ultrasound.

Beyond this, the results of this investigation also suggest that the increase in the number of ultrasounds in a government-sponsored health care system, with (presumably) universal access to prenatal services, is not solely explained by maternal risk. Even after controlling for risk factors, the type of health care provider, province of prenatal care, place of residence, and timing of the first ultrasound are the strongest predictors of the number of ultrasounds. This suggests, in the first instance, that there are substantial regional variations in the utilization of obstetric ultrasonography. Birthing women who receive most of their care from Ontario were

likely to have more ultrasounds than women who received their prenatal care from other provinces/territories. The variations across provinces might be due to a number of factors, including variations in style of practice and in availability of health-care resources. The higher utilization in Ontario could also be due to the prevalence of a medico-legal environment that encourages more defensive medicine among physicians to protect themselves from litigation (You *et al.,* 2010; Gudex *et al*., 2006; Meire, 1996). Living in urban centers also increased the chance of having more ultrasounds by almost seven percent, compared to women who lived in semi-urban areas. This may reflect the availability of more resources, including the highly skilled professionals in urban centers (Thompson *et al.,* 1998).[48]

Wide differences are also observed in the frequency of ultrasounds across providers. Midwives, nurse practitioners, and doctors/family physicians were likely to recommend fewer ultrasounds than obstetricians/gynecologists. This could reflect adverse selection, as obstetricians/gynecologists tend to attract high-risk birthing women.[49] However, these results turn out to be statistically-significant, even after controlling for maternal risk factors – suggesting that adverse selection is not the main motivator of this result.[50] Also, other studies also report that the number of ultrasounds received by birthing women is independent of maternal risk (You *et.al*., 2010; Thompson *et al.*, 1998; Siddique *et al.*, 2009). Instead, it is likely to have derived from the fact that ultrasounds were likely to be recommended for non-medical reasons. These

[48] The MES data set suggests that 49.18% of women who live in urban areas received their care form Obstetricians and Gynecologists, as compared to 9.8% residing in rural areas. Moreover, Thompson *et al.,* (1998) suggest that due to lack of availability of specialists in rural areas, there has been an increase in the use of prenatal ultrasound by family physicians due to the need for recommending more competent care.

[49] Siddique *et al.,* (2009) also suggest that some Obstetricians' and Gynecologists' categorizations of high risk pregnancy might be very conservative, as compared to other physicians.

[50] There may, however, be some self-selection in the sense that patients who prefer a more technical (test-heavy) approach to medicine may choose the more highly-trained specialist over the midwives, nurses and family doctors.

non-clinical factors at play here likely include the practice of defensive medicine to support the management decisions by highly skilled obstetricians, patient expectations, the desire on the part of providers to reassure their patients that their pregnancy is progressing normally, economic incentives of the physicians, and, in some cases, the 'entertainment value of seeing one's fetus' (Baldwin *et al.,* 1995; Berwick and Weinstein, 1985; Gudex *et al.,* 2006; Studdert *et al.,* 2005; Meire, 1996; Stephens *et al.,* 2000; Simonsen, 2008; You *et al,* 2010). All these non-clinical factors, combined with the lack of defined risks in usage, put pressure on physicians to perform such obstetrical ultrasounds when demanded or expected by patients (Anderson *et al.,* 1994). It may also reflect the inclination of specialists (obstetricians/gynecologists) to use the most advanced technology, such as ultrasounds, even among low-risk patients (the "engineering man" problem), perhaps because specialists find the delivery of high-tech care professionally rewarding, and perhaps they feel that reliance of high-tech care helps them to attract more patients, at least to the extent to which the perceived quality of care by patients is equated with the provision of high-tech care (Ikegami and Campbell, 1999).

Some caveats are in order. First, the timings of interview in MES varied from 5 to 14 months postpartum, which might have influenced both maternal recall and perceptions of some of the events and experiences. Second, since the data captures only those respondents who have singleton live births, it ignores the cases of multiple gestations. Therefore, the data does not allow us to control for twins/triplets, which may have led to overestimates of our results Third, MES datasets provides no information on where scans were actually performed (in private-physicians' offices or in hospitals-based facilities). We assumed that most of the scans in Canada are now performed almost exclusively in hospital settings but we have no explicit proof that this

is the case. In any case, the actually location of the ultrasound has no immediate bearing on the investigation method or results.

4.6 CONCLUSION

Ultrasonography in prenatal care is not inherently negative. It provides an opportunity for communication between patient and physicians on important congenital abnormalities (where they occur) that serve to improve the quality of care. However, the repetitive use of ultrasonography, particularly among low-risk pregnancies, calls into question the efficacy of limited health-care resources in a cost-conscious health-care environment. Using the Maternity Experience Survey (MES) of the Canadian Perinatal Surveillance System, and employing a count data regression model, this paper clearly demonstrated that the use of prenatal ultrasonography in Canada is driven by much more than the pregnancy risk factors. The use of prenatal ultrasounds is strongly related to socioeconomic and demographic factors such as province of prenatal care, type of prenatal care provider, and the timings of first ultrasound, besides pregnancy risk factors. Thus, these findings have important policy implications with respect to the utilization and funding of prenatal ultrasonographic imaging.

In an era of growing concerns over health-care costs, considerable attention must be devoted to the higher utilization of prenatal ultrasound and the underlying motivation. Fiscal restraints necessitate the need for selectively allocating health-care resources by reducing the use of medical interventions, such as ultrasounds among those for which there is no documented benefit (i.e. low-risk pregnancies). Providers and patients should fully understand the implications of using it. Physicians should carefully balance patients' desires and expectations against the clinical usefulness of the information provided by prenatal ultrasonography (Stephens

et al., 2000). Expectant women and their families should be made aware that the long-term effects of repeated ultrasounds are unknown and that, therefore, prudence in its use is advisable. Further, because the information obtained from ultrasound imaging is dependent on the operator's technical accuracy (Peek *et al.*, 1994; Ewigman *et al.*, 1993), there is a strong justification for emphasis on quality of care so that repeat scans can be avoided.

APPENDIX 4

Table A.4.1: Summary Statistics for the Dependent and independent variables

Variable name	Description	Mean	Bootstrap Std. Error
Dependent variable			
Number of ultrasounds	A count variable indicating the frequency of ultrasounds	2.9014	0.0187
Independent variables			
Maternal Risk profile			
Health problems Before pregnancy	1=if woman had any health problems before pregnancy, 0 otherwise	0.1523	0.0047
Health problems During pregnancy	1=if woman had any health problems during pregnancy, 0 otherwise	0.2445	0.0055
Overnight Hospital Stay before labour/birth	1=if woman stayed in the hospital overnight before labour or birth, 0 otherwise	0.1245	0.0043
Technical pregnancy	1=if woman has taken medications or used technical procedures to get pregnant, 0 otherwise	0.0466	0.0028
Complications during labour/ birth	1=if woman has faced any complications during labour or birth, 0 otherwise	0.1460	0.0046
Body mass index before pregnancy			
Under Weight	1= if women Body mass index is below 18.5, 0 otherwise	0.0611	0.0033
Normal Weight (the reference category)	1= if women Body mass index is below 18.5-24.9, 0 otherwise	0.5932	0.0066
Overweight	1= if women Body mass index is below 25-29.9, 0 otherwise	0.2100	0.0056
Obese	1= if women Body mass index is greater than 30, 0 otherwise	0.1357	0.0045
Type of birth			
Caesarean	1= if women had caesarean birth, 0 otherwise	0.2625	0.0058
Vaginal (the reference category)	1= if women had vaginal birth, 0 otherwise	0.6180	0.0063
Forceps or vacuum	1= if women had vaginal birth with forceps or vacuum used, 0 otherwise	0.1195	0.0043
Term of delivery			
Preterm	1=if women had preterm delivery (less than 27 weeks of gestation), 0 otherwise	0.0504	0.0029
Full term (the reference category)	1=if women had full term delivery, 0 otherwise	0.9084	0.0037
Post term	1=if women had post term delivery (greater than 40 weeks of gestation), 0 otherwise	0.0412	0.0025
Week of pregnancy when had First ultrasound			
<=10	1=if women had her first ultrasound in this week of pregnancy, 0 otherwise	0.2735	0.0059
11-19 (the reference category)	1=if women had her first ultrasound in this week of pregnancy, 0 otherwise	0.6518	0.0063
>=20	1=if women had her first ultrasound in this week of pregnancy, 0 otherwise	0.0747	0.0034

Table A.4.1(Continued)

Variable name	Description	Mean	Bootstrap Std. Error
Socioeconomic and Demographic Factors			
Maternal age at selected birth			
15-19 years	1=if woman is in this age group, 0 otherwise	0.0298	0.0010
20-24 years	1=if woman is in this age group, 0 otherwise	0.1311	0.0039
25-29 years (reference category)	1=if woman is in this age group, 0 otherwise	0.3328	0.0043
30-34 years	1=if woman is in this age group, 0 otherwise	0.3308	0.0045
35-39 years	1=if woman is in this age group, 0 otherwise	0.1458	0.0042
>=40 years	1=if woman is in this age group, 0 otherwise	0.0297	0.0022
Province of Prenatal care			
Newfoundland	1=if woman receive care in this province, 0 otherwise	0.0134	0.0002
Prince Edward Island	1=if woman receive care in this province, 0 otherwise	0.0038	0.0001
Nova Scotia	1=if woman receive care in this province, 0 otherwise	0.0222	0.0002
New Brunswick	1=if woman receive care in this province, 0 otherwise	0.0194	0.0002
Quebec	1=if woman receive care in this province, 0 otherwise	0.2350	0.0011
Ontario (the reference category)	1=if woman receive care in this province, 0 otherwise	0.3932	0.0013
Manitoba	1=if woman receive care in this province, 0 otherwise	0.0350	0.0003
Saskatchewan	1=if woman receive care in this province, 0 otherwise	0.0310	0.0004
Alberta	1=if woman receive care in this province, 0 otherwise	0.1233	0.0008
British Colombia	1=if woman receive care in this province, 0 otherwise	0.1186	0.0006
Territories[1]	1=if woman receive care in this province, 0 otherwise	0.0052	0.0001
Area of Residence			
Rural	1=if household reside in rural area, 0 otherwise	0.1781	0.0047
Semi-urban (the reference category)	1=if household reside in semi-urban area, 0 otherwise	0.3705	0.0057
Urban	1=if household reside in urban area, 0 otherwise	0.4514	0.0054
Maternal education			
Less than High School	1=if less than high school education, 0 otherwise	0.0767	0.0039
High School graduate	1=if completed high school graduate, 0 otherwise	0.1937	0.0051
Post-secondary Diploma (reference category)	1=if post-secondary diploma, 0 otherwise	0.3746	0.0062
University Graduate	1=if university Graduate, 0 otherwise	0.3550	0.0062
Household Income			
<30,000	1=if household income is in this group, 0 otherwise	0.1704	0.0050
30,000-59,000	1=if household income is in this group, 0 otherwise	0.3070	0.0060
60,000-99,000 (the reference category)	1=if household income is in this group, 0 otherwise	0.3217	0.0061
>=100,000	1=if household income is in this group, 0 otherwise	0.2009	0.0053

Table A.4.1 (Continued)

Variable name	Description	Mean	Bootstrap Std. Error
Immigrant status			
Canadians(the reference category)	1= if Canadian non-aboriginal, 0=otherwise	0.7175	0.0060
Aboriginals	1= if Canadian aboriginal, 0=otherwise	0.0422	0.0024
Immigrants	1= if landed immigrant of Canada, 0=otherwise	0.2403	0.0057
Type of health care provider			
Obstetrician and/or Gynaecologists (reference category)	1=if woman receive care from any of these type of providers, 0 otherwise	0.5811	0.0062
Family Doctor/General Practitioners/Doctors(Unspecified)	1=if woman receive care from any of these type of providers, 0 otherwise	0.3486	0.0057
Midwife	1=if woman receive care from this type of provider, 0 otherwise	0.0602	0.0032
Nurse or Nurse practitioner	1=if woman receive care from this type of provider, 0 otherwise	0.0056	0.0007
Other	1=if woman receive care from Other provider, 0 otherwise	0.0044	0.0009
Timings of Prenatal care			
First trimester (reference category)	1=if woman receive first prenatal care in the first trimester (1-14 weeks), 0 otherwise	0.9581	0.0026
Second trimester	1=if woman receive first prenatal care in the second trimester, 0 otherwise	0.0401	0.0025
Third Trimester	1=if woman receive first prenatal care in the third trimester, 0 otherwise	0.0018	0.0006
Reproductive history			
Parity			
1 (reference category)	1=if first parity, 0 otherwise	0.4547	0.0038
2	1=if second parity, 0 otherwise	0.3645	0.0053
3	1=if third parity, 0 otherwise	0.1256	0.0042
4	1=if fourth parity, 0 otherwise	0.0384	0.0025
5+	1=if five and above parity, 0 otherwise	0.0169	0.0017
Any miscarriage, tubal or ectopic pregnancy or still birth history	1=if having a still birth (the reference category), or miscarriage or tubal pregnancy before, 0 otherwise	0.3242	0.0061

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CHAPTER 5

Prenatal Care in Developed and Developing Countries: Summary and Conclusions

The purpose of this dissertation was to empirically analyze some important issues relating to maternal health care utilization. The dissertation consists of three essays. The first essay examines the impact of prenatal care attendance, and a wide array of observed individual-, household- and community-level characteristics, on the decision to use a health facility for delivery in thirty-two low-income countries (across the three geographical regions of Asia, Africa and Latin America). The second essay tries to identify the factors that determine prenatal care attendance, and the relationship of those factors to the related choice of frequency of visits (also in thirty-two low-income countries across the three geographical regions of Asia, Africa and Latin America). The third essay examines the determinants of prenatal ultrasonography in Canada.

The results of the first essay indicated that the number of prenatal visits have a significant impact on women's decision to use a health facility for delivery across all three geographical regions. In particular, women who had the WHO-recommended four visits were, on average, 7.3 times more likely to deliver at a health facility than those with no prenatal care. The effect of prenatal care attendance on the choice of delivery setting was found to be most pronounced for Sub-Saharan Africa. Given the high rate of maternal mortality and morbidity in these economies,

these results suggest a need for concerted effort in motivating women to utilize antenatal services, since this may be an effective way to increase facility delivery (and, therefore, access to skilled attendants). The influence of the number of prenatal visits, maternal age, education, parity level, and the economic status of the birthing women on the place of delivery was found to vary across the three geographical regions. The results also indicate that geography and economic circumstances matter a great deal. Being urban and being wealthy were two of the strongest predictors of the use of obstetrics care.

The second essay answered two related questions. First, what factors determine a woman's decision to seek prenatal care; and second, are the factors that determine the decision to seek care similar or different from those that determine the frequency of visits. The investigation uses data from thirty-two low-income countries (across three geographical regions of Asia, Africa and Latin America) and a two-part model that allows for the sequential nature of the two decisions. The results suggest that, though both the decision to seek care and the number of prenatal visits are influenced by a similar range of observed individual-, household- and community-level characteristics, the influence of these determinants vary in magnitude across the two decisions (prenatal care attendance and the frequency of prenatal visits) as well as across the three geographical regions. In effect, the two-part modelling strategy suggests that whether or not to use health services and the decision regarding the frequency of use appear to be based on separate, sequential, decision–making processes. Moreover, while unobserved community-level variables appear to have an impact on the decision to seek care, these variables have no apparent impact on the number of visits. Additionally, the research finding that teenage mothers, unmarried women, and those with unintended pregnancies are less likely to seek prenatal care and have fewer visits suggests that safe-mother hood programs need to pay particular attention to

these disadvantaged and vulnerable sub-groups of the population whose reproductive health issues are often fraught with controversy.

The third essay of this dissertation examined the influence of various socioeconomic and demographic factors on the frequency of prenatal ultrasounds in Canada, while controlling for maternal risk profiles. The results of this investigation, using a count data model (the Poisson distribution), indicates that the increase in the number of ultrasounds is not solely explained by maternal risk. Even after controlling for these risk factors, the type of health care provider, province of prenatal care, and timings of first ultrasound were found to be the strongest predictors of number of ultrasounds. Birthing women who receive most of their care from obstetricians/gynecologists were likely to have a significantly higher number of ultrasounds than women who received their prenatal care from midwives, nurse practitioners or family physicians. Similarly, women who lived in Ontario during the time of prenatal care were also likely to have more ultrasounds than those who lived in other provinces and substantially more than those who lived in the Territories. This study thus suggests that, in an era of growing concerns over health care costs, unease about the overutilization of prenatal ultrasound (or beyond the point for which there is any documented benefit) may, in fact, be well-placed.