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Inadequate Prenatal Care Utilization: Late Initiation and Inadequate Subsequent Visits in Vespasiano, Brazil

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An abstract of
A thesis submitted to the Faculty of the Rollins School of Public Health of Emory University
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Abstract

Inadequate Prenatal Care Utilization: Late Initiation and Inadequate Subsequent Visits in Vespasiano, Brazil
By Lucio R Verani

BACKGROUND: Risk factors for poor uptake of prenatal care are often assessed with indexes that measure overall prenatal care utilization, but few studies assess if risk factors for late initiation of prenatal care differ from risk factors for poor continuation of visits after initiation.

GOAL: To evaluate the risk factors for inadequate prenatal care usage when comparing the adequacy of prenatal care utilization to its two components, defined as the adequacy of initiation and the adequacy of subsequent visits.

METHODS: 252 women that received prenatal care in Family Health Units-Vespasiano, Brazil, between October 2009 and September 2010, were surveyed about demographic characteristics and their pregnancy. Timing of initiation was available from participant recall and from the prenatal health information system (SISPRENATAL). Both data sources were used to assign women to outcome variables (inadequate initiation, inadequate subsequent visits and inadequate prenatal care utilization). Factors associated with concordant assignments to the adequacy of initiation were assessed. Then factors associated with the outcome variables were assessed.

RESULTS: When comparing recall to SISPRENATAL, there was a fair level of agreement for assignments to the adequacy of initiation (K=0.35, 95% CI:0.22-0.48). Concordant assignments were more likely with a shorter recall period, higher household wealth and non-use of the private sector. Participant recall for the timing of initiation was used in analysis because, unlike SISPRENATAL, it captured private sector visits. Of the included women, approximately 30% had inadequate initiation, 10% had inadequate subsequent visits and 36% had inadequate overall prenatal care utilization. Not living with a partner was associated with inadequate subsequent visits (aOR=2.95; 95% CI: 1.01-8.64) but not significantly associated with inadequate initiation or with inadequate overall prenatal care utilization. Black skin color was associated with inadequate overall prenatal care utilization (aOR=2.59; 95% CI:1.26-5.34) but not significantly associated with initiation or subsequent visits.

CONCLUSIONS: Assessment of the risk factors for late initiation and the risk factors for poor continuation of prenatal visits can add useful information to traditional analysis that use summary measures of overall prenatal visitation.

IMPLICATIONS: This evaluation method can help inform the design of interventions to increase performance of prenatal care visits.

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I am indebted to Juan S. Leon for his mentorship throughout the research project and for his valuable feedback and guidance on this thesis. Dr. Roger W. Rochat provided content area expertise and important feedback on this thesis as well.

And finally, thank you to Alice for continuing her prenatal care visits while I was away and for bringing Dahlia into our lives.

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ROLE IN THESIS

I was part of a Multidisciplinary Team funded by the Emory Global Health Institute (GHI) to conduct field research in the Summer of 2011. I designed and led the portion of the project that studied prenatal care utilization.

I began working on my research project during the Spring semester of 2011. As a team member, I contributed to the Emory GHI award application, and I obtained Institutional Review Board approval from Emory and from the ethics committee of the Brazilian medical school that was our partner. As a student at the Rollins School of Public Health, I also enrolled in a course (EPI 565: Data Sources and Utilization in Maternal and Child Health Epidemiology) in order to become more familiar with research methods in my field of study. During this time, I designed the questionnaire and decided upon a research design, which was a retrospective cross-sectional survey conducted by household visits.

In the Summer of 2011, I carried out the data collection. I gained field research experience in a poor urban setting in Brazil and collaborated with health workers in the primary health care system. I used the municipal health information system to generate a sampling frame and took a representative sample of women who previously accessed prenatal care in the public health sector. I also trained my research team (three medical students) on research methods and interview techniques. We implemented household surveys during one month, and I managed this field work. I also managed the data-entry process, including double-data entry, and performed data cleaning.

After return from the field, I conducted data analysis and wrote this thesis during the Fall of 2011 and Spring of 2012. Notably, I hypothesized that the risk factors for late initiation of prenatal care might be different than the risk factors for inadequate subsequent visits, and I selected appropriate indicators to test this theory. I adapted the indicators to the prenatal care schedule recommended by the Brazilian Ministry of Health. Also, I became extremely knowledgeable about prenatal care utilization in Brazil and categorized the independent variables according to the literature and my field experience. I improved my statistical background in order to test my hypothesis and to explore the data. For example, I learned new techniques, when I compared the two data sources for the gestational age at initiation. The members of my thesis committee helped me revise my thesis, with Professor Leon providing advice on its structure and Professor Rochat providing content area expertise. Both Professor Leon and Professor Rochat also made helpful suggestions to the analysis comparing data from participant recall to data from the health information system. In summary, I designed the study, led the data collection effort and conducted the analysis presented herein.

INTRODUCTION AND LITERATURE REVIEW

Each year more than 300,000 women die globally due to complications during pregnancy and childbirth and more than 3 million babies die during their first month of life [1, 2]. Health interventions, including interventions delivered during antenatal care, have important impacts on reducing maternal mortality [reviewed in 3] and neonatal mortality [reviewed in 4]. In Brazil, despite a right to free health care, many pregnant women are underutilizing prenatal care [5]. The characterization of risk factors that reduce access or utilization of prenatal care is an area of active research, and can help in the development of interventions that seek to increase utilization with potential public health benefits.

In addition to considering the risk factors for inadequate prenatal care, interventions may be more effective if they consider the possibility that risk factors for inadequate prenatal care may differ when assessing the late initiation of care and the poor continuation of care after initiation. The risk factors for late initiation of prenatal care may be more informative in the design of interventions that target women of reproductive age regardless of pregnancy status, while risk factors for inadequate continuation of prenatal care may be more informative to interventions that reach women already identified as pregnant. Nonetheless, previous research in Brazil has not attempted to separately characterize the risk factors for late first prenatal visit and the risk factors for a low number of subsequent services. Therefore I will assess if risk factors for a late first visit differ from risk factors for a low number of subsequent visits in a population of women

in Brazil, which could inform the development of appropriate interventions to increase utilization of prenatal services.

First, I provide a literature review of issues related to prenatal care. The potential health benefits from prenatal care are discussed, before describing three methods to characterize the performance of prenatal care visits. Next, the utilization of prenatal care in Brazil is described through the use of relevant data sources. The review summarizes Brazilian adaptations of the Adequacy of Prenatal Care Utilization Index, which characterizes the performance of prenatal care visits. Then I summarize the risk factors for inadequate prenatal care utilization identified in Brazilian populations. Finally, I describe the study site, research goals and potential public health implications.

Health Impact of Antenatal Care

Antenatal care can reduce maternal mortality and morbidity through several interventions, but inferences about the effectiveness of prenatal care in reducing mortality and morbidity are limited by few randomized control trials of specific interventions. A thorough review by Carroli *et al.* found that treatment of severe pre-eclampsia and eclampsia reduces maternal mortality [3]. Blood pressure screening can assist in identification of pre-eclampsia and may be an effective step in preventing eclampsia [reviewed in 3]. Educating mothers to recognize danger signs in pregnancy is also effective, although "education interventions at prenatal clinics appear to be less successful at raising awareness and increasing the use of emergency obstetric care than the use of pictorial cards or community education" [reviewed in 6]. Routine iron and folic acid

supplementation during pregnancy has also been shown to reduce the prevalence of anemia in pregnant women [reviewed in 3]. Although antenatal care is often conceptualized as protective of the child's health, the aforementioned interventions can improve maternal health.

Many interventions may also reduce perinatal mortality and morbidity. For example, screening and treatment for syphilis and gonorrhea reduces fetal death, while screening for urinary tract infections reduces infant morbidity [reviewed in 3]. There is also strong evidence that folic acid supplementation before conception and during early pregnancy reduces neural tube defects (NTD) [reviewed in 7]. Performance of an ultrasound before 24 weeks, allows for accurate ascertainment of gestational age, thereby allowing for the inducement of labor at the appropriate time during a prolonged gestation [reviewed in 8]. Although micronutrient supplementation is a widely implemented antenatal intervention, Cochrane systematic reviews found no significant association between antenatal vitamin supplementation and miscarriage or stillbirth [reviewed in 9]. Nonetheless, Bhutta et al judged that there is a moderate level of evidence to support the role of antenatal care in reducing morbidity and mortality [10]. Additionally, antenatal care is estimated to have a high level of cost-effectiveness at a cost of $15-47 per disability adjusted life year averted [10]. Because of the likely benefits from antenatal care upon maternal and child health, adequate antenatal care is a recommended component of primary care as envisioned by the Alma-Ata Declaration [10].

Therefore, we need to better characterize the risk factors for making too few prenatal care visits, in order to develop targeted interventions that increase

utilization and improve health. Before discussing different methods developed in the United States to characterize the adequacy of prenatal care visits, I will review different international recommendations for the timing and number of prenatal care visits.

International Recommendations for Antenatal Care Visits

World Health Organization Recommendations

The WHO's Integrated Management of Pregnancy and Childbirth provides recommendations for prenatal care at the primary care level. The recommendations specify that all pregnant women should receive at least 4 routine antenatal care visits: one before 16 weeks, one between weeks 24 and 28, one between weeks 30 and 32 and one between weeks 36 and 38 [11].

In 2010, these recommendations were qualified due to the findings of a Cochrane review [reviewed in 12]. The review included randomized control trials in high-income countries and in low- and middle-income countries. These trials compared the standard practice of antenatal care to a reduced-visits model where visit number was reduced to around 8 in high-income countries and to less than 5 in low-income countries. Globally the reduced-visits model was associated with a higher risk of perinatal mortality (RR 1.14; 95% CI 1.00-1.31) compared to performance of the standard number of visits for the given country. Pregnant women, who were randomly assigned to the reduced visits model experienced a 15% increased risk of perinatal mortality (95% CI 1.01-1.32) compared to women assigned to a standard number of visits. A potential explanation for this finding was that women assigned to the reduced visits model were less likely to use

neonatal intensive care services, although this association did not reach significance (RR 0.89; 95% CI 0.79-1.02). Therefore, the review recommended that in settings "where the standard number of visits is low, visits should not be reduced without close monitoring of fetal and neonatal outcome."

Recommendations in the United States

The recommendations in the United States are relevant because the Kotelchuck Index and Kessner Index were designed in the United States and will be discussed later as tools to evaluate the adequacy of prenatal care visits. The American Academy of Pediatrics (AAP) and the American College of Obstetricians and Gynecologists (ACOG) publishes *Guidelines for Perinatal Care*. The guidelines specify the timing of antenatal care visits for uncomplicated pregnancies: every 4 weeks until 28 weeks, every 2 weeks until 36 weeks, and one per week thereafter [13].

Antenatal Care Guidelines in Brazil

The recommendations for the timing and number of prenatal care visits in Brazil are the basis by which this research project will characterize the performance of prenatal care. In Brazil, the public health care sector is the Brazilian Unified Health System (*Sistem Única de Saúde*, SUS). Antenatal care delivered through SUS should adhere to the guidelines of the Prenatal and Birth Humanization Program (*Programa de Humanizacao no Pre-Natal e Nascimento,* PHPN). The PHPN technical manual describes the minimum requirements for antenatal care delivered through SUS [14]. State governments and municipalities, in turn, develop specific implementation protocols appropriate for their resource level [15, 16].

In the State of Minas Gerais, Brazil (where the study took place), guidelines indicate that all exams should be performed at the first visit [15]. These exams include measurement of blood pressure, uterine height and fetal heartbeat, vaginal specular examination, physical examinations, and laboratory tests, including blood group and Rh factor, hemogram, fasting glucose, syphilis, toxoplasmosis, urine culture, hepatitis B, and voluntary HIV testing. Also at the first visit, women should be referred for tetanus vaccination, if necessary, and referred to a dental appointment. Women identified at high risk are referred to a maternity center. Women identified at normal risk return for subsequent visits where any required vaccinations are performed, blood pressure is measured, uterine height is measured and fetal heartbeat is measured. Then at gestational age 30 weeks, the exams for syphilis, gestational diabetes and urinary tract infections should be repeated [15]. The guidelines of Vespasiano Municipality, the study location, specify what listening device should be used to measure fetal heartbeat according to gestational age [16]. In Vespasiano, all other tests to perform and repeat should agree with the state guidelines.

According to the PHPN technical manual, pregnant women should be enrolled in the PHPN program and perform their first visit by 120 days. In addition, women should perform at least six antenatal care visits. The manual recommends at least one visit in the first trimester, two visits in the second trimester and three visits in the third trimester [14]. Nonetheless, this timeline is not utilized in program evaluation or in funding decisions. Municipalities receive financial incentivizes, deposited in the Municipal Health Fund, for each woman who performs the first visit by 120 days (R$ 10: ~ US$ 6) and additional

compensation (R$ 40: ~ US$ 24) for each woman who performs the following: six antenatal care visits, one puerperal visit within 42 days of birth and all recommended exams and interventions [17].

The six antenatal visits only apply to normal risk pregnancies with a delivery at full term. The Ministry of Health (MoH) guidelines define a prolonged gestation as more than 40 weeks and recommend at least one subsequent visit at a referral center during week 41 [14]. The technical manual for high risk pregnancies further recommends inducement of labor before the pregnancy reaches 42 weeks [18]. Therefore, per MoH guidelines the minimum number of antenatal care visits at 42 weeks is 7.

Evaluating Antenatal Care Visit Number

There are several ways to evaluate the utilization of antenatal care. The most basic manner would be to dichotomize women who met all antenatal care guidelines and those that did not. Such categorization could mask important differences in health care utilization since there could be a dose-response effect where increased number of prenatal visits is associated with improved outcomes. Therefore, there is often a need to further categorize the utilization of prenatal care. The Kessner Index, the revised graduated index (R-GINDEX) and the Kotelchuck Index are the principal evaluation tools utilized to categorize the level of antenatal care utilization.

Kessner/Institute of Medicine (IOM) Index

As part of a United States Institute of Medicine report published in 1973, Kessner *et al.* developed an index based on three factors: the sector of the health

service (public or private), the month antenatal care began, and visit number adjusted for gestational age at delivery [19]. The adjustment for gestational age at delivery entails a reduction in the expected number of visits for pre-term pregnancies. The Kessner Index categorizes antenatal care as adequate, intermediate or inadequate, depending on the timing of first visit and the total number of visits. Most subsequent research utilizing the Kessner Index ignored its requirement that only private sector health care could be considered as adequate [20]. The index is based on the aforementioned antenatal care schedule by ACOG. Women with adequate ratings meet the guidelines, while those with inadequate ratings make the first visit after 3 months, make less than 50% of the recommended number of visits or have both initiation after 3 months and less than 50% of recommended visits. An important limitation was that the index was originally constructed to analyze data from a vital records database, which allowed for only one digit to record the number of prenatal care visits. All people with nine or more visits received a nine in the vital records database. The Kessner Index classified this group of people as having received adequate care, even though the AAP/ACOG guidelines recommend more than 9 visits for pregnancies of more than 35 weeks [20]. Therefore, the proportion of women making adequate visits would be overestimated through use of an unmodified Kessner Index, if applied to populations that have a with a recommended prenatal care schedule of more than 9 visits.

Revised Graduated Index (R-GINDEX)

In 1987, Alexander and Cornely proposed a graduated index (GINDEX), which allowed for further characterization of the adequacy of utilization

according to the trimester of initiation. The GINDEX allowed for more detailed characterization of prenatal care, than present in the Kessner Index, by including categories for missing data, no care and intensive care in addition to categories for inadequate, intermediate and adequate care. Alexander and Cornely argued that women with intensive prenatal care use should be analyzed separately from those with adequate care because the intensive use of services was likely the result of a pregnancy at a higher risk of negative outcomes. GINDEX categorized the initiation of care by trimester. The original GINDEX also used 9 visits as the upper limit, just as the Kessner Index. In 1996, Alexander and Kotelchuck proposed a revised-GINDEX (R-GINDEX), which increased the maximum number of visits to be in line with ACOG recommendations [20]. The characterization of care into the five categories depends both upon the trimester of care and the number of visits assigned. For example, adequate care requires initiation in the first trimester and 13-16 visits for a 40 week gestation, while intermediate care for a 40 week gestation could include initiation in first trimester (8-12 visits) or the second trimester (8-14 visits).

Kotelchuck's Adequacy of Prenatal Care Utilization Index

The most widely used index utilized is the Kotelchuck Index or the Adequacy of Prenatal Care Utilization (APNCU) Index. The APNCU Index is actually a summary index based on its two components. The Adequacy of Initiation of Prenatal Care characterizes gestational age at the first visit, and the Adequacy of Received Services categorizes the number of visits adjusting for gestational age at delivery and the timing of first visit [21]. The adjustments to the Adequacy of Received Services present an advantage over other indices. Late

entry into prenatal care reduces the amount of time to perform visits, and the APNCU Index assumes that missed visits are not made up [21]. Therefore, the timing of first antenatal care visit and the subsequent utilization of prenatal care can be analyzed separately. Kotelchuck argues, "The independent assessment of prenatal care utilization after initiation, adjusted for the full range of gestational age, is clearly the most important new feature of the APNCU Index" [21]. The Adequacy of Received Services allows for the continuity of care to be analyzed independently of when care is initiated.

Most studies on antenatal care utilization employ Kotelchuck's summary APNCU Index. The summary APNCU Index combines its two component indices. The summary index qualifies all prenatal care that begins after month 4 as inadequate and adjusts the expected number of visits for gestational age at delivery and initiation of care. If the first visit is by month 4, then utilization can be categorized as adequate plus (110% or more of expected visits), adequate (80-109%), intermediate (50-79%) and inadequate (less than 50%) [21].

A review of literature citing Kotelchuck's original publication identified 28 studies published in developing countries[1]. None of these studies analyzed the Adequacy of Received Services independent from its inclusion in the overall summary index for the Adequacy of Prenatal Care Utilization, even though Kotelchuck described the Adequacy of Received Services as the Index's most important contribution. In developed countries, some analyses have used both the Adequacy of Initiation and the Adequacy of Received Services in order to

[1] Of 324 articles citing Kotelchuck's original article, 28 were published by authors from developing countries: Argentina (1), Brazil (11), China (1), Ecuador (1), Iran(2), Mexico(3), Peru(1), Turkey(3) and South Africa(1). Source: Web of Science, 15 August 2011.

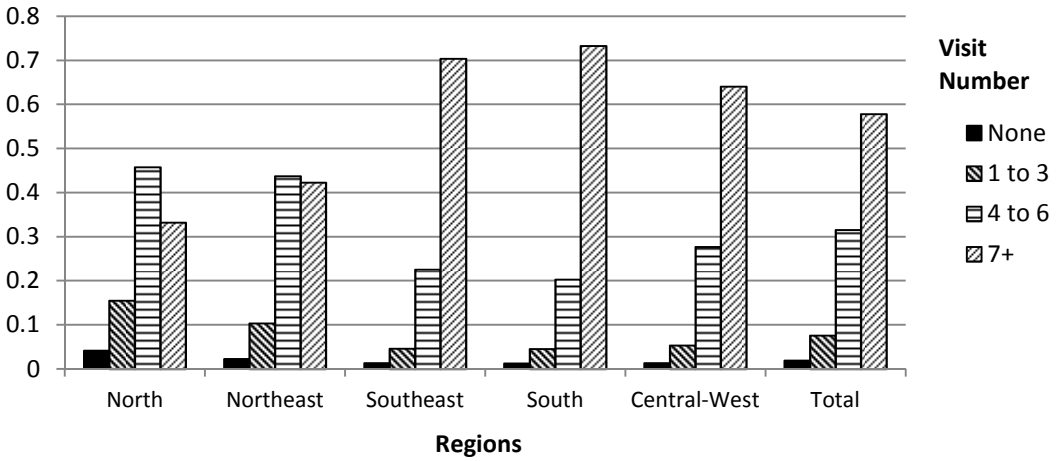
identify potential risk factors for late initiation and risk factors for low subsequent visit number. For example, a study in California found that psychiatric diagnosis and substance use were both associated with increased risk for inadequate initiation of antenatal care and for inadequate received services [22]. In addition, Gazmararian *et al.* identified "feeling too tired to go for care" and physical violence during pregnancy as risk factors for inadequate initiation of care [23]. Also, the receipt of help from the infant's father was significantly related to the overall adequacy of prenatal care [23]. The later findings suggest that interventions to improve utilization of antenatal care should consider if the risk factors differ comparing late initiation to the performance of subsequent visits. This idea—that the risk factors for late initiation of care may differ from the risk factors for poor continuity of care—may also apply in developing countries such as Brazil.

Utilization of Antenatal Care in Brazil

The prenatal health information system (SISPRENATAL) is used to monitor implementation of the Prenatal and Birth Humanization Program. Currently, it is unreliable for tracking the number of antenatal visits [24]. The most frequently utilized source of secondary data on prenatal care visits is the Live Birth Information System (SINASC) by the MoH. Data completeness is above 95% in every state [25], although the reliability of the data has been questioned [26]. The information is gathered by interviews of all women during or after delivery and includes both the private and public sectors. Data on visit number is grouped according to the following categories: no visits, 1-3 visits, 4-6

visits and 7 or more visits. Therefore the SINASC data does not allow for a performance evaluation according to the MoH recommendation of at least 6 antenatal care visits, since there is no way to know how many women in the category of 4-6 visits actually performed the recommended 6 visits[2]. Nonetheless, SINASC provides detailed information on antenatal care visits in Brazil.

Figure 1. Proportion of women according to number of antenatal care visits, by region. Brazil, 2009.



Source: Brazil MoH, Live Birth Information System (SINASC), 2009. Available: http://tabnet.datasus.gov

For example, SINASC reveals large regional disparities in antenatal care utilization, with lower proportions of women obtaining at least 7 antenatal care visits in the North and Northeast regions, in comparison to the Southeast, South and Central-West regions (see Figure 1). Nonetheless, access to antenatal care has increased dramatically according to demographic and health surveys. In 1981, 74.7% of women received antenatal care and 40.5% performed more than 6

[2] As described by the MoH's database on Basic Indicators and Data for Health (IDB). See the limitations section for the indicator "Coverage of Prenatal Visits". Accessed 18 Aug. 2011. Available: http://tabnet.datasus.gov.br/cgi/idb2009/matriz.htm?

antenatal care visits, while coverage increased to 98.7%, with 80.9% of women completing more than 6 visits in 2006-2007 [5].

Brazilian Adaptations of the Utilization Indices

Several adaptations of the summary APNCU Index have been made for Brazil (see Table 1). Leal *et al.* adapted the summary APNCU Index in 2004 [27], and their adaptation was subsequently used by several Brazilian researchers. A unique adaptation by Coimbra *et al.* includes an adjustment to the expected number of visits, according to late entry into prenatal care [28]. If the first visit occurs in month 5 or 6, utilization is classified as intermediate if at least 5 visits are performed, adjusted for gestational age at delivery [28]. This differs from the summary APNCU Index which classifies first visit after 4 months as inadequate care and does not adjust the expected number of visits for gestational age at first visit.

Table 1. Brazilian indices for adequacy of prenatal care utilization, adjusted for gestational age at birth.

Reference	Year	Categories	Criteria			Frequency of usage
			Timing of First Visit		Number of Visits	
Coimbra et al. [28]	2003	Missing	-	-	-	2 [28, 29]
		None	-	-	0	
		Inadequate	after month 6	or	<5 w/ adjustment[a]	
		Intermediate	by month 6	and	5 w/ adjustment	
		Adequate	by month 4	and	6 w/ adjustment	
Coimbra et al. [30]	2007	Inadequate	after month 4	or	<7 w/ adjustment	1 [30]
		Adequate	by month 4	and	7 w/ adjustment[a]	
Leal et al. [27]	2004	None	-	-	0	7 [27, 31-36]*
		Inadequate	after month 4	or	<50% of expected[a]	
		Intermediate	by month 4	and	50-79% of expected	
		Adequate	by month 4	and	80-109% of expected	
		Adequate plus	by month 4	and	110% of expected	

Notes:
a: Visit number adjusted per MoH guidelines: 5 (33-36 wks); 4 (29-32 wks); 3 (25-28 wks); 2 (<24 wks)
* Ribeiro *et al.* [31] use a very similar index, where gestational age at first visit is measured in weeks.

The original APNCU Index was based on the AAP/ACOG guidelines that recommend many more visits than the minimum recommended by the Brazilian MoH. Therefore, it may be inappropriate to utilize the same proportions originally developed by Kotelchuck as the cutoff values in Brazil, given the reality of a reduced schedule of visits. Rather than utilizing the proportion of the expected visits as in the adaptation by Leal, it may be more appropriate to utilize the minimum MoH recommendations to define adequate number of visits, as done by Coimbra *et al*.

Several other indices have been used in Brazil to classify the adequacy of prenatal care, although these do not adjust for gestational age. Takeda developed a widely used adaptation of the Kessner Index, although it does not adjust for gestational age at delivery [37]. Adequate care was defined as 5 or more visits and initiation of prenatal care by month 4, while less than four visits and initiation after month 7 were inadequate; other situations were defined as intermediate care [37]. Notably, many of the indices use indicators for the quality of care delivered, most often measured by the performance of the procedures and exams recommended by the MoH during antenatal care. For example, Almeda and Barros constructed an index based on initiation of care by week 14, at least 6 total visits, performance of all routine exams, at least five clinical procedures in every visit, counseling for breastfeeding and at least one echocardiogram [38].

Sociodemographic and Behavioral Risk Factors in Brazil

I performed a search for peer-reviewed literature on the potential risk factors for inadequate prenatal care in Brazil. Searches were performed with

PubMed and Scielo using the term “Brazil” and “prenatal care” or “perinatal care”. The references cited by relevant articles were also perused to identify other articles of interest.

Several researchers have analyzed the potential risk factors for inadequate prenatal care in Brazil. Maternal sociodemographic characteristics associated with inadequate utilization include skin color [27, 39, 40], age [27, 30, 31, 40] and educational attainment [27, 28, 30, 31]. Behavioral characteristics including smoking status [30, 31, 40], parity [27, 28, 30, 31, 40, 41] and pregnancy intention [41] have also been identified as potential risk factors. In addition, marital status (i.e. coinhabiting with partner) [27, 28, 30, 31, 40, 41], use of the private health sector [28, 30, 31, 40, 42] and maternal paid employment [27] have been associated with adequate care. Finally, Leal *et al.* found a significant interaction between skin color and educational attainment, where inclusion of the interaction term reversed the association between skin color and adequate prenatal care, making black or mulatto skin color a risk factor [27].

Only one Brazilian study was identified that analyzed the potential risk factors for inadequate initiation of antenatal care, as well as risk factors for inadequate number of antenatal care visits. Trevisan *et al.* found that higher maternal education was associated with earlier initiation of prenatal care and an increased number of visits, while parity was associated with later initiation and a lower number of visits [43]. Nonetheless, since the number of visits was not adjusted for gestational age at first visit, it is unknown if the associations between the independent variables and the number of visits were attributable to late first

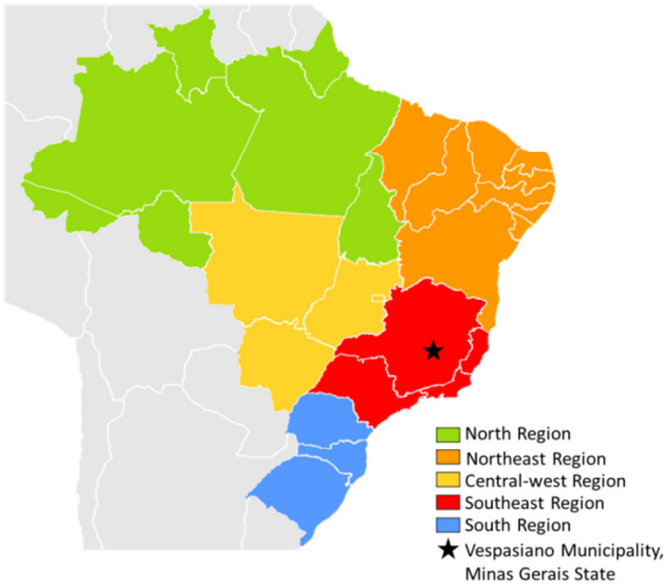
visit, to the poor performance of subsequent visits or to a combination of both factors.

Some factors identified in international research were not identified as risk factors in Brazilian studies of adequate prenatal care utilization. A review by Sakhada *et al.* found that media exposure, cost, husband's education and history of obstetric complications have been identified as risk factors internationally [reviewed in 44], but these factors were not considered in studies identified through my search of the Brazilian literature on adequate utilization.

Study Site

Vespasiano Municipality is located in the metropolitan area of Belo Horizonte, a city of 4.9 million people, in Minas Gerais state in the southeast region of Brazil (see Figure 2). Vespasiano has a population of 104,527 according to the 2010 Census and a population density of approximately 1,468 people per square kilometer [45]. Data from 2003, indicated that the poverty rate was 21% with a moderate level of inequality in the municipality (Gini Index 0.36) [46].

Figure 2. Regions of Brazil and location of Vespasiano Municipality



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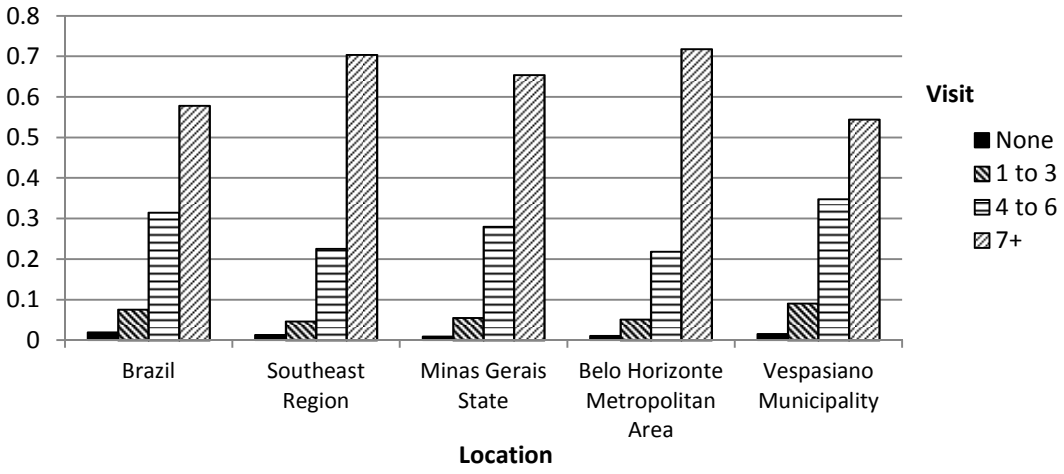
The study population consisted of women pregnant in Vespasiano municipality that were enrolled in SISPRENATAL at a Family Health Unit (FHU) from October 2009 to September 2010. There were 10 FHU in the municipality during the study period (personal communication with Municipal Secretary of Health). Approximately, 35.8% (36419/101844) of the population was enrolled in the Family Health Strategy by December 2009, although pregnant women can obtain care from FHUs even if they are not covered by the FHU. In Vespasiano, utilization of antenatal care among pregnant women was low, when compared to the Belo Horizonte metropolitan area or the entire state of Minas Gerais (see Figure 3).

Figure 3. Proportion of women according to number of antenatal care visits, for Vespasiano municipality, Minas Gerais state. Brazil, 2009.



Source: Brazil MoH, Live Birth Information System (SINASC), 2009. Available: http://tabnet.datasus.gov

Nonetheless, utilization of antenatal care in Vespasiano does not differ substantially from national level attendance patterns. In 2009, about 1,337 live births occurred in Vespasiano, according to the Live Birth Information System. Approximately 1.5% of new mothers of among residents of Vespasiano received

zero prenatal care visits in 2009. Therefore, most women do receive some prenatal care, although a large proportion of pregnant women do not perform the 6 recommended visits.

Goals

GOALS: To use an adaptation of the Adequacy of Prenatal Care Utilization (APNCU) Index, in order to evaluate if the risk factors for inadequate prenatal care use vary when comparing the APNCU Index to its two components, which are the Adequacy of Initiation and the Adequacy of Received Services (hereafter referred to as the Adequacy of Subsequent Visits), in the population of women in Vespasiano, Brazil, who were pregnant between October 2009 and September 2010.

AIM 1: To identify the risk factors associated with three outcome variables (the APNCU Index to its two components, which are the Adequacy of Initiation and the Adequacy of Subsequent Visits) describing adequacy of prenatal care.

AIM 2: To discuss how using the Adequacy of Initiation index and the Adequacy of Subsequent Visits index could lead to the development of different interventions, when compared to use of the APNCU Index alone.

Significance

The risk factors for inadequate timing of first antenatal visit may differ from the risk factors for inadequate subsequent use of antenatal care services. Although there is substantial research regarding the adequacy of prenatal care in Brazil, the use of the summary APNCU Index and adaptations of the Kessner Index do not allow researchers to assess if the risk factors vary when comparing

the timely initiation of care to the subsequent number of visits. Data derived from this research question may be of practical significance in efforts to increase the utilization of care. Interventions, to increase the proportion of women that start prenatal care by the recommended gestational age, must reach at-risk women before health workers have even verified the pregnancy. In contrast, interventions to increase the performance of subsequent visits would be targeted to a much smaller group of women that are already identified as pregnant. It is possible that some risk factors are much more relevant in the late initiation of care while other factors are more strongly associated with poor subsequent visits. Therefore a demonstration of this concept may lead other Brazilian researchers to adopt this evaluation method, which may help design more effective and less costly interventions to increase the utilization of prenatal care.

METHODS

Study Population

A cross-sectional household survey was conducted in June 2011 with women that were pregnant between October 2009 and September 2010 and enrolled in prenatal care at a Family Health Unit in the Vespasiano municipality. The project was approved by the Institutional Review Board of Emory University in the United States (IRB00020524) and by the Ethics Research Committee of the *Faculdade de Saúde e Ecologia Humana* in Brazil (No. 403/2011).

Sample Size

The sample size was originally calculated at 373 women, in order to complete 325 interviews assuming a response rate of 87%. The calculation assumed a prevalence of 50% for the performance of inadequate prenatal care utilization and used a precision of 0.05, alpha of 5% and power of 80%. After encountering a lower than expected response rate, a new sample size was calculated with a response rate of 60%, with a prevalence of 70% and with adjustment for the small population size (N=1,337), yielding a new sample size of 433 interviews. Therefore, the original sample was increased accordingly. The final number of women sampled was 423, and 252 interviews were completed.

Sampling Strategy

Eligible women were identified from the Brazilian Information System of the Prenatal and Birth Humanization Program (SISPRENATAL). The Vespasiano municipal epidemiology department provided a complete address list of the eligible study population, which included a total of 649 women enrolled in the 10

Family Health Units that were operational between October 2009 and September 2010. One unit was excluded due to security concerns identified by CHWs and the study team. The information system was unable to restrict the complete address list to specific age groups. Therefore any woman that was age less than 18 years at time of survey administration was randomly replaced with another woman from SISPRENATAL.

The sampling strategy was stratified by the specific Family Health Unit. In each health unit, the number of participants selected was proportional to the number of gravid women in that health unit. Random selection within each stratum was performed through use of a random number calculator available from GraphPad (GraphPad Software Inc., http://graphpad.com).

Recruitment and Consent

CHWs assisted with identification of addresses and by introducing study staff to a household member. Each residence was visited at least twice, during different times of the day. If a neighbor, family member or the CHW could refer us to a woman's new place of residence (and it was located within the municipality), the study team visited those houses. A total of 423 women were sampled, and 252 women answered the survey (59.6% response rate). Among non-responders, 83 (19.6%) were not home during at least two visits, and 68 (16.1%) had moved outside of the municipality or to an unknown location. Ten women (2.4%) were not visited because they lived within the catchment area of health units that were visited by our research team during this study, and logistical difficulties prohibited us from returning to these previously completed

neighborhoods. The remaining 2.4% of women could only meet outside of study work hours (5), refused participation (2), reported not being pregnant (1) or lived in houses that community health workers (CHW) considered too unsafe for us to visit (2).

Voluntary informed consent was obtained from each participant by reading an oral script by the study staff, confirming that the participant could accurately summarize their rights before agreeing to participate, and providing corrections and clarification as needed. The study staff re-emphasized that women could refuse to participate in the study, withdraw from the interview or refuse to answer any specific questions. Consent was documented by study staff checking a box on the oral consent form. The questionnaire was administered in houses with varying degrees of privacy from other household members. Study staff was sensitive to not disclose a woman's prior pregnancy to family members.

Independent Variables

Survey topics included risk factors for inadequate prenatal care that were identified in the literature. Marital status was dichotomized as either co-inhabiting (1)/not co-inhabiting (0) with a partner [28, 31, 41]. Parity was operationalized as number of living children born to the mother and was categorized as 0 (reference group), 1-3, and 4 or more children [28, 30, 40]. Maternal age was categorized as <20, 20-34 and 35 or more years at date of child's birth [30, 40, 47]. Mother's skin color was self-reported as either white, black, mixed, yellow or Amerindian. Skin color was dichotomized as black/mixed (1) and not black/mixed (0) [47], and also dichotomized as black (1)/not black

(0). Pregnancy intention was categorized as planned (1)/not planned (0) [41]. Although all these women received some services in the public sector, any use of the private sector (defined as both private out-of-pocket payments and use of health insurance plans) was ascertained as yes (1)/no (0). Distance to the facility was asked in minutes walking and was categorized as ≤10 minutes (reference group), >10 to ≤20 minutes, and >20 minutes. The regularity of household visits by CHWs and satisfaction with prenatal care services were ascertained, since a previous study in this community identified regular CHW visits and satisfaction as important factors in the use of child health services [48]. CHW visits were dichotomized as current receipt of household visits at least once per month (1)/less frequently (0). Satisfaction with prenatal care was dichotomized as very satisfied/satisfied (1) and indifferent/unsatisfied/very unsatisfied (0). Date of last menstrual period and date of first prenatal visit were available from the municipal SISPRENATAL database and were originally gathered by health professionals to enroll women in the SISPRENATAL program. A previously validated wealth index, built with questions from the 2000 Census, was calculated using 12 questions on household possessions and 1 question on the education of the head of household [49]. Educational attainment of women was categorized in accordance with the wealth index. This categorization was the same as one other study on adequacy of prenatal care [47] and similar to other cutoff values [28, 30, 31, 40] utilized in Brazil.

The four field researchers (AM, MO, LV & TA) piloted the survey with the first 10 participants. One question about previous intentional abortions was dropped from the questionnaire, two questions about the performance of

Papanicolaou smears were added, and minor language changes for clarity were made to the script.

Outcome Variables

Three outcome variables were constructed to characterize the timing and number of prenatal care visits. Prenatal care was described using the Adequacy of Initiation of Prenatal Care and the Adequacy of Subsequent Visits, which can be combined to create a summary Adequacy of Prenatal Care Utilization Index originally proposed by Kotelchuck [21]. The original indices were developed in the United States, using the prenatal care schedule recommended by the American College of Obstetrics and Gynecology and classified the adequacy of prenatal care into four categories: inadequate, intermediate, adequate and adequate-plus [21].

For this study, the three indices were adapted to the guidelines of the Brazilian MoH [14]. The MoH recommends 1 visit in the first trimester (i.e. weeks 1-12), 2 visits in the second trimester (i.e. weeks 13-24), and then 1 visit per month in the third trimester (i.e. weeks 25-28, 29-32 and 33-36) so that a minimum of 6 total visits should be performed in a full gestation pregnancy. The three indices were dichotomized as adequate or inadequate. Inadequate care was assigned a value of 1 and adequate care a value of 0.

Per MoH guidelines, the *Adequacy of Initiation of Prenatal Care* was defined as performing the first visit by month 3. Initiation after month 3 was characterized as inadequate (1) and initiation by month 3 was characterized as

adequate (0). The timing of the first visit and the number of total visits were ascertained through the survey.

The *Adequacy of Subsequent Visits* was defined as adequate when performing 6 or more prenatal care visits, when adjusting for gestational age at first visit and gestational age at delivery. In order to calculate gestational age at delivery, the date of last menstruation obtained in SISPRENATAL was subtracted from the date of birth reported by the woman. Therefore, the Adequacy of Subsequent Visits could be characterized as adequate even if a woman performed less than the MoH recommended 6 visits. The adjustment considering the timing of the first visit defined the expected visit number as: 6 visits, if prenatal care was initiated in week 12 or earlier; 5 visits for initiation in weeks 13 to 24; 3 visits for initiation in weeks 25 to 28; 2 visits for initiation in weeks 29 to 32; and 1 visit, if first visit was after 32 weeks. Likewise, the adjustment considering gestational age at delivery entailed a reduction in the number of expected visits: -1 expected visit, if gestational age at delivery was 33-36 weeks; -2 visits, if gestational age was 29-32 weeks; -3 visits, if gestational age was 25-28; and -2 visits, if gestational age was <24 weeks. For example, if a woman began prenatal care during week 13 and gave birth in week 32, the adequate visit number was at least 4 (a total reduction of 2 visits: one less visit due to gestational age at initiation of prenatal care and one less visit due to gestational age at delivery). The Adequacy of Subsequent Visits was characterized as adequate (0)/inadequate (1).

Finally, the summary *APNCU* index assessed both the initiation and number of prenatal care visits. Adequate utilization required first visit by month 3 and performance of the expected number of visits adjusting for gestational age

at delivery and the initiation of care. If prenatal care was initiated after month 3 and/or less than the expected number of visits was performed, then the APNCU was characterized as inadequate (1); otherwise, the APNCU was characterized as adequate (0).

Data Quality

Data were double-entered by study staff in Microsoft Excel 2010 (Microsoft Corporation, Washington) spreadsheets, and initial data-entry errors were reduced through use of the data validation tool to set acceptable data ranges. Discrepancies between the two spreadsheets were identified, recorded through an error log, compared to the completed questionnaires, and resolved by manual corrections made to a third spreadsheet. Finally, approximately 5% of the questionnaires were randomly selected for comparison to the data in the database. Since no errors were found, a subsequent 100% data-check was deemed unnecessary.

Women that did not have a live birth, and those with infeasible gestational ages were excluded from analysis. Fourteen women were excluded (9 fetal deaths or stillbirths; 1 not pregnant, as she reported the original physician performed a cursory examination with no actual pregnancy exam; 3 had a date of last menstruation after the date of child birth, possibly because of errors in the information system or they did not want to disclose the loss of a pregnancy; and 1 with an extreme gestational age outside 20-50 weeks). The study did not determine if women had a multiparous pregnancy, and therefore this potential

exclusion criterion was not used. Of 252 interviews in the original sample, data for 238 women were used in analysis.

Data Analysis

All data analysis was performed with the SAS 9.3 software package (SAS Institute Inc., North Carolina). Recall reliability was assessed through kappa statistics by comparing the date of first prenatal care visit reported in the SISPRENATAL information system to the date reported in the survey.

Crude odds ratios were calculated through logistic regression models (Table 4). Odds ratios were calculated for the two binary definitions used for skin color. To ease interpretation in the crude analysis, the wealth index was categorized into quartiles of the sample, using the highest wealth quartile as the reference group.

For the adjusted analysis, only one definition of skin color was assessed. The definition selected to dichotomize skin color (black and not black) was based on the consistency of associations from the crude odds ratios.

Adjusted odds ratios were generated through a logistic regression model that included all independent variables for each dependent variable (Table 5). The model also allowed for the inclusion of potential interaction terms, if the interaction term was selected for inclusion by a backwards selection procedure with $p < 0.10$. In households where the woman was the head of household, the woman's level of education was a component of the wealth index. In these instances, because women's level of education and wealth index could not be run in the same model, the modeling procedure was performed twice for each

outcome variable. One model used the variable for level of education and the other model used the linear variable for wealth index. Therefore, six models were generated using the full set of independent variables—two models for each of the three outcomes.

Collinearity was assessed utilizing the SAS macro %Collin. If the condition indices for the full model were high (≥30), then variables with a high variance decomposition proportion were removed. The model was refitted to assess if collinearity remained a problem in the reduced model. Collinearity was assessed at various stages of the modeling process for each of the outcomes.

The choice of potential effect modifiers was guided by the conceptual framework (Figure 2). Potential interaction terms were included after checking for collinearity. In models using the wealth index or models using the woman's level of education, the potential interaction terms were "age group and number of children," "distance to clinic and receipt of monthly CHW visits," "living with partner and planned pregnancy" and "planned pregnancy and number of children." In addition, the models using the mother's level of education included an extra potential interaction term (education and planned pregnancy).

For Table 8 (Appendix), logistic regression analysis was conducted with a stepwise selection procedure, using entry criteria of 0.2 and exit criteria of 0.1. After the models were generated, collinearity and confounding were assessed. Potential confounders were added to the models, and the models were refit. Original effect estimates were compared to the new point estimates, which controlled for the potential confounders, in order to assess if there was

meaningful difference between the adjusted odds ratios. Significance was assessed at $p < 0.05$ and $p < 0.10$.

RESULTS

Characteristics of the Population

The study goal was to evaluate whether the risk factors for inadequate prenatal care use vary when defining inadequate prenatal care by either the APNCU Index or its two components, which are the Adequacy of Initiation and the Adequacy of Subsequent Visits. 238 women having a live birth were included in analysis (Table 2). Most women were age 20 to 34 years at child birth and lived with their partner. Approximately, half of women reported their skin color as mixed, and one-quarter of women reported their skin color as black, with the remaining women reporting white or other skin colors. More than half of women had 1 to 3 previous children, and 38% did not have a previous child. One-quarter of women did not complete primary school, and almost half completed secondary school. A minority of women reported any use of the private health sector. About half of women reported having a planned pregnancy. Satisfaction with the prenatal care services received was high. About half of women reported receiving a monthly visit by CHWs. In summary, the characteristics of the study population varied considerably, and generally, the sample was racially diverse and had low educational attainment.

In order to characterize the adequacy of prenatal care, three outcome variables were constructed to characterize the Adequacy of Initiation, the Adequacy of Subsequent Visits and the Adequacy of Prenatal Care Utilization. Women were assigned to the appropriate group for each of the three outcome variables: adequate or inadequate initiation; adequate or inadequate subsequent

visits; and adequate or inadequate utilization of prenatal care (data not shown). Three women did not recall their gestational age at first prenatal visit and were excluded in analysis of inadequate initiation. Of the remaining 235 participants, approximately 30% did not initiate care within the first trimester (inadequate initiation). An additional thirteen women did not recall the number of prenatal visits performed, and therefore 16 women were excluded in the analysis of inadequate subsequent visit number. Of the remaining 222 women, 10% performed an inadequate number of subsequent visits. Combining inadequate initiation and inadequate subsequent visits, led to approximately 35% of the 222 remaining women having inadequate prenatal care utilization, and eleven women had both inadequate initiation and inadequate subsequent visits.

Comparison of Timing of Initiation between SISPRENATAL and Recall

Due to the long time period between the receipt of prenatal care and the interview date, we assessed the level of agreement between the recalled timing of first visit and the timing of fist visit obtained from a secondary data source. The month of first prenatal visit was obtained by participant recall through the interviews, and the date of fist prenatal visit was obtained from the prenatal health information system (SISPRENATAL). Each data source for the timing of first prenatal visit was used to assign participants into the outcome categories (Adequacy of Initiation, Adequacy of Subsequent Visits and Adequacy of Prenatal Care Utilization). Then the level of agreement and kappa value comparing the two data sources were calculated (Table 3). For the Adequacy of Initiation, both data sources (recall and SISPRENATAL) assigned approximately 30% of women

into the group for inadequate initiation (did not initiate care within the first trimester). Nonetheless, when using the guidelines proposed by Landis and Koch for interpreting kappa values [50], there was only fair agreement for assignment to inadequate initiation when comparing recall to SISPRENATAL (Table 3). Though the proportion of participants assigned to inadequate initiation was equivalent, the kappa value indicated fair agreement because, in the two-by-two table generated to calculate the kappa value, the 32 discordant assignments were evenly divided between the two cells for discordant assignments with 16 discordant assignments per cell. For the Adequacy of Subsequent Visits, the proportion of women assigned as inadequate was approximately 10% for both data sources, and the kappa value showed substantial agreement (Table 3). A higher level of agreement was expected for the Adequacy of Subsequent Visits, because in addition to gestational age at first visit, the variable uses other factors (number of visits and gestational age at delivery) which came from the same data source for both classification methods. Combining inadequate initiation and inadequate subsequent visits, led to approximately 35-36% of women assigned to the inadequate category for both data sources. The kappa value showed moderate agreement using the guidelines by Landis and Koch (Table 3). In summary, the assessment of reliability found fair agreement in assignments to the Adequacy of Initiation, substantial agreement in assignments to the Adequacy of Subsequent Visits and moderate agreement in assignments to the Adequacy of Prenatal Care Utilization, when comparing the two data sources for the timing of fist visit.

This study asked women to recall the timing of the first visit by their gestational age in half month increments. In contrast, the SISPRENATAL system

listed a specific date for the first visit, allowing for calculation of gestational age in days. Due to this difference, some divergence may be expected to result from the different time scales. To assess whether discordant assignments were an artifact of the different classifications used to measure the timing of first visit, we also calculated the proportion of women, who recalled a month of first visit that was within 15 days of the date reported in SISPRENATAL. Approximately, 67% of participants had a recalled month of initiation within the 15 day window from the date provided in SISPRENATAL, which was similar to the 72.8% agreement found in Table 3 for assignments to the Adequacy of Initiation. Therefore, the fair level of agreement between the two data sources for the timing of initiation was not an artifact of the different scales used and reflected real differences between the data sources.

We also explored potential reasons for discordant assignments to the Adequacy of Initiation, by focusing on the length of the recall period and on any use of the private sector. We imputed the recall period in days (mean of 542 days and standard deviation of 113 days) by subtracting the date of last menstrual period from the date of interview. Then, we conducted a logistic regression analysis where the outcome variable was concordant assignment (1)/discordant assignment (0). The model included the length of recall in days as a linear variable and all the independent variables included in the full models (excluding level of education). A longer recall period was significantly associated with lower odds of a concordant assignment (OR=0.996, 95%CI: 0.994-0.999). Also, household wealth was positively associated with concordant assignment (OR=1.002, 95%CI 1.000-1.004), and any use of the private sector was associated

with lower odds of concordant assignment (OR=0.38, 95%CI: 0.16-0.91). We further studied which independent variables were associated with a difference in gestational age at initiation between SISPRENATAL and recall. We created a linear variable to measure the difference between SISPRENATAL and recall for the timing of initiation in days. Positive numbers indicated that SISPRENATAL recorded a later date of initiation than reported by recall, and negative numbers indicated that SISPRENATAL recorded an earlier date of initiation than reported by recall. This variable was the outcome variable in a simple linear regression model that included the full set of independent variables (data not shown). The only variable significantly associated with a difference in initiation between SISPRENATAL and recall was any use of the private sector (β=15.98, SE=7.97, p=0.046). In other words, SISPRENATAL recorded a gestational age at first visit that was on average 16 days later than what was recalled by those women who performed any prenatal visits in the private sector. In summary, shorter recall periods, higher household wealth and non-use of the private sector were associated with a greater level of agreement between SISPRENATAL and participant recall for the timing of first prenatal visit.

Factors Associated with Uptake of Prenatal Care

In order to investigate if the Adequacy of Initiation and the Adequacy of Subsequent Visits contributed new information to the adequacy of overall prenatal care utilization, the associations between the descriptive characteristics and these outcome variables were assessed in crude and adjusted analyses. Crude odds ratios were calculated for the association between the independent variables

and each outcome variable, through use of logistic regression (Table 4). Considering the outcome variable for the Adequacy of Initiation, the odds of inadequate initiation significantly:

- increased among women with four or more previous children compared to women with no previous children;
- increased among women who completed less than four years of education compared to those who completed secondary education;
- increased among those with an unplanned pregnancy compared to those with a planned pregnancy;
- increased among women in the lowest wealth quartile compared to women in the highest wealth quartile.
- decreased among women who used the private sector compared to those that only used the public sector, and;
- decreased among those who reported satisfaction with services received in the public sector compared to those that did not report satisfaction.

The odds of inadequate subsequent visits significantly:

- increased among women with four or more previous children compared to women with no previous children.

The odds of inadequate prenatal care utilization significantly:

- increased also among women with four or more previous children compared to women with no previous children;

- increased at lower levels of education compared to women who completed secondary education;
- increased among women in the lowest wealth quartile compared to women in the highest wealth quartile, and;
- decreased among women who used the private sector compared to those that only used the public sector.

Overall, the crude odds ratios indicate that the independent variables with significant associations may vary depending on the outcome variable (i.e. index used).

In order to account for potential confounders and more accurately describe the association between the independent variables and the outcome variables, adjusted odds ratios were generated through logistic regression models. The models adjusted for the wealth index as a linear variable. Since the level of education was a component of the wealth index when the woman was the head of household, the variables for education and wealth index were not included together in the same model. Models using the wealth index are presented here because they provided better fit (lower Akaike Information Criteria and Schwartz Criterion) than models using the level of education (data not shown). All analyses were repeated using the education variable instead of the wealth index (Appendix), and where appropriate the differences and similarities between the results of modeling with the education variable are discussed.

Three logistic regression procedures were performed (one for each outcome), and all the independent variables were used to model associations with

the outcome variables (Table 5). No interaction terms reached the $p<0.10$ criteria for entry into the full model.

The full models for each of the outcome variables produced different results. For example, after adjustment the only variable significantly associated with inadequate initiation ($p < 0.05$) was the receipt of monthly CHW visits, such that not receiving monthly household visits was associated with significantly increased odds of inadequate initiation (OR=2.05, 95%CI: 1.05-3.99). Inadequate subsequent visits was significantly associated with two independent variables. Not living with a partner (OR=2.95, 95%CI: 1.01-8.64) and having four or more previous children (OR=13.53, 95%CI: 1.78-103.0) were associated with increased odds of inadequate subsequent visits. Considering the outcome variable for the adequacy of overall prenatal care utilization, black skin color (OR=2.59 95%CI: 1.26-5.34), four or more prior children (OR=9.59, 95%CI: 2.04-45.05) and the non-receipt of household visits by CHWs (OR=2.02, 95%CI: 1.03-3.94) were associated with increased odds of inadequate prenatal care utilization. In summary, some significant associations of the independent variables, such as living with a partner, varied according to the outcome (i.e. index) measured.

As described in the preceding paragraph, interestingly, the variable for black skin color was significantly associated with inadequate overall prenatal care utilization, although black skin color was not significantly associated with inadequate initiation nor inadequate subsequent visits. To explain why the variable for black skin color was significantly associated with inadequate utilization but not inadequate initiation nor inadequate subsequent visits, I hypothesized that black skin color was less common among women who had both

inadequate initiation and inadequate subsequent visits, when compared to women who had one inadequate measure. I investigated this possibility using the outcome variable for the adequacy of subsequent visits. Among the 22 women with inadequate subsequent visits, 11 had adequate initiation and 11 had inadequate initiation. I hypothesized that self-reported black skin color was more common among the women with adequate initiation than among women with inadequate initiation. Among those with inadequate subsequent visits, six of the 11 women with adequate initiation reported black skin, whereas two of the women with inadequate initiation reported black skin (data not shown). When a full logistic regression model for inadequate subsequent visits was restricted to participants with adequate initiation, black skin became significantly associated with inadequate subsequent visits at $p<0.05$ (data not shown). In summary, black skin was significantly associated with inadequate overall utilization of prenatal care but not significantly associated with its two components, in part, because black skin was more common among the 11 women with adequate initiation and inadequate subsequent visits than it was among the 11 women with inadequate initiation and inadequate subsequent visits.

In addition to Table 5, two further adjusted analyses were performed with full models. One analysis used the timing of initiation from SISPRENATAL, and the other analysis maintained the timing of initiation from recall but used the variable for level of education rather than the wealth index. The analysis that used the timing of first visit per SISPRENATAL was conducted in order to explore if the same significant associations found in Table 5 would be maintained, but the results changed dramatically (Table 6). Nonetheless, this

model was judged as inferior to the model using participant's recall because SISPRENATAL does not capture prenatal care visits performed in the private sector. A full model was also performed using mother's level of education instead of the household wealth index, in order to explore if the associations found in Table 5 persisted. In the full models utilizing level of education rather than wealth index, fewer of the same significant variables described in Table 5 were significantly associated with the outcomes at $p < 0.05$ (Appendix, Table 7). In general though, the adjusted model using the level of education provided similar effect estimates as the model using the wealth index.

Other researchers have assessed the factors associated with inadequate prenatal care utilization by generating reduced models through use of selection criteria [28, 31, 51], and therefore, we generated reduced models for each of the outcome variables using a stepwise selection procedure. To enter the model, the variable had to be statistically significant at $p<0.20$, and to remain in the model it had to be statistically significant at $p<0.10$. Through this approach, the model for inadequate initiation included the variables for any use of the private sector and the receipt of monthly visits from CHWs (Appendix, Table 8). In contrast, inadequate subsequent visits were associated with not living with a partner and the number of prior children. The model selected for inadequate overall prenatal care utilization included black skin color, the number of prior children, any use of the private sector and the receipt of monthly CHW visits. Overall, the variables retained through the stepwise selection procedure varied substantially between the reduced models for inadequate initiation, inadequate subsequent visits and inadequate prenatal care utilization.

The stepwise selection procedure was also re-run using level of education instead of the wealth index. The variable for receipt of monthly CHW visits was removed in the model for inadequate initiation and in the model for overall inadequate prenatal care utilization (Appendix, Table 9). For inadequate initiation, the variable for having a planned pregnancy entered the model instead. All other variables remained the same in the three reduced models using level of education. For example, living with a partner was once again selected for inclusion only when modeling inadequate subsequent visits. In summary, when using level of education, the logistic regression procedure with stepwise selection produced models that were somewhat similar as models that included the wealth index, and once again, the variables selected for the reduced models differed between inadequate initiation, inadequate subsequent visits and inadequate prenatal care utilization.

Figure 4. Conceptual framework for factors potentially influencing the use of prenatal services. Boxes indicate independent variables, circles indicate outcome variables, dashed arrows indicate relationships to analyze for effect modification and confounding and solid arrows represent the potential relationship between independent variables and the outcome variables.

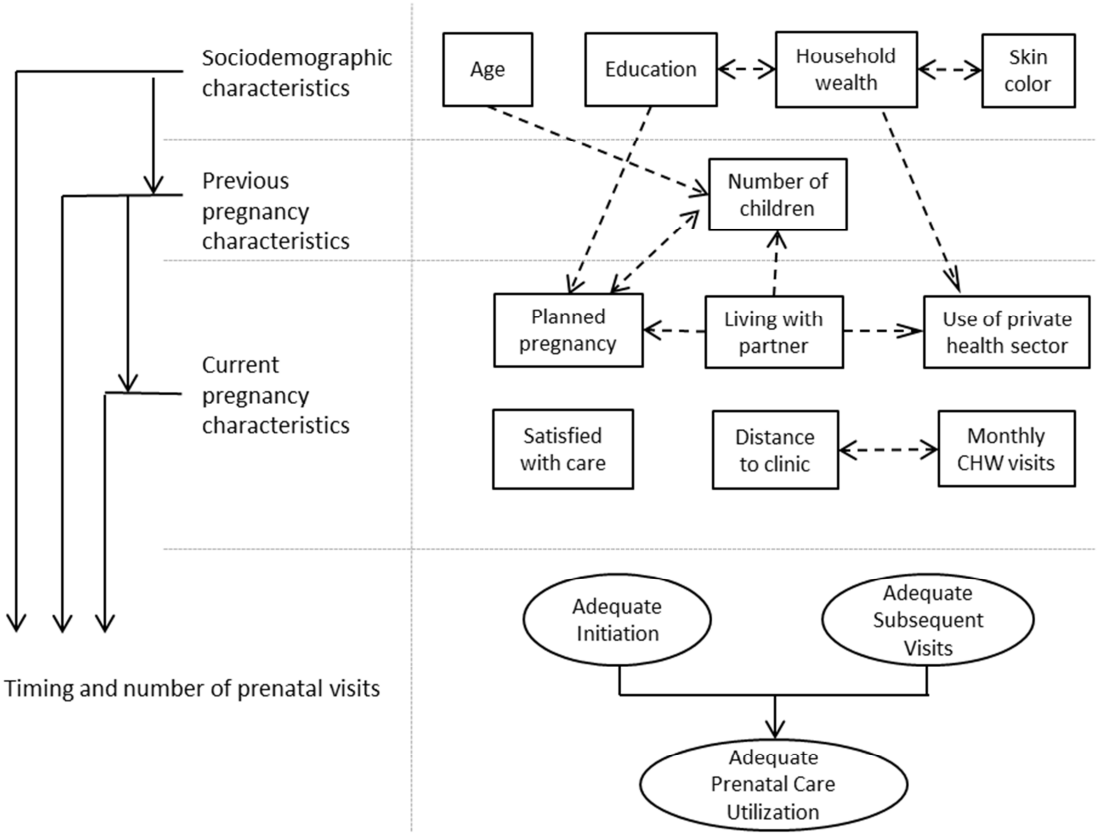


TABLE 2. Characteristics of women having live births. Vespasiano, Minas Gerais State, Brazil, 2011. (N=238)

Characteristics†	n	(%)
Age at childbirth		
< 20 years	30	(12.6)
20-34 years	174	(73.1)
35+ years	34	(14.3)
Relationship status		
Living with partner	189	(79.4)
Skin color		
Mixed	122	(51.3)
Black	57	(24.0)
White	32	(13.4)
"Yellow"	21	(8.8)
Amerindian	6	(2.5)
Prior children		
0 children	90	(37.8)
1-3 children	133	(55.9)
4+ children	15	(6.3)
Mother's education		
<4 years	15	(6.3)
4-7 years	47	(19.7)
8-10 years	70	(29.4)
11+ years	106	(44.5)
Used private health sector	39	(16.4)
Pregnancy intended	112	(47.1)
Satisfied with care (n=234)	192	(82.1)
Monthly CHW visit, yes (n=237)	108	(45.6)
Distance, mean minutes ± SD	16.2 ± 14.1	
Wealth Index, mean score ± SD (n=231)	474.7 ± 151.1	

†CHW: community health worker, SD: standard deviation

TABLE 3. Relationship between caregiver recall and SISPRENATAL for inadequate initiation, subsequent visits, and utilization. Vespasiano, Brazil, 2011.

Outcome Variables	Recall n (%)	SISPRENATAL n (%)	% agreement	Kappa	(95% CI)
Inadequate Initiation (n=235†)	70 (29.8)	70 (29.8)	72.8	0.35	(0.22-0.48)
Inadequate Subsequent Visits (n=222‡)	22 (9.9)	23 (10.4)	95.9	0.78	(0.64-0.92)
Inadequate Prenatal Care Utilization(n=222‡)	79 (35.6)	77 (34.7)	76.6	0.49	(0.37-0.61)

†3 non-responses for month of initiation; ‡ 16 non-responses (3 for month of initiation and 13 for number of visits).

TABLE 4. Crude odds ratios for the three outcome measures assessing performance of prenatal visits. Vespasiano, Minas Gerais State, Brazil, 2011.

	Inadequate Initiation (n=235†)		Inadequate Subsequent Visits (n=222‡)		Inadequate Prenatal Care Utilization(n=222‡)	
Characteristics‖	n (%)	OR (95% CI)	n (%)	OR (95% CI)	n (%)	OR (95% CI)
Age at childbirth						
< 20 years	11 (37.9)	1.63 (0.56-4.76)	2 (7.1)	0.69 (0.11-4.49)	12 (42.9)	1.50 (0.52-4.36)
20-34 years	50 (28.9)	1.08 (0.47-2.50)	17 (10.4)	1.04 (0.28-3.80)	57 (34.8)	1.06 (0.47-2.43)
35+ years	9 (27.3)	ref	3 (10.0)	ref	10 (33.3)	ref
Relationship status						
Not living with partner	19 (39.6)	1.75 (0.90-3.39)*	8 (17.4)	2.44 (0.95-6.22)*	21 (45.7)	1.71 (0.88-3.31)
Living with partner	51 (27.3)	ref	14 (8.0)	ref	58 (32.3)	ref
Skin color, black/mixed						
Black or mixed	54 (30.7)	1.19 (0.62-2.30)	15 (9.0)	0.68 (0.26-1.76)	60 (35.9)	1.06 (0.56-2.01)
Not black or mixed	16 (27.1)	ref	7 (12.7)	ref	19 (34.5)	ref
Skin color, black						
Black	20 (35.1)	1.38 (0.73-2.61)	8 (15.1)	1.97 (0.78-4.99)	26 (49.1)	2.11 (1.12-3.95)*
Not black	50 (28.1)	ref	14 (8.3)	ref	53 (31.4)	ref
Prior Children						
0	22 (24.4)	ref	5 (6.0)	ref	23 (27.4)	ref
1-3	40 (30.8)	1.37 (0.75-2.52)	13 (10.6)	1.87 (0.64-5.45)	45 (36.6)	1.53 (0.84-2.80)
4+	8 (53.3)	3.53 (1.15-10.85)**	4 (26.7)	5.74 (1.34-24.70)**	11 (73.3)	7.29 (2.11-25.21)**
Mother's education						
<4 years	8 (53.3)	3.90 (1.28-11.87)**	1 (7.7)	1.12 (0.13-9.90)	8 (61.5)	4.61 (1.39-15.37)**
4-7 years	15 (32.6)	1.65 (0.77-3.56)	6 (14.3)	2.24 (0.70-7.11)	18 (42.9)	2.16 (1.01-4.61)**
8-10 years	23 (33.8)	1.75 (0.89-3.44)	8 (12.1)	1.85 (0.64-5.38)	27 (40.9)	2.00 (1.03-3.88)**
11+ years	24 (22.6)	ref	7 (6.9)	ref	26 (25.7)	ref
Used private health sector						
Yes	5 (12.8)	0.30 (0.11-0.79)**	2 (5.4)	0.47 (0.10-2.11)	6 (16.2)	0.30 (0.12-0.75)**
No	65 (33.2)	ref	20 (10.8)	ref	73 (39.5)	ref
Pregnancy Intention						
Unplanned	45 (36.0)	1.91 (1.07-3.40)**	15 (12.4)	1.90 (0.74-4.86)	50 (41.3)	1.75 (1.00-3.07)*
Planned	25 (22.7)	ref	7 (6.9)	ref	29 (28.7)	ref
Satisfied with care						
No	7 (16.7)	0.41 (0.17-0.97)**	6 (14.6)	1.74 (0.63-4.75)	10 (24.4)	0.51 (0.23-1.11)*
Yes	62 (32.8)	ref	16 (9.0)	ref	69 (38.8)	ref
Monthly CHW visit						
No	43 (33.6)	1.48 (0.84-2.62)	15 (12.1)	1.77 (0.69-4.53)	48 (38.7)	1.34 (0.77-2.35)
Yes	27 (25.5)	ref	7 (7.2)	ref	31 (32.0)	ref
Distance						
≤10 minutes (n=119)	34 (28.6)	ref	11 (9.7)	ref	38 (33.6)	ref
10-20 minutes (n=72)	19 (27.1)	0.93 (0.48-1.80)	7 (10.1)	1.05 (0.39-2.84)	24 (34.8)	1.05 (0.56-1.98)
>20 minutes (n=47)	17 (37.0)	1.47 (0.71-3.01)	4 (10.0)	1.03 (0.31-3.44)	17 (42.5)	1.46 (0.70-3.05)
Wealth Quartile						
Q1 (n=61)	21 (40.4)	2.45 (1.07-5.60)**	3 (6.1)	0.86 (0.18-4.06)	22 (44.9)	2.50 (1.10-5.71)**
Q2 (n=59)	17 (28.8)	1.46 (0.64-3.37)	6 (11.1)	1.66 (0.44-6.23)	20 (37.0)	1.81 (0.80-4.09)
Q3 (n=58)	15 (25.9)	1.26 (0.54-2.95)	9 (16.1)	2.54 (0.73-8.78)	19 (33.9)	1.58 (0.70-3.58)
Q4 (n=60)	13 (21.7)	ref	4 (7.0)	ref	14 (24.6)	ref

†n=235 except for the following variables: satisfied with care (n=231), monthly CHW visit (n=234) and wealth quartile (n=229); ‡ n=222 except for the following variables: satisfied with care (n=219), monthly CHW visit (n=221) and wealth quartile (n=216). || CHW: community health worker *p<0.10; ** p<0.05;

TABLE 5. Adjusted odds ratios for the three measures assessing performance of prenatal visits, using the timing of initiation from recall †. Vespasiano, Minas Gerais State, Brazil, 2011.

Characteristics‡	Inadequate Initiation (n=224)		Inadequate Subsequent Visits (n=212)		Inadequate Prenatal Care Utilization (n=212)	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Age at childbirth						
<20	1.97	(0.46-8.48)	3.23	(0.28-37.52)	2.22	(0.52-9.50)
20-34	2.00	(0.67-5.95)	3.03	(0.53-17.32)	2.05	(0.68-6.23)
35+	ref		ref		ref	
Relationship status						
Not living with partner	1.56	(0.73-3.35)	2.95	(1.01-8.64)**	1.57	(0.73-3.38)
Living with partner	ref		ref		ref	
Skin color						
Black	1.69	(0.82-3.48)	1.79	(0.63-5.13)	2.59	(1.26-5.34)**
Not black	ref		ref		ref	
Prior children						
0	ref		ref		ref	
1-3	1.29	(0.63-2.65)	2.72	(0.76-9.74)	1.63	(0.80-3.32)
4+	3.92	(0.95-16.17)*	13.53	(1.78-103.0)**	9.59	(2.04-45.05)**
Used private health sector						
Yes	0.41	(0.13-1.32)	0.53	(0.10-2.87)	0.50	(0.18-1.41)
No	Ref		ref		ref	
Pregnancy Intention						
Unplanned	1.57	(0.81-3.06)	1.43	(0.51-4.04)	1.40	(0.73-2.69)
Planned	ref		ref		ref	
Satisfied with care						
No	0.43	(0.17-1.10)*	2.11	(0.66-6.76)	0.56	(0.23-1.34)
Yes	ref		ref		ref	
Monthly CHW visit						
No	2.05	(1.05-3.99)**	1.79	(0.61-5.25)	2.02	(1.03-3.94)**
Yes	ref		ref		ref	
Distance						
≤10 minutes	ref		ref		ref	
10-20 minutes	0.80	(0.38-1.67)	1.19	(0.40-3.59)	0.86	(0.42-1.76)
>20 minutes	1.64	(0.72-3.74)	1.10	(0.29-4.16)	1.49	(0.64-3.50)

† The models adjusted for the wealth index as a linear variable and excluded level of education. No interaction terms were selected at p<0.10.

‡ CHW: community health worker; * p<0.10 ; ** p<0.05

TABLE 6. Adjusted odds ratios for the three measures assessing performance of prenatal visits, using the timing of initiation from SISPRENATAL†. Vespasiano, Minas Gerais State, Brazil, 2011.

Characteristics‡	Inadequate Initiation (n=224)		Inadequate Subsequent Visits (n=212)		Inadequate Prenatal Care Utilization (n=212)	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Age at childbirth						
<20	1.36	(0.30-6.12)	3.30	(0.33-32.74)	3.62	(0.78-16.85)
20-34	2.12	(0.72-6.27)	2.69	(0.44-16.22)	3.67	(1.10-12.24)**
35+	ref		ref		ref	
Relationship status						
Not living with partner	2.92	(1.36-6.27)**	2.23	(0.80-6.24)	2.87	(1.32-6.24)**
Living with partner	ref		ref		ref	
Skin color						
Black	0.87	(0.41-1.85)	2.10	(0.78-5.62)	1.34	(0.65-2.79)
Not black	ref		ref		ref	
Prior children						
0	ref		ref		ref	
1-3	0.96	(0.48-1.94)	2.35	(0.74-7.47)	1.21	(0.60-2.45)
4+	4.97	(1.24-19.94)**	3.35	(0.39-28.36)	7.85	(1.78-34.55)**
Used private health sector						
Yes	1.86	(0.77-4.51)	0.70	(0.14-3.58)	2.09	(0.85-5.12)
No	ref		ref		ref	
Pregnancy Intention						
Unplanned	1.33	(0.68-2.59)	1.78	(0.64-4.97)	1.63	(0.84-3.15)
Planned	ref		ref		ref	
Satisfied with care						
No	0.81	(0.35-1.90)	0.72	(0.18-2.83)	0.80	(0.34-1.88)
Yes	ref		ref		ref	
Monthly CHW visit						
No	1.38	(0.71-2.66)	1.62	(0.60-4.39)	1.53	(0.79-2.97)
Yes	ref		ref		ref	
Distance						
≤10 minutes	ref		ref		ref	
10-20 minutes	2.09	(1.01-4.33)**	1.41	(0.51-3.88)	2.60	(1.26-5.35)**
>20 minutes	2.29	(1.00-5.26)*	0.95	(0.23-3.90)	1.82	(0.76-4.36)

† The models adjusted for the wealth index as a linear variable and excluded level of education. No interaction terms were selected at p<0.10.

‡ CHW: community health worker; * p<0.10 ; ** p<0.05

DISCUSSION

This study sought to evaluate if the risk factors for poor prenatal care usage vary when comparing the adequacy of overall prenatal care utilization to its two components, defined as the Adequacy of Initiation and the Adequacy of Subsequent Visits. For the Vespasiano population of women, the different prevalences for inadequate initiation, inadequate subsequent visits and inadequate prenatal care utilization revealed similar trends as other studies. Also, the categorization for the Adequacy of Initiation showed fair agreement when comparing the timing of first visit available from participant's recall to the timing of first visit from SISPRENATAL. Recall bias and any use of the private sector were significantly associated with discordant information between the data sources (SISPRENATAL and recall). The factors significantly associated with inadequate initiation, with inadequate subsequent visits and with inadequate prenatal care utilization varied substantially, and the use of all three outcome variables provided a more complete understanding of the risk factors for inadequate performance of prenatal visits.

Prevalence of Inadequate Usage

The findings regarding the prevalence of inadequate initiation, inadequate subsequent visits and inadequate prenatal care utilization agreed with other studies that found a higher prevalence of inadequate initiation than inadequate subsequent visits [21, 41]. In our study, inadequate initiation and inadequate overall prenatal care utilization were 3-4 times more common than inadequate subsequent visits. In the original demonstration of the Adequacy of Prenatal Care

Utilization with a representative sample of US births in 1980, Kotelchuck identified the same trend where late initiation (i.e. after the fourth month of pregnancy, which included both inadequate and intermediate initiation per Kotelchuck) was almost two times as common as inadequate subsequent visits (Inadequate Received Services) [21]. In Porto Alegre, Brazil, a study found that late initiation accounted for about 69% of women who received inadequate or partially inadequate care, with the remainder of women who received partially inadequate or inadequate care attributed to a low number of total visits [41]. A similar finding was identified by our study where 72% (52/79) of women had inadequate initiation as the only cause of inadequate prenatal care utilization. An implication from these findings is that late initiation may be more frequent than inadequate subsequent visits in other populations as well. Therefore, statistical power may be much higher when analyzing risk factors for late initiation or inadequate prenatal care utilization than when analyzing risk factors for inadequate subsequent visits. In future studies, sample size calculations should consider the potential for a much lower prevalence of inadequate subsequent visits compared to the other outcomes.

Participant Recall Compared to SISPRENATAL

It is unclear what information source should be considered the gold standard to assess the timing of initiation in Brazil, and our study contributed to the existing literature that compares the different data sources. In addition to surveys (i.e. recall from women) and to SISPRENATAL, the timing of initiation could also be obtained from the Prenatal Card that women carry to each visit and

to the delivery location. Other studies have compared SISPRENATAL to the Prenatal Card and compared the Prenatal Card to surveys (i.e. recall from women). SISPRENATAL and the Prenatal Card were compared in a study in São Paulo with 1,489 women, and the prevalence of initiation during the first trimester was 80.5% per SISPRENATAL and 66.7% per the Prenatal Card, although the kappa value or the percent agreement were not provided [24]. The implications were that SISPRENATAL may incorrectly assign some women to an earlier date than reality, that the Prenatal Card may incorrectly assign some women to a later date than reality or that both errors were occurring. In contrast to the above assessment that found substantially different proportions of women with timely initiation, our study identified an equivalent proportion of women beginning care in the first trimester comparing SISPRENATAL and the survey data. However, we encountered 72.8% agreement when comparing the individual assignments, which agrees with the above finding that the timing of initiation may vary greatly according to the data source used. The Prenatal Card and a survey (i.e. recall from women) were compared in Victoria, in the State of Espírito Santo, and a poor level of agreement was found for gestational month at first visit (K=0.17, 95%CI: 0.14-0.21) [52]. These findings support the idea that the timing of initiation varies greatly according to the data source used. In addition to the aforementioned data sources, it may be possible to assess the timing of initiation through a review of medical records, although no studies were identified in Brazil that compared the timing of initiation from medical records to another data source. Our study supplements the existing literature in Brazil with a comparison of SISPRENATAL and a survey.

Our study also explored potential mechanisms to explain disagreements in the timing of initiation between SISPRENATAL and the participants' recall. In our study, longer recall periods were associated with lower odds of concordant assignments to the Adequacy of Initiation, which supports the hypothesis that longer recall periods generated less reliable data compared to shorter recall periods. In addition, any use of the private sector was associated with lower odds of concordant assignment. This can be explained by the fact that SISPRENATAL does not record prenatal care visits conducted outside the public health system. This explanation was supported by our finding that use of the private sector was significantly associated with SISPRENATAL recording a later date of initiation than reported by recall. When using the month of initiation per participant recall, our findings agreed with prior research in Brazil that applied questionnaires in maternity hospitals and found significant associations between inadequate prenatal care and use of the public sector [30, 31]. A study conducted in Pelotas, Southern Brazil, showed that even among the lowest income group of the adult population, there was substantial use of the private sector and health insurance plans during 2004-2005 [53]. This indicates the importance of assessing private sector prenatal visits in Brazil because a meaningful proportion of lower income Brazilians used a mix of public and private health services. Although the timing of initiation recorded in SISPRENATAL does not suffer from recall bias, our study opted to report the results generated when using participant recall for the timing of initiation because the existing literature, as previously described, did not indicate that SISPRENATAL is more reliable than recall. In addition, this study sought to characterize the full spectrum of prenatal visits, and there was a

possibility that SISPRENATAL (and the Prenatal Card and the medical records available in Family Health Units) would underestimate prenatal care usage among women who also utilized the private sector. Therefore, we considered the participant's recall for the timing of initiation as the best data source for this study. It remains unclear, though, if recall from surveys should be considered the gold standard for measuring prenatal care visits in Brazil because our study did not compare recall to the participants' Prenatal Card, and the only study that directly compared the Prenatal Card and recall [52] did not conclude that one data source was superior to the other.

Potential Risk Factors According to the Outcome Variables

The use of all three outcome variables provided a more complete understanding of potential risk factors for inadequate performance of prenatal visits than the use of an overall measure of prenatal care utilization by itself. For example, this study found that monthly visits by CHWs, living with a partner and black skin color were significantly associated with one or two outcome variables but not the other outcome variable(s).

Monthly household visits by CHWs were significantly associated with inadequate initiation and with inadequate prenatal care utilization but were not significantly associated with inadequate subsequent visits. The significant association between monthly CHW visits and the timely initiation of prenatal care indicates that efforts to increase the utilization of prenatal care in Vespasiano may need to increase the proportion of women of reproductive age who receive monthly CHW visits. It bears mentioning that the monthly receipt of

CHW visits might also be related to inadequate subsequent visits with a larger sample size. Nonetheless, these findings show that using only a summary measure for the adequacy of overall prenatal care utilization would likely not reveal that a significant factor was associated with late initiation, with inadequate subsequent visits or with both inadequate initiation and inadequate subsequent visits.

Not living with a partner was significantly associated with subsequent visits but not with inadequate initiation or with inadequate prenatal care utilization in the adjusted analysis. Women who did not live with a partner were at statistically significant increased odds of inadequate subsequent visits. Considering the low level of precision for inadequate subsequent visits compared to the other outcomes, it was noteworthy that the variable for not living with a partner was significantly associated with inadequate subsequent visits but not inadequate initiation or inadequate utilization of prenatal care. The benefits of living with a partner may be explained in part by the ability of pregnant women, who live with a partner, to share child care responsibilities with more people. Previous studies in Brazil also found that women who did not live with their partner had increased odds of inadequate overall prenatal care utilization in São Luis, Maranhão State (OR=1.48, 95%CI: 1.22-1.80) [28] and in Aracaju, Sergipe State (OR=1.65, 95%CI: 1.39-1.94) [31]. Globally, not living with a partner has been identified as a risk factor for underutilization of prenatal care in England [54] and marital status (defined less broadly as either married or not married) has been identified as a risk factor in several developing countries [reviewed in 44]. Our findings contribute to this literature with evidence that the beneficial

effect from living with a partner may vary according to the dimension of prenatal care utilization that is assessed.

Self-reported black skin color was significantly associated with inadequate prenatal care utilization but not with inadequate initiation or with inadequate subsequent visits. Previous studies in Brazil have also identified important inequities related to skin color and prenatal care [27, 55] and similar dynamics have also been identified with indigenous people in Guatemala [56], black and other minority groups in England [54] and blacks and in the U.S [57, 58]. If only the Adequacy of Initiation and the Adequacy of Subsequent Visits had been used by the current study to assess the risk factors of poor uptake of prenatal care, then this important finding would not have been identified by our study.

Health researchers in Brazil do not commonly categorize people as black and non-black, where people of mixed skin color are grouped together with people of white skin color. Cultural researchers have generally addressed skin color in Brazil by comparing three groups: black, mixed (or brown or mulatto) and white [59]. Given the difficulty in differentiating between these three groups, the black skin color and mixed skin color groups are often combined into one group and compared to whites [60]. This form of categorization is common in the public health literature in Brazil [27, 58], although studies on prenatal care use have also used the three main categories of skin color [39]. The current study classified skin color as black or non-black, in part, because an unexpectedly high proportion of women self-reported as Indian and Asian and we thought it would be inappropriate to group these women with white women or to exclude them from analysis.

The use of the three measures characterizing the adequacy of prenatal visits leads to a fuller understanding of the risk factors for poor uptake of prenatal care, with potential programmatic implications. Interventions, to increase the proportion of women that initiate prenatal care within the first trimester may need to involve all women of reproductive age, since the pregnancy may not yet be confirmed. In contrast, interventions to increase the performance of subsequent visits would be targeted only to women identified as pregnant. For example, women that do not live with a partner should receive additional support to continue performing regular prenatal visits after the initial visit. The study demonstrates that different risk factors may have a greater magnitude of effect upon adequate initiation or upon adequate subsequent visits. The use of this evaluation method can therefore inform the design of more effective interventions to increase the utilization of prenatal care.

Strengths and Limitations

Our study had some notable strong points. In order to calculate gestational age at first visit and gestational age at childbirth, we used the date of last menstrual period available from SISPRENATAL, which was gathered at the time of enrollment into the public sector's prenatal care program. This tactic avoided the potential for recall bias for this specific question, which was a fundamental variable used in the creation of the outcome variables. In addition, data collection by means of a survey allowed for prenatal visits in the private health sector to be included in our analysis. The study was also able to gather information on many independent variables of interest, which are unavailable from secondary data

sources such as medical records or health information systems. Overall, the study used the most reliable measure for gestational age that was available, included prenatal visits in the private sector and assessed several independent variables of interest.

This study also suffered from some limitations that deserve attention. The research question only assessed the performance of prenatal visits but did not measure the actual quality of care received. The goal of prenatal care is to improve maternal and infant outcomes through the effective delivery of specific interventions, which was not assessed. Another study limitation was the cross-sectional nature of the data because all data (except for the date of last menstrual period) was collected from maternal recall at interview. The associations between some of the independent variables and the outcome variables suffer from temporality bias due to the cross-sectional study design. For example, women that have an infant from the pregnancy in question may be more likely to receive monthly CHW visits and therefore may over report the receipt of CHW visits. In addition, our study confirmed that a longer recall period may lead to less reliable data than a shorter recall period, and this study had a longer recall period than an alternative design where surveys could be administered in maternity hospitals following birth. In summary, the study did not assess the content of prenatal care received, and the study involved temporality bias and recall bias.

Overall this study demonstrated that the assessment of risk factors for inadequate initiation and inadequate subsequent visits can provide a valuable supplement to the traditional method that assesses risk factors for inadequate overall prenatal care utilization. The use of the outcome variables for inadequate

initiation and inadequate subsequent visits can inform the design of more effective interventions to increase the use of prenatal care, by indicating if particular interventions should work with all women of reproductive age or work with a smaller group of women who have already performed their first prenatal visit.

IMPLICATIONS AND RECOMMENDATIONS

Implications

Surveys can capture health service utilization that occurs in both the public and private sectors. In Brazil, the potential secondary data sources on prenatal care usage—such as SISPRENATAL, the woman's prenatal card or a review of medical records—would likely fail to capture prenatal visits in the private sector. Therefore, in Brazilian communities where women have mixed patterns of prenatal care utilization, surveys may be a preferable method to assess the full spectrum of prenatal care utilization, despite the inherent limitation of recall bias.

Interventions to increase the uptake of prenatal care in Vespasiano, Brazil can focus on the specific risk factors identified by this study. For example, women that do not live with a partner should be a priority group that receives additional support and encouragement to continue performing prenatal visits. Interventions to increase prenatal care utilization can also target women with four or more children and can seek to increase the proportion of households receiving monthly CHW visits, and both these interventions can be targeted to all women of reproductive age and more narrowly targeted to women who have already performed a prenatal visit.

In a broader sense, this study demonstrates that this evaluation method can inform the design of more effective interventions to increase prenatal uptake. For example, the association between not living with a partner and inadequate subsequent visits would not have been identified in an analysis that only studied

the summary measure for inadequate prenatal care utilization. In addition, the current study demonstrated a benefit from using the overall measure of prenatal care utilization because a significant association between black skin color was identified for overall prenatal care utilization but not for the Adequacy of Initiation nor the Adequacy of Subsequent Visits. Therefore, the study demonstrates that it is valuable to conduct analyses that utilize the three outcome measures to characterize prenatal care uptake.

Recommendations

Considering the importance given to the role of CHWs by the Brazilian primary health system, the SISPRENATAL health information system should consistently record if a woman was covered or not covered by the Family Health Strategy. During our study, no simple method was identified to determine if a woman was actually enrolled in the Family Health Strategy at the time of her pregnancy or if she was attending the family health unit as a non-enrolled pregnant woman who would not regularly receive CHW visits. The SISPRENATAL database contains a potential solution that was already utilized by one of the nine health units. In the SISPRENATAL database, where the micro-area is generally listed, a standard code can instead indicate that the pregnant woman lives in an area not covered by the Family Health Strategy. Regular use of this code could provide important context to any future findings related to the non-receipt of monthly CHW visits as a risk factor for under-utilization of prenatal care.

This study demonstrated that an understanding of the risk factors for inadequate initiation and the risk factors for inadequate subsequent visits can supplement the traditional evaluation method, which only assesses risk factors for inadequate overall prenatal care utilization. The use of the outcome variables for inadequate initiation and inadequate subsequent visits can inform the design of more effective interventions to increase the use of prenatal care, by indicating if particular interventions should work with all women of reproductive age or work with a smaller group of women who have already performed their first prenatal visit. In Brazil, datasets currently exist that could be reanalyzed with this evaluation method, since the datasets allow for the necessary adjustments using gestational age at first visit and gestational age at childbirth. This evaluation method should be applied in future studies that assess risk factors for inadequate utilization of prenatal care.

APPENDIX

TABLE 7. Adjusted odds ratios for the three measures assessing performance of prenatal visits, using the timing of initiation from recall and the education variable †. Vespasiano, Minas Gerais State, Brazil, 2011.

Characteristics‡	Inadequate Initiation (n=224)		Inadequate Subsequent Visits (n=212)		Inadequate Prenatal Care Utilization (n=212)	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Age at childbirth						
<20	3.40	(0.83-13.86)*	2.55	(0.23-28.91)	3.53	(0.86-14.44)*
20-34	2.31	(0.77-6.96)	3.13	(0.52-18.96)	2.40	(0.78-7.42)
35+	ref		ref		ref	
Relationship status						
Not living with partner	1.52	(0.72-3.22)	2.61	(0.88-7.76)*	1.50	(0.71-3.19)
Living with partner	ref		ref		ref	
Skin color						
Black	1.55	(0.75-3.18)	2.06	(0.73-5.78)	2.47	(1.20-5.08)**
Not black	ref		ref		ref	
Prior children						
0	ref		ref		ref	
1-3	1.41	(0.68-2.90)	2.34	(0.68-8.10)	1.69	(0.83-3.45)
4+	3.76	(0.87-16.23)*	14.15	(1.63-123.03)**	7.85	(1.78-34.55)**
Education						
<4 years	2.46	(0.66-9.10)	0.35	(0.03-4.61)	2.41	(0.57-10.30)
4-10 years	1.26	(0.63-2.51)	1.41	(0.47-4.22)	1.57	(0.80-3.08)
11+ years	ref		ref		ref	
Used private health sector						
Yes	0.42	(0.13-1.34)	0.62	(0.11-3.33)	0.53	(0.19-1.48)
No	ref		ref		ref	
Pregnancy Intention						
Unplanned	1.71	(0.88-3.32)	1.34	(0.47-3.80)	1.54	(0.80-2.95)
Planned	ref		ref		ref	
Satisfied with care						
No	0.41	(0.16-1.05)*	2.11	(0.66-6.67)	0.53	(0.22-1.26)
Yes	ref		ref		ref	
Monthly CHW visit						
No	1.73	(0.90-3.33)	2.04	(0.70-5.95)	1.80	(0.93-3.46)*
Yes	ref		ref		ref	
Distance						
≤10 minutes	ref		ref		ref	
10-20 minutes	0.78	(0.37-1.62)	1.34	(0.44-4.09)	0.85	(0.41-1.75)
>20 minutes	1.80	(0.80-4.04)	1.06	(0.28-3.94)	1.65	(0.71-3.83)

† The models did not include the wealth index.

‡ CHW: community health worker; * p<0.10 ; ** p<0.05

TABLE 8. Adjusted odds ratios for the three measures assessing performance of prenatal visits, using the timing of initiation from recall, the wealth index and a stepwise selection procedure to fit a model for each outcome variable†. Vespasiano, Minas Gerais State, Brazil, 2011.

Characteristics‡	Inadequate Initiation		Inadequate Subsequent Visits		Inadequate Prenatal Care Utilization	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Relationship status						
Not living with partner	-		2.85	(1.08-7.53)**	-	
Living with partner	-		ref		-	
Skin color						
Black	-		-		2.61	(1.30-5.22)**
Not black	-		-		ref	
Prior children						
0	-		ref		ref	
1-3	-		2.04	(0.68-6.11)	1.45	(0.76-2.78)
4+	-		6.51	(1.39-30.38)**	5.94	(1.62-21.74)**
Used private health sector						
Yes	0.32	(0.11-0.98)**	-		0.43	(0.16-1.15)*
No	ref		-		ref	
Monthly CHW visit						
No	1.82	(0.99-3.35)*	-		2.04	(1.08-3.88)**
Yes	ref		-		ref	

† Interaction terms were included in the stepwise selection procedure (using a 0.2 entry criteria and a 0.1 exit criteria), and no interaction terms were selected for inclusion in the final models.

‡ CHW: community health worker; * p<0.10; ** p<0.05

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TABLE 9. Adjusted odds ratios for the three measures assessing performance of prenatal visits, using timing of initiation from recall, the education variable and a stepwise selection procedure to fit a model for each outcome variable†. Vespasiano, Minas Gerais State, Brazil, 2011.

Characteristics‡	Inadequate Initiation		Inadequate Subsequent Visits		Inadequate Prenatal Care Utilization	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Relationship status						
Not living with partner	-		2.85	(1.08-7.53)**	-	
Living with partner	-		ref		-	
Skin color						
Black	-		-		2.23	(1.14-4.36)**
Not black	-		-		ref	
Prior children						
0	-		ref		ref	
1-3	-		1.99	(0.67-5.90)	1.52	(0.81-2.86)
4+	-		6.12	(1.38-27.15)**	5.87	(1.64-21.00)**
Used private health sector						
Yes	0.29	(0.10-0.87)**	-		0.42	(0.16-1.09)*
No	ref		-		ref	
Pregnancy Intention						
Unplanned	0.55	(0.31-1.00)*	-		0.60	(0.33-1.09)*
Planned	ref		-		ref	

† Interaction terms were included in the stepwise selection procedure (using a 0.2 entry criteria and a 0.1 exit criteria), and no interactions were selected for inclusion in the final models.

‡ CHW: community health worker; * p<0.10; ** p<0.05

REFERENCES

1. Wilmoth J, Mathers C, Say L, Mills S: **Maternal deaths drop by one-third from 1990 to 2008: a United Nations analysis**. *Bull World Health Organ* 2010, **88**(10):718-718A.
2. Oestergaard MZ, Inoue M, Yoshida S, Mahanani WR, Gore FM, Cousens S, Lawn JE, Mathers CD: **Neonatal mortality levels for 193 countries in 2009 with trends since 1990: a systematic analysis of progress, projections, and priorities**. *PLoS Med* 2011, **8**(8):e1001080.
3. Carroli G, Rooney C, Villar J: **How effective is antenatal care in preventing maternal mortality and serious morbidity? An overview of the evidence**. *Paediatr Perinat Epidemiol* 2001, **15 Suppl 1**:1-42.
4. Darmstadt GL, Bhutta ZA, Cousens S, Adam T, Walker N, de Bernis L: **Evidence-based, cost-effective interventions: how many newborn babies can we save?** *Lancet* 2005, **365**(9463):977-988.
5. Victora CG, Aquino EM, Leal MC, Monteiro CA, Barros FC, Szwarcwald CL: **Maternal and child health in Brazil: progress and challenges**. *Lancet* 2011, **377**(9780):1863-1876.
6. Graham WJ, Cairns J, Bhattacharya S, Bullough CHW, Quayyum Z, Rogo K: **Maternal and Perinatal Conditions**. In *Disease Control Priorities in Developing Countries 2nd Edition*. 2011/01/21 edition. Edited by Jamison DT, Breman JG, Measham AR, Alleyne G, Claeson M, Evans DB, Jha P, Mills A, Musgrove P. Washington (DC): World Bank; 2006.
7. De-Regil LM, Fernandez-Gaxiola AC, Dowswell T, Pena-Rosas JP: **Effects and safety of periconceptional folate supplementation for preventing birth defects**. *Cochrane Database Syst Rev* 2010(10):CD007950.
8. Bergsjo P, Villar J: **Scientific basis for the content of routine antenatal care. II. Power to eliminate or alleviate adverse newborn outcomes; some special conditions and examinations**. *Acta Obstet Gynecol Scand* 1997, **76**(1):15-25.
9. Rumbold A, Middleton P, Pan N, Crowther CA: **Vitamin supplementation for preventing miscarriage**. *Cochrane Database Syst Rev* 2011(1):CD004073.
10. Bhutta ZA, Ali S, Cousens S, Ali TM, Haider BA, Rizvi A, Okong P, Bhutta SZ, Black RE: **Alma-Ata: Rebirth and Revision 6. Interventions to address maternal, newborn, and child survival: what difference can integrated primary health care strategies make?** *Lancet* 2008, **372**(9642):972-989.
11. World Health Organization, Department of Making Pregnancy Safer: **Pregnancy, Childbirth, Postpartum and Newborn Care: A guide for essential practice**. Geneva: 2006.
12. Dowswell T, Carroli G, Duley L, Gates S, Gulmezoglu AM, Khan-Neelofur D, Piaggio GG: **Alternative versus standard packages of antenatal care for low-risk pregnancy**. *Cochrane Database Syst Rev* 2010(10):CD000934.
13. American Academy of Pediatrics and American College of Obstetricians and Gynecologists: ***Guidelines for Perinatal Care***. 6th edition; 2007.
14. Ministério da Saúde, Departamento de Ações Programáticas Estratégicas, Secretaria de Atenção à Saúde: **Pré-natal e puerpério: atenção qualificada e humanizada – manual técnico.** Brasília: Ministério da Saúde; 2005.
15. Minas Gerais State Secretary of Health: **[Prenatal, birth and puerparal care: the Live Life protocol]**. 2 edition. Belo Horizonte, Brazil: SAS/SES; 2006.
16. Secretaria Municipal de Saúde, Prefeitura Municipal de Vespasiano: **Protocolo de Assistência à Mulher no Período do Pré-Natal no Município de Vespasiano** Vespasiano, Minas Gerais: Prefeitura Municipal de Vespasiano; 2009.

17. Serruya SJ, Cecatti JG, Lago TG: **[The Brazilian Ministry of Health's Program for Humanization of Prenatal and Childbirth Care: preliminary results]**. *Cad Saude Publica* 2004, **20**(5):1281-1289.
18. Ministério da Saúde, Área Técnica de Saúde da Mulher, Departamento de Gestão de Políticas Estratégicas, Secretaria de Políticas de Saúde: **Gestação de Alto Risco: Manual Técnico**. Brasília: Ministério da Saúde; 2000.
19. **Infant Death: An Analysis by Maternal Risk and Health Care**. 1973. Institute of Medicine and National Academy of Sciences: Washington, DC.
20. Alexander GR, Kotelchuck M: **Quantifying the adequacy of prenatal care: a comparison of indices**. *Public Health Rep* 1996, **111**(5):408-418; discussion 419.
21. Kotelchuck M: **An evaluation of the Kessner Adequacy of Prenatal Care Index and a proposed Adequacy of Prenatal Care Utilization Index**. *Am J Public Health* 1994, **84**(9):1414-1420.
22. Kelly RH, Danielsen BH, Golding JM, Anders TF, Gilbert WM, Zatzick DF: **Adequacy of prenatal care among women with psychiatric diagnoses giving birth in California in 1994 and 1995**. *Psychiatr Serv* 1999, **50**(12):1584-1590.
23. Gazmararian JA, Arrington TL, Bailey CM, Schwarz KS, Koplan JP: **Prenatal care for low-income women enrolled in a managed-care organization**. *Obstet Gynecol* 1999, **94**(2):177-184.
24. Andreucci CB, Cecatti JG, Macchetti CE, Sousa MH: **[SISPRENATAL as a tool for evaluating quality of prenatal care]**. *Rev Saude Publica* 2011, **45**(5):854-864.
25. Romero DE, Cunha CB: **[Evaluation of quality of epidemiological and demographic variables in the Live Births Information System, 2002]**. *Cad Saude Publica* 2007, **23**(3):701-714.
26. Mascarenhas MD, Gomes KR: **[Reliability of data available in the Information System for Live Birth in the city of Teresina, Piaui State, Brazil--2002]**. *Cien Saude Colet* 2011, **16 Suppl 1**:1233-1239.
27. Leal MC, Gama SG, Ratto KM, Cunha CB: **[Use of the modified Kotelchuck index in the evaluation of prenatal care and its relationship to maternal characteristics and birth weight in Rio de Janeiro, Brazil]**. *Cad Saude Publica* 2004, **20 Suppl 1**:S63-72.
28. Coimbra LC, Silva AA, Mochel EG, Alves MT, Ribeiro VS, Aragao VM, Bettiol H: **[Factors associated with inadequacy of prenatal care utilization]**. *Rev Saude Publica* 2003, **37**(4):456-462.
29. de Silva AA, Coimbra LC, da Silva RA, Alves MT, Lamy Filho F, Carvalho Lamy Z, Gomide Mochel E, Aragao VM, Ribeiro VS, Tonial SR *et al*: **Perinatal health and mother-child health care in the municipality of Sao Luis, Maranhao State, Brazil**. *Cad Saude Publica* 2001, **17**(6):1413-1423.
30. Coimbra LC, Figueiredo FP, Silva AA, Barbieri MA, Bettiol H, Caldas AJ, Mochel EG, Ribeiro VS: **Inadequate utilization of prenatal care in two Brazilian birth cohorts**. *Braz J Med Biol Res* 2007, **40**(9):1195-1202.
31. Ribeiro ER, Guimaraes AM, Bettiol H, Lima DD, Almeida ML, de Souza L, Silva AA, Gurgel RQ: **Risk factors for inadequate prenatal care use in the metropolitan area of Aracaju, Northeast Brazil**. *BMC Pregnancy Childbirth* 2009, **9**:31.
32. Moraes CL, Arana FD, Reichenheim ME: **Physical intimate partner violence during gestation as a risk factor for low quality of prenatal care**. *Rev Saude Publica* 2010, **44**(4):667-676.
33. Vettore MV, Leal MC, Leao AT, Silva AMM, Lamarca GA, Sheiham A: **The relationship between periodontitis and preterm low birthweight**. *J Dental Res* 2008, **87**(1):73-38.

34. Oliveira EF, Gama SG, Silva CM: **[Teenage pregnancy and other risk factors for fetal and infant mortality in the city of Rio de Janeiro, Brazil]**. *Cad Saude Publica* 2010, **26**(3):567-578.
35. Leal MC, Pereira AP, Lamarca G A, Vettore MV: **The relationship between social capital, social support and the adequate use of prenatal care**. *Cad Saude Publica* 2011, **27 Suppl 2**:s237-253.
36. Vettore MV, Dias M, Domingues RM, Leal MC: **[Prenatal care and management of hypertension in pregnant women in the public healthcare system in Rio de Janeiro, Brazil]**. *Cad Saude Publica* 2011, **27**(5):1021-1034.
37. Takeda SMP: **[Evaluation of primary care units: modification of indicators for health and quality of care (masters dissertation)]**. Federal University of Pelotas; 1993.
38. Almeida SD, Barros MB: **[Equity and access to health care for pregnant women in Campinas (SP), Brazil]**. *Rev Panam Salud Publica* 2005, **17**(1):15-25.
39. Leal MC, da Gama SG, da Cunha CB: **[Racial, sociodemographic, and prenatal and childbirth care inequalities in Brazil, 1999-2001]**. *Rev Saude Publica* 2005, **39**(1):100-107.
40. Goldani MZ, Barbieri MA, Silva AA, Bettiol H: **Trends in prenatal care use and low birthweight in southeast Brazil**. *Am J Public Health* 2004, **94**(8):1366-1371.
41. Bassani DG, Surkan PJ, Olinto MT: **Inadequate use of prenatal services among Brazilian women: the role of maternal characteristics**. *Int Perspect Sex Reprod Health* 2009, **35**(1):15-20.
42. Victora CG, Matijasevich A, Silveira M, Santos I, Barros AJ, Barros FC: **Socio-economic and ethnic group inequities in antenatal care quality in the public and private sector in Brazil**. *Health Policy Plan* 2010, **25**(4):253-261.
43. Trevisan MR, Lorenzi DRS, Araújo NM, Ésber K: **[Pré-natal Care Profile among Public Health Service ("Sistema Único de Saúde") Users from Caxias do Sul]**. *Rev Bras Gyn Obst* 2002, **24**(5):293-299.
44. Simkhada B, Teijlingen ER, Porter M, Simkhada P: **Factors affecting the utilization of antenatal care in developing countries: systematic review of the literature**. *J Adv Nurs* 2008, **61**(3):244-260.
45. Brazilian Institute of Geography and Statistics: **Demographic Census**. 2010. Available: http://tabnet.datasus.gov.br/ [Accessed: 15 Sep. 2011]
46. Brazilian Institute of Geography and Statistics: **Household Income Survey**. 2003.
47. Leal MC, Gama SGNd, Ratto KMN, Cunha CBd: **Uso do índice de Kotelchuck modificado na avaliação da assistência pré-natal e sua relação com as características maternas e o peso do recém-nascido no Município do Rio de Janeiro**. *Cadernos de Saúde Pública* 2004, **20**(1):S63-S72.
48. Mues KE, Resende JC, dos Santos OC, Ferreira JA, Leon JS: **Community perceptions of Brazil's Programa de Saúde da Família (PSF) on child health and diarrhea: results of a cross-sectional household Survey in Vespasiano, state of Minas Gerais, Brazil**. *Pan American Journal of Public Health* [Accepted for publication].
49. Barros AJD, Victora CG: **[A nationwide wealth score based on the 2000 Brazilian demographic census]**. *Rev Saude Publica* 2005, **39**(4):523-529.
50. Landis JR, Koch GG: **The measurement of observer agreement for categorical data**. *Biometrics* 1977, **33**(1):159-174.
51. Tough SC, Siever JE, Johnston DW: **Retaining women in a prenatal care randomized controlled trial in Canada: implications for program planning**. *BMC Public Health* 2007, **7**:148.

52. Neto ETS, Leal MC, Oliveira AE, Zandonade E, de Gama SGN: **[Agreement between information from the Pregnant Card and the mother's memory of antenatal care]**. *Cad Saude Publica* 2012, **28**(2):256-266.
53. Dias-da-Costa JS, Gigante DP, Horta BL, Barros FC, Victora CG: **[Pattern of health services utilization by adults of the Pelotas birth cohort from 1982 to 2004-5, Southern Brazil]**. *Rev Saude Publica* 2008, **42 Suppl 2**:51-59.
54. Rowe RE, Magee H, Quigley MA, Heron P, Askham J, Brocklehurst P: **Social and ethnic differences in attendance for antenatal care in England**. *Public Health* 2008, **122**(12):1363-1372.
55. Matijasevich A, Victora CG, Barros AJ, Santos IS, Marco PL, Albernaz EP, Barros FC: **Widening ethnic disparities in infant mortality in southern Brazil: comparison of 3 birth cohorts**. *Am J Public Health* 2008, **98**(4):692-668.
56. Glei DA, Goldman N, Rodriguez G: **Utilization of care during pregnancy in rural Guatemala: does obstetrical need matter?** *Soc Sci Med* 2003, **57**(12):2447-2463.
57. Melnikow J, Alemagno S: **Adequacy of prenatal care among inner-city women**. *J Fam Pract* 1993, **37**(6):575-582.
58. LaVeist TA, Keith VM, Gutierrez ML: **Black/white differences in prenatal care utilization: an assessment of predisposing and enabling factors**. *Health Serv Res* 1995, **30**(1):43-58.
59. Winant, H: **Rethinking Race in Brazil**. *J Latin Amer Studies,* **24**(1): 173-192.
60. Heringer, R: **[Racial inequalities in Brazil: a synthesis of social indicators and challenges for public policies]**. *Cad Saude Publica* 2002, **18 Suppl 1**: 57-65.