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Prenatal Care Adequacy in the U.S.-Mexico Border Region: An Analysis of Spatial Distribution and the Factors Associated with Low or Late Utilization

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Drake University
2006

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An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in the Hubert Department of Global Health
2012

Abstract

Prenatal Care Adequacy in the U.S.-Mexico Border Region: An Analysis of Spatial Distribution and the Factors Associated with Low or Late Utilization

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Background

An early, coordinated program of prenatal care is recognized in the obstetric community as an important means of preventing, screening for, and intervening to address adverse maternal and perinatal outcomes during pregnancy. In both the United States and Mexico, objectives have been established to increase the percent of women entering prenatal care in the first trimester. The United States has also established goals to increase the proportion of women receiving adequate levels of care. In recent decades, several indices have been developed to measure adequacy of prenatal care. The R-GINDEX considers timing of first prenatal visit and the number of expected visits a woman should receive given the total length of pregnancy gestation.

Methods

The current study offers a descriptive analysis of combined 2009 natality files from the 10 states located along the United States-Mexico border. A total of 1,376,123 singleton birth records were analyzed, including 1,023,767 U.S. resident births and 352,356 resident births. Border-specific analysis included 262,248 women residing in the 124 counties and municipalities along the U.S.-Mexico border. Regression analysis was conducted to evaluate maternal state of residence as a predictor of low-late utilization, after adjusting for other maternal characteristics available in the birth file.

Key Findings and Conclusions

Using an adaptation of the R-GINDEX to assess prenatal care adequacy, 46.4% of Mexican border residents received low or late prenatal care in 2009. In contrast, low-late utilization was observed among 16.9% of American residents in the region. Significant variation in adequacy was observed across states, with adjusted relative risk of low-late utilization ranging from 1.73 in Arizona to 3.33 in Coahuila, when compared to outcomes observed among California border residents. Findings suggest that the disparities may be driven by low numbers of prenatal care visits received by Mexican women. Similar rates of first trimester prenatal care entry and no utilization imply a need to further consider the utility of available instruments used to evaluate adequacy of prenatal care.

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Acknowledgements

I am indebted to several individuals for their generous time, support and wisdom shared throughout this endeavor. Foremost, I would like to thank my thesis committee members, Drs. Roger Rochat and Jill McDonald, for their tireless commitment and infinite patience to ensure this project was beneficial both for my learning and as a tool for advancing reproductive health in the border region. Dr. McDonald's presence in El Paso and work as a CDC Epidemiologist assigned to the U.S.-Mexico Border Health Commission, provided invaluable insight into realities along the border. In a similar way, I am immensely grateful for the support of Mr. Octavio Mojarro, who graciously participated in regular project communications to contribute his expertise as a demographer and public health professional in Mexico. I own an additional debt of gratitude to Dr. Ruben Smith, Ms. Dyanne Herrera and Dr. Stephanie Ventura, who provided early assistance with access to prepared documents and datasets available through the National Center for Health Statistics. I also wish to thank Dr. Sukhjeet Ahuja and the staff at the National Association for Public Health Statistics and Information Systems for facilitating access to U.S. natality files. Finally, I wish to thank faculty in the Department of Biostatistics and Informatics at Emory University, namely Dr. Paul Weiss, as well as staff at the Emory Data Center, who kindly provided assistance to overcome early data access challenges.

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Notes for Tables 4-10:

- *Low or Late PNC* refers to: (1) women who began PNC in their third trimester; (2) women who began PNC in their first or second trimester, but who received fewer visits than is considered adequate for gestational age according to ACOG guidelines; and (3) women who received no PNC.

- *Low visits for parity* refers to: fewer than 7 visits for multiparous women and fewer than 10 visits for nulliparous women, with parity based on previous live births.

- All municipalities in the Mexican state of Baja California fall within the border region; therefore, a comparison between border and non-border municipalities is not possible (Table 7.1)

- Missing records have been excluded from data presented in these tables 4-10. The extent of these data are instead presented separately in Table 12; percentages may not sum to 100 due to rounding errors.

Chapter 1: Introduction

Background & Rationale

Current clinical standards recommend an early, coordinated program of evidence-based prenatal care, including preventive services, counseling and maternal screening for known pregnancy risk factors. Adequate prenatal care supports improved maternal and infant health outcomes in several important ways. Direct benefits may result from early detection and timely intervention for pregnancy-related disorders, or from the appropriate management of pre-pregnancy conditions and co-morbidities known to be associated with poor birth outcomes [1]. In addition, indirect benefits include:

- Detection of women at increased risk for delivery complications and referral to obstetric and neonatal care facilities with sufficient technology and adequately trained personnel for appropriate treatment;
- Education to encourage healthy lifestyle choices and to reinforce positive maternal behaviors, such as exclusive breastfeeding and tobacco cessation; and
- Establishment of maternal care-seeking behaviors to increase postpartum utilization of preventive health services (e.g., childhood immunizations, well-child visits).

Despite these benefits, in 2008, 29% or at least one in every four live births to women in the U.S. received no prenatal care during the first trimester of pregnancy [2]. Previous analyses have observed even lower rates of prenatal care utilization among women residing in states along the U.S.-Mexico border. In 2003, Arizona, New Mexico and Texas were among states comprising the bottom quartile for first trimester prenatal care in the United States [3]. Moreover, while New Mexico displayed the lowest rates in the U.S. that year (68.9%), in 2000, Mexico reported combined national rates of first and second trimester entry of only 59 percent [4]. More recently, 2008 birth data from the border region indicate continued disparities both across U.S. border states and between border and non-border counties [5]; current rates of prenatal care utilization in Mexico have not been well established, particularly with the six border states.

Consequently, national health objectives in both countries have incorporated benchmarks for improved rates of early prenatal care entry. The United States' *Healthy People 2020*, sets the current U.S. target for first trimester entry at 77.9 percent (MICH-10.1); this target represents a 10% increase over the 2007 baseline of 70.8 percent [6]. Based on the Healthy People framework, shared U.S. and Mexico targets have been established to increase rates of early prenatal care utilization within the border region. The binational agenda, *Healthy Border 2010*, established for U.S. border counties an objective to increase the proportion of mothers entering prenatal care in the first trimester to 85% by 2010 [4, 7]. The corresponding benchmark in Mexico was lower, requiring an increase in first or second trimester entry to 70%.

In approaching these targets, prenatal care adequacy in the border region should be considered in the context of the region's unique demographic features. The U.S.-Mexico border region extends over 2,100 miles in length and comprises 44 U.S. counties and 80 Mexican municipalities (Appendix A). According to the 2000 census data, the border region was home to more than 6.5 and 6.3 million U.S. and Mexican residents, respectively [4]. Due to rapid growth, however, the U.S. border population was estimated to exceed seven million in 2006 [8]. Currently, fifteen "sister cities" are recognized along the border; the most populous jurisdictions include San Diego, California (2,813,833); Tijuana, Baja California (1,288,615); Juarez, Chihuahua (1,249,655); Pima, Arizona (843,746); Mexicali, Baja California (828,022); El Paso, Texas (679,622); Hidalgo, Texas (569,463); and Cameron, Texas (335,227) [9, 10]. An economically and socially interdependent region, more than 360 million border crossings are estimated to occur annually [11]. Additionally, twenty-five Native American tribal lands comprise parts of the border region; and two of the 10 fastest growing metropolitan areas are found along the Texas border [12].

Moreover, the health experiences that characterize border residents are of particular interest. In 2008, the United States exceeded Mexico in its percent of infants born weighing less than 2,500 grams (8.2%, compared with 7.1%) [4]. During the same period, however, the infant mortality rate in Mexico (15.2 per 1,000) more than doubled the U.S. rate (6.6 per 1,000). In U.S. states and counties along the border, rates of low birth weight and preterm delivery among Hispanic mothers appear to closely approximate rates in the general population; rather, the most troubling disparities in low birth weight as well as in preterm birth are observed among non-Hispanic Blacks, who display rates over 1.5 times higher than the general population [2, 5]. Additionally, in 2008, border counties in the U.S. observed teen birth rates ranging from 39 births per 1,000 women age 15-19 in California to 87 per 1,000 in Texas; the high-population centers of Cameron and Hidalgo Counties reached 90 births per 1,000 women age 15-19 [5].

The United States-Mexico Border Health Commission (USMBHC) was established in 2000 to define bi-national health objectives and to direct related research efforts within the border region. With the positioning of a CDC-affiliated Maternal and Child Health Epidemiologist on the border, its efforts in recent years have focused, at least in part, on a range of reproductive health issues. Indicative of the growing capacity for collaborative, cross-border surveillance to address reproductive health issues, in 2007, the USMBHC launched a demonstration project, the Brownsville-Matamoros Sister City

Project for Women's Health, which became the first successful attempt to achieve comparable reproductive health data from both sides of the border [13, 14].

Problem statement

Through a variety of pathways, inadequate prenatal care may elevate a mother's risk for poor perinatal and long-term child health outcomes. To the author's knowledge, no previous studies have conducted a binational analysis of combined natality files to assess current levels of prenatal care utilization along the U.S.-Mexico border. Though exciting efforts are underway to more fully examine a range of reproductive health needs in the border region, the distribution of prenatal care utilization is poorly understood, as is the extent to which unique characteristics of border counties and municipalities impact adequacy of prenatal care. If either country hopes to achieve established prenatal care targets, as set forth in Healthy People 2020 and border-specific policy documents, further research is needed to understand the levels of care received and the factors associated with its timing and use.

Research questions, purpose and aims

This project was undertaken to support ongoing USMBHC efforts, by addressing current gaps in knowledge of prenatal care timing, adequacy, and determinants across the border region. The project's foremost aim was to describe the distribution of prenatal care utilization across U.S. counties and Mexican municipalities in states along both sides of the border. This information is essential for state and local public health officials charged with developing policy and health promotion strategies for the region. It will also facilitate the prioritization of communities along the border with the greatest need for resource allocation. In addition to providing a descriptive overview of prenatal adequacy, the following secondary research questions are also addressed:

1. Which socio-demographic variables, collected through national vital records systems in both the United States and Mexico are significantly associated with low or late prenatal care utilization in border counties and municipalities?
2. Controlling socio-demographic characteristics, do rates of low or late prenatal care utilization vary significantly by maternal state of residence?

Finally, in order to enhance the communication of the results to local stakeholders, mapping techniques were used to depict the spatial distribution of low-late utilization and alternative measures of adequacy.

Definition of Key Terms

Gestational age	The length of the current pregnancy in weeks from the first day of the mother's last menstrual period (LMP).
Live birth order (parity)	The total number of past pregnancies resulting in the birth of a live infant, not including the current pregnancy.
Low or late prenatal care	A dichotomous index variable used to classify prenatal care according to the R-GINDEX. Adequate numbers of visits are determined by the American College of Obstetricians and Gynecologists' standards, adjusting for trimester of first visit and gestational age of the infant at time of birth.
Low-risk	The absence of health or obstetric complications in the current or previous pregnancies, such as recurrent miscarriage, multiple gestation or chronic conditions that could increase the likelihood for development of complications during the current pregnancy, labor, delivery or the postpartum period.
Non-resident	Provides a means of classifying women based on location of birth relative to their place of residence. A mother is considered a non-resident if she delivers outside the county of her current permanent residence.
Prenatal care visit	For the purposes of this analysis, refers to any routine visit received by an appropriately licensed medical professional (physician, advanced practice nurse or midwife) as part of the normal course of pregnancy-related care, from the time a woman became aware of a pregnancy through delivery of the product of conception. Derived from maternal self-report and maternal medical records, as available at the time the birth certificate was completed.
R-GINDEX	The Revised Graduated Prenatal Care Utilization Index (Alexander & Kotelchuck, 1996) defines six categories of prenatal care use based on total number of visits, timing of first visit, and gestational age at time of birth.
State of residence	The mother's self-reported state of permanent residence at the time of delivery.
Trimester of entry	Defined according to the completed gestational period in which the first prenatal visit occurred (1^{st}=0 to 13 completed weeks or months 1 to 3; 2^{nd}=14 to 27 completed weeks or months 4 to 6; and 3^{rd}=28+ weeks or 7+ months).

Chapter 2: Review of the Literature

A comprehensive review of the literature on prenatal care adequacy begins herein with a synthesis of available evidence regarding the efficacy of such care. Consideration is next given to the range of current guidelines for adequate care, in addition to basic measures and more complex indices of prenatal care utilization that have evolved from existing standards. Subsequently, known patterns of prenatal care utilization are reviewed for both general U.S. and Hispanic populations, including cross-border care seeking behaviors and demographic characteristics previously found to be associated with health care access. The review ends with consideration given to gaps in the current knowledge surrounding prenatal care adequacy in the combined border region.

Effectiveness of prenatal care in preventing adverse pregnancy outcomes

The potential benefits of prenatal care are well accepted throughout the international obstetric community. Formal integration of prenatal care with maternity services in higher resource countries first took place in the early decades of the 20th century, when the estimated maternal mortality ratio in the United States was between 600-900 per 100,000 live births [15, 16]. Since that time, the mortality rate in Mexico has declined to 57.2 per 100,000 live births (2008), and in the United States, the maternal mortality ratio has declined to an estimated 12.7 per 100,000 live births (2007) [17]. Adverse neonatal outcomes, such as infant mortality, prematurity and low birth weight, have also been significantly reduced [18]. In Mexico, for example, infant mortality was an estimated 178 per 1,000 live births in 1930; it since declined to 21 per 1,000 live births in 2002 [16]. Given shifts in home to hospital-based delivery and corresponding improvements in obstetric care during this period, the independent influence of prenatal care on adverse maternal and neonatal outcomes has not been well established. Still, review of studies exploring the association can be useful in informing the methods used to evaluate prenatal care adequacy.

A 2001 review by Carroli, et al. aimed to identify effective pregnancy interventions focused on reducing maternal mortality and major morbidities [1]. Potential interventions were explored for the prevention of maternal mortality and morbidity from hemorrhage, anemia, hypertensive disorders of pregnancy, obstructed labor, and infections, including urinary tract, sepsis, and sexually transmitted disease. On the whole, several prevention pathways were addressed with optimism regarding the efficacy of prenatal investments in maternal health. However, the authors also caution that the benefits of prenatal care are contingent on the efficacy of its intervention components. For example, minimal evidence supports the effectiveness of interventions to reduce hypertensive disorders, such through the use of calcium supplementation; the benefits, they say, are only significant among high-risk women. Thus, rather than via a primary prevention pathway, prenatal care may be most beneficial in the screening and detection of high risk women for referral to early treatment.

In 2003, a population-based study of nearly 18,000 women in the United Kingdom identified variation according to both parity and risk status in the outcomes associated with number of prenatal care visits [19]. Among multipara, statistically significant reductions of odds were observed for low birth weight (only among low risk women) and delivery by cesarean (only among high risk women). The same outcomes were significant among primiparous women, though increasing prenatal care visits had a greater magnitude of effect on improved birth weight, particularly in high risk women.

No association was found between amount of prenatal care received and either neonatal intensive care admissions or perinatal mortality.

Subsequent studies have reported similar perinatal outcomes among women receiving high and low levels of prenatal care. For example, a 2010 study by Schillaci, et al. found that "despite reduced utilization [of prenatal care services], mothers from low-income areas of New Mexico are either receiving an adequate level of prenatal care, or…differences in prenatal care have exerted little direct impact on birth outcomes" [20]. These findings echo those of Alexander and Kotelchuck nearly 10 years earlier, who note that "nearly all of the decline in infant mortality rates in the US during the last several decades has been attributed to decreases in birthweight-specific mortality and not to improvements in the birthweight distribution," suggesting greater gains from obstetric or neonatal advances and a lesser impact of preventive services, such as prenatal care [21].

However, aside from peer-reviewed studies and systematic reviews, governmental entities, including the World Health Organization, Pan-American Health Organization, and the U.S. Department of Health and Human Services have undertaken extensive reviews of evidence in support of prenatal care and conclude that potential benefits of early care are sufficient to promote widespread use [6, 22, 23]. In 1993, the Secretary of Health of Mexico formalized the country's support for early prenatal care in Mexican Official Norm NOM-007-SSA2-1993, "Attention of the pregnant woman during pregnancy, labour and puerperal stage," which prescribes care begin no later than 12 weeks gestation [24].

Given this public affirmation, and despite the heterogeneity of effects observed in studies of the association between prenatal care and pregnancy outcomes, the present study assumes that a range of benefits may be derived from prenatal care when delivered according to appropriate standards of clinical practice. Thus, it is also important to consider the range of guidance directed to practitioners in the delivery of prenatal care.

Standard clinical guidelines for prenatal care

A range of prenatal care schedules have evolved since the advent of pregnancy care in the early to mid-20th century, and a vast amount of literature exists regarding recommended prenatal screening and intervention [25]. Medical provider groups and professional organizations within several countries have established standards of care, as have governments and private insurance providers. Select guidelines are described below, beginning with the most recent:

- **Institute for Clinical Systems Improvement** (ICSI, 2010)

  Established in Minnesota in 1993, ICSI is the largest regional healthcare improvement collaborative in the United States and represents more than 55 medical groups and all major health plans in the state. The 14th edition of the institute's routine prenatal care guideline is widely accepted as "an analytic framework for the evaluation and treatment of patients" during pregnancy. The ICSI guidelines outline prenatal care content according to an 11-visit schedule that should begin by 6-8 weeks gestation, with follow-up visits at 10-12, 16-18, 22, 28, 32, and 36 weeks, and weekly from 38 to 41 weeks. Content includes recommended screening tests, patient education and counseling interventions, and necessary immunization and prophylaxis.

- **Royal College of Obstetricians & Gynaecologists** (RCOG, United Kingdom, 2008)

  The 2008 RCOG guidelines update recommendations first developed in 2003 by a multi-professional and lay working group of obstetricians, midwives, neonatologists, health economists, consumers and other stakeholders. The RCOG standards base the recommended visit schedule on parity, requiring 10 visits for nulliparous women and a reduced schedule of seven visits for women with at least one previous live birth. An overview of the suggested spacing and content of these visits is available in a document produced by the National Collaborating Centre for Women's and Children's Health [26]. Over 150 stakeholder organizations in the United Kingdom recognize these standards.

- **American College of Obstetricians & Gynecologists** (ACOG, 2007)

  For uncomplicated pregnancies, ACOG guidelines recommend visits every four weeks during the first 28 weeks, every two to three weeks from week 28 to 36, and weekly thereafter. The full recommended schedule typically includes 13-14 visits, depending on gestation at birth. For a 40 week pregnancy beginning in the first trimester, a woman would require no less than 11 visits according to this schedule.

- **Public Health Service Expert Panel on Prenatal Care** (1989)

  This report, published by an expert panel convened in the United States more than two decades ago, emphasizes the inclusion of three primary components in any prenatal care schedule, including early and routine screening and risk assessment; health promotion; and follow-up for necessary interventions, both medical and psychosocial [27]. A recommended schedule of visits is delineated for low-risk women, beginning in the preconception period. First visit is recommended to occur by gestational week 6-8. The second visit should occur within four weeks, or by the 10^{th} gestational week. For nulliparous women, subsequent visits occur at 14-16, 24-28, 32, 36, 38, 40 and 41 weeks, for a total of nine visits. Parous women require a reduced 7-visit schedule.

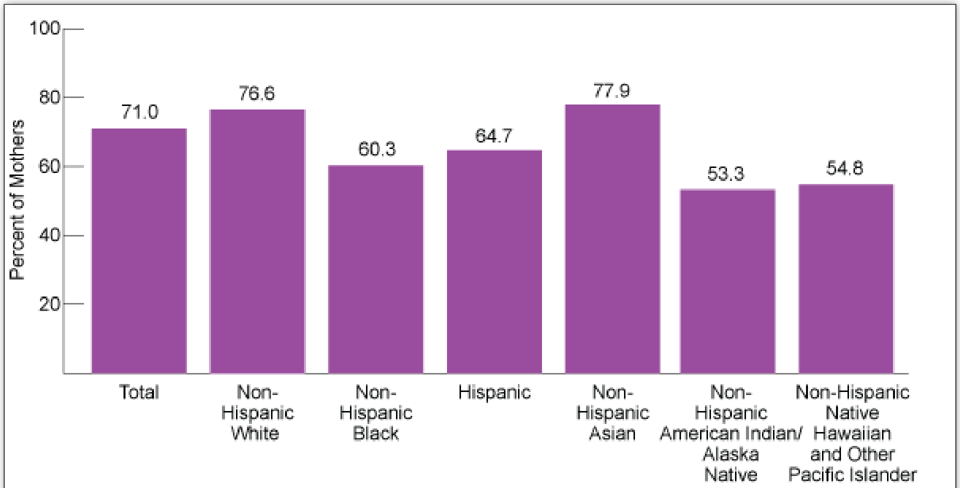
In addition to the above, alternative schedules have been proposed, such as reduced visit programs for low-risk women that include more structured and focused content, but less frequent appointments than traditional schedules (typically, 6 to 8 visits). Support for a reduced-visit schedule rests on evidence from several recent studies. One study by Villar, et al., republished in 2009, was among the earliest Cochrane systematic reviews to examine the efficacy of reduced antenatal visits. Based on 10 trials involving over 60,000 births, investigators found that a reduced-visit antenatal care package could be implemented without increasing risks for adverse maternal and perinatal outcomes [28]. In higher resource countries, it also identified lower satisfaction levels among women receiving reduced visits.

Dowswell, et al (2010) report similar findings in a subsequent Cochrane systematic review, but emphasize the relatively greater impact of reduced visits in low- or middle-income countries, where the standard number of visits is already low. Based on three trials in low-resource settings, though maternal health outcomes were similar, perinatal mortality was significantly higher when visits were reduced to four (RR 1.15, 95% CI 1.01-1.32).

General and population-specific barriers to adequate PNC

Indeed, Latina women in the border region experience a unique set of demographic features and social conditions that may contribute to barriers or facilitators of prenatal care. Several studies have assessed these potential barriers to adequate prenatal care both for the general population, as well as those specific to border populations [29-32]. As indicate in the figure, below, Hispanic women in the United States receive lower levels of care than non-Hispanic Whites, with just 64.7 percent of Latina women reporting a prenatal care visit in the first trimester in 2008 [2].

Figure 1: Receipt of First Trimester Prenatal Care*, by Maternal Race/Ethnicity, 2008



In the 27 reporting areas (States and territories) that used the revised birth certificate.

Source: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics, National Vital Statistics System. Unpublished data. Analyzed by Maternal and Child Health Bureau and National Center for Health Statistics.

Additionally, cross-border mobility within the border region may have important implications for service utilization. Based on survey data collected in 2008, roughly one-third (33.1%) of Hispanic border residents in Texas reported ever crossing the border into Mexico to receive care from a physician (Su & Wang, 2011). The same study found that utilization of cross-border physician services was highest among first generation residents of the United States, at 44.7%, as compared to only 18.4% among residents third generation or higher. When adjusting for the effects of a host of demographic, socio-cultural and economic variables, third generation residents or higher displayed significantly reduced odds of cross-border utilization of physician services as compared to their first generation counterparts (AOR 0.35, 0.23 – 0.55).

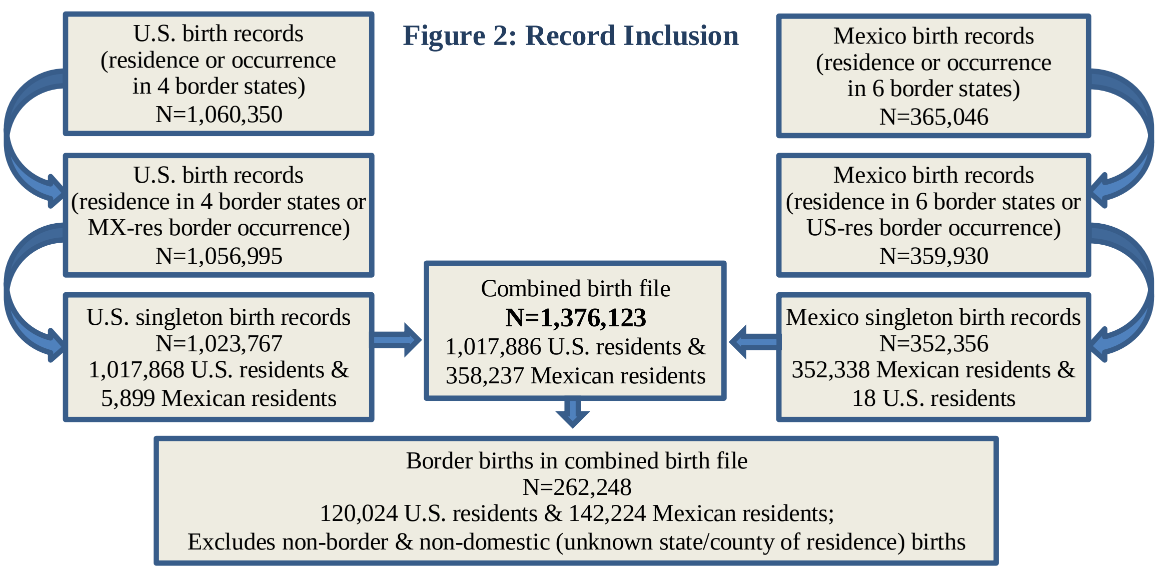
Chapter 3: Data & Methods

Population of Interest

The present study represents a secondary data analysis of births occurring along the United States-Mexico border. Natality data used in this analysis were restricted to singleton births occurring between January 1 and December 31, 2009 to residents of the states of Arizona, California, New Mexico and Texas in the United States, and the states of Baja California, Chihuahua, Coahuila, Nuevo Leon, Sonora and Tamaulipas in Mexico. Prior to obtaining birth data, a study protocol was submitted to the Emory Institutional Review Board (IRB) for determination of exempt status. Emory IRB determined no review required on the basis that the study proposed secondary data analysis of de-identified data sets.

A total of 1,376,123 birth records were analyzed as part of this study, including 358,237 Mexican resident births and 1,017,886 U.S. resident births. The figure below indicates record inclusion and exclusion criteria resulting in the final study population.

Figure 2: Record Inclusion



Vital records systems in both the United States and Mexico exclude resident births occurring in foreign countries [33]. However, merging of the data sets allowed inclusion of records for births occurring across the border from the mother's place of residence. As a result, Mexican resident births occurring in U.S. border counties (n=5,899) and U.S. resident births occurring in Mexican border counties (n=18) were included for descriptive analysis based on county of occurrence. No further assumptions were made for this population regarding county or state of residence, as this information is not recorded for foreign residents. Rather, outcomes for Mexican resident births in the U.S. were analyzed and reported either in aggregate or by county of *occurrence* for comparative purposes only.

Births to residents of counties within 100 kilometers (62 miles) of the border comprised the primary population of interest in this study. This geographic area, herein "border region," consists of 44 counties in the United States and 80 municipalities in Mexico. Refer to Appendix A for a list of these localities. A total of 142,224 births to Mexican border residents and 120,024 births to U.S. border residents were included in this analysis. Women living in one of the 10 border states but outside of the designated border region (n=1,107,319) were included only for descriptive comparison of outcomes between border and non-border counties. Additional analysis also excluded births to Mexican women for whom county of residence was unknown (n=639) and births occurring outside the mother's country of residence. The latter was due in part to avoid assumptions regarding border residence, as well as due to the potentially unique care-seeking patterns of this population. Inferences made based on this data may be extrapolated only to births occurring among residents of the border region.

Sources of Data

Datasets were obtained from the national vital record systems of Mexico and the United States, comprising all births occurring in these countries in 2009. The Mexican birth file was made publicly available through the Sistema Nacional de Informacion en Salud (SINAIS), or National Health Information System of the Ministry of Health [34]. All birth records were maintained in a Microsoft Access database file as part of the Subsistema de Informacion sobre Nacimientos (SINAC), or Subsystem of Information about Births. The database was downloaded and stored on a secure server until time of analysis.

Birth files available publicly in the United States restrict access to certain geographic identifiers. Given the need to distinguish border from non-border resident births and to perform spatial analysis of county-level outcomes, a request for U.S. natality files containing county-level identifiers was submitted to the National Association of Public Health Statistics & Information Systems (NAPHSIS), the national organization representing state vital records offices. NAPHSIS approval is required for all research use of restricted vital records data maintained by the National Center for Health Statistics (NCHS). Upon approval and execution of the required data use agreement, compressed electronic birth files were received from NCHS on a secure, password-protected disk. Once extracted, these data were also stored on a secure server until time of analysis. To ensure that records in the birth file were not personally identifiable, data were subject to established suppression standards, which require that no figure of less than 10 annual birth events be included in tabulations for sub-national geographic areas (NCHS).

Measurements

Considerable cleaning and recoding of variables were necessary prior to merging of the two national datasets. In the United States, California, New Mexico and Texas had adopted the 2003 revised version of the standard certificate of live birth, while Arizona records still utilized the 1989 standard form. Thus, an initial challenge was determining variables consistent across three data collection formats—the current Mexican certificate and two versions of the U.S. certificate. The Mexican natality file layout also required translation into English prior to use, and cultural-based variations in content were considered in defining recoded variables.

Three categories of measures were considered from among available natality data, including: 1) indicators of prenatal care utilization, the outcome of interest in this study; 2) spatial features corresponding to maternal place of residence, from which state would serve as the primary explanatory variable of interest; and 3) additional covariates, available in both datasets and either known in the literature or assumed to be associated with access to prenatal care.

Two measures of prenatal care utilization were initially derived from the birth files. First, women who initiated prenatal care at any point during their pregnancy were assessed for timing of entry, including the proportion entering care in each trimester. Timing of initiation was determined according to the reported date, month or trimester of the first prenatal visit. In the Mexican birth file, data were collected on trimester of first visit for those women receiving any prenatal care. In the United States, data collection methods varied based on state of occurrence and version of the standard birth certificate in use. All U.S. natality files included a variable deriving the month prenatal care began. To create a comparable measure across countries, month of prenatal care initiation was collapsed into four categories: months one to three (first trimester), months four to six (second trimester), months seven or later (third trimester), and no care.

The second prenatal care measure addressed quantity of care, or the number of visits received during the current pregnancy. This measure was coded with similar discrete values across birth files. However, Mexican records restricted reporting to 30 visits, while U.S. records allowed a maximum of 49 visits to be reported. In order to prevent artificially reducing the variance in visits among U.S. births, numbers of visits were not modified in the recoded variable. During analysis, however, calculation of mean visits was limited to records with 30 or fewer for consistency across the data sets. In general, standalone measures of the quantity of care received did not take into account variation in length of pregnancy. For measures that did, gestational age was calculated based on the interval between self-reported first day of last menstrual period (LMP) and the date of birth. In the U.S., clinician estimate was also used when LMP was missing or when gestation estimates based on LMP appeared inconsistent with birthweight.

Three new variables were generated to dichotomize number of visits according to recognized care standards. These variables were used to determine the proportion of women receiving: 1) fewer than four visits, as deemed minimal for low-risk women by the World Health Organization (WHO); 2) fewer than 10 visits for primiparous women and seven visits for multiparous women, according to standards set by the UK Royal College of Obstetricians and Gynaecologists (RCOG) for uncomplicated pregnancies; and 3) fewer than 11 visits, consistent with recommendations for low risk women by the American College of Obstetricians and Gynecologists (ACOG). Similar rates were not assessed according to early recommendations of the Public Health Service Expert Panel on Prenatal Care (PHS/EPPC, 1989), which prescribe nine visits for women with no previous children and a minimum of seven visits for those with higher parity [35].

While timing and quantity of care were of interest independently, the primary outcome measure used to characterize adequacy of prenatal care was a binary index variable derived from both. The new variable, ***low or late prenatal care***, was based on the revised GINDEX (R-GINDEX) first proposed in the mid-nineties and used in numerous studies since to assess the impact of prenatal care on birth outcomes [35-38]. The R-GINDEX represents an improvement over the modified IOM, or Kessner index, though it similarly places births into categories according to timing of first visit and total number of visits adjusted for gestational age at birth. The index is based on the full recommended number of visits consistent with ACOG standards for low risk pregnancies. Importantly, virtually all other available indices base their algorithm on month of prenatal care initiation; the R-GINDEX index was uniquely able to accommodate timing of entry based on trimester of first visit. Its six categories of utilization represent a further expansion of previous measures by capturing intensive levels of care, as well as no care.

In the interest of testing for significant variation in levels of *late* prenatal care, the R-GINDEX was minimally adapted to distinguish intensive care beginning in the first or second trimester from intensive care utilized thereafter. This decision was consistent with the Adequacy of Prenatal Care Utilization (APNCU) index, which classifies as inadequate all births initiating care in the third trimester. Table 1, below, describes the range of R-GINDEX values, by category, for four illustrative cases. As this table indicates, the derived outcome variable, *low-late care*, combined the categories of first and second trimester inadequate care, third trimester inadequate or intensive care, and no care to create the positive binary condition. Remaining women were considered to have received medium to high levels of prenatal care for purposes of analysis.

Table 1: R-GINDEX criteria for 28-, 36-, 40- and 45-week gestational ages at birth.

		28-wk delivery		**36-wk delivery**		**40-wk delivery**		**45-wk delivery**	
		Trimester	Visits	Trimester	Visits	Trimester	Visits	Trimester	Visits
Med-High (0)	Intensive	1	≥14	1	≥16	1	≥17	1	≥19
		2	≥12	2	≥14	2	≥15	2	≥17
	Adequate	1	5-13	1	9-15	1	13-16	1	16-
	Intermediate	1	2-4	1	5-8	1	8-12	1	9-15
		2	2-11	2	6-13	2	8-14	2	9-16
Low-Late (1)	Inadequate	1	1	1	1-4	1	1-7	1	1-8
		2	1	2	1-5	2	1-7	2	1-8
		3	1-9	3	1-11	3	1-12	3	1-14
	Intensive*	3	≥10	3	≥12	3	≥13	3	≥15
	No Care	-	0	-	0	-	0	-	0

Explanatory variables of greatest interest were spatial. Rates of prenatal care utilization were examined descriptively at all geographic levels by place of maternal residence. Of primary interest was variation across states in the region, given potential policy implications at this level. However, examination of local data enabled cross-border comparisons among sister-counties and municipalities in the region. To create a unique identifier for all U.S. counties and Mexican municipalities within the 10 border states, the county- and state-level FIPS codes assigned to each local unit were concatenated to a single code. This allowed counties and municipalities to be grouped according to location within or external to the border region for purposes of comparison. To examine cross-border resident births by occurrence, the concatenation of local and state FIPS was repeated for each record based on county or municipality of delivery.

In addition to the primary outcome and explanatory variables, the following covariates were derived from data available in both national birth files:

- **Maternal age** was included to adjust for variation in age distribution across states. For Mexican records, maternal age was derived from the difference between the date of the child's birth (occurrence) and the birth date of the mother. Women were classified as age 18 or younger; age 19 to 24; age 25 to 34; and age 35 and older. Implausible values (below age 10 and over age 59) were set to missing (n=11), and women ages 25 to 34 served as the comparison group in regression analysis.
- **Maternal country of birth** (origin) was used to control for differential patterns of migration and first generationality by state of residence. Women were classified as born in: the United States; Mexico; another foreign country of Latin origin; or a foreign, non-Latin country. U.S.-born women served as the referent group.
- **Residence** in the county or municipality in which the birth occurred served as a proxy measure of physical access to health services. Women were classified as non-residents if the county of occurrence differed from their reported county or municipality of current residence.
- **Marital status** of the mother was included to adjust for variation by state in the proportion of deliveries to married versus unmarried women.
- **Maternal education** was included to control for variation in levels of educational attainment by state. In order to accommodate information gathered on each set of certificates, levels of education were classified as follows: less than high school completion (through completion of 11^{th} grade in the United States and incomplete secondary education in Mexico); high school diploma or equivalent (12 completed years in the United States and secondary completion in Mexico); some college or preparatory education (incomplete Bachelors or preparatory education in Mexico and either Associate degree equivalent or 13 to 15 years completed education in the

United States); Bachelor's degree or equivalent completion (degree completion in Mexico and either 16 completed years of education or degree completion in the United States); and professional or higher education (any formal degree training beyond Bachelors in either country or at least 17 completed years in the U.S.).

- **Live birth order** describes the total live birth history of the mother, including the current birth. Fetal deaths and stillbirths are excluded. This variable was included to adjust for the effects of parity on care seeking and maternal risk (e.g., among primiparous versus multiparous mothers).

While ethnicity was excluded during combined analysis, it was retained for all births occurring in the United States to support a more complete demographic sub-analysis. Mothers giving birth in the U.S. were classified as Hispanic if they reported Mexican, Cuban, Puerto Rican, Central or South American, or other/unknown Hispanic heritage.

Additional variables of interest not comparable across vital records datasets due to inconsistent or under-reporting included: presence of the father's name on the birth certificate; maternal race; pre-pregnancy risk factors, such as diabetes, hypertension, or previous poor birth outcomes; and eligibility or enrollment in public assistance programs, payor at time of birth, or other proxy measures of socio-economic status. Technical documents prepared by SINAIS and NCHS assisted in the identification of common variables, as well as highlighted potential limitations for analysis, described in further detail in Chapter 5 (Discussion and Public Health Implications). See also Appendix B for a tabular summary of the variables utilized across birth files.

Analysis

All combined analysis of U.S. and Mexican natality files were completed using the SAS 9.3 statistical package (Cary, NC). Limited cleaning of Mexican birth data initially occurred in Microsoft Access 2010. Once exported from this environment to a SAS dataset, records underwent further cleaning prior to merge with U.S. data. Birth files from the United States were imported directly to SAS for cleaning, merge and analysis. Missing data were considered missing at random (MAR) and were addressed using list-wise deletion; that is, only records with complete data for variables of interest were analyzed.

In all calculations, consideration was given to the appropriateness of computing measures of variability. Natality data for the border region effectively represent a complete count of births and should not be subject to sampling error [38]. As such, confidence intervals and standard errors are not reported for point estimates in Tables 1-7. However, it should be noted that according to NCHS, "the number of events that *actually* occurred can be thought of as one outcome in a large series of possible results that *could have* occurred under the same (or similar) circumstances." In this way, "the number of births is subject to random variation and a probable range of values estimated from the actual figures" [33]. Consistent with this guidance, statistical tests, including chi-square tests for proportions and two sample t-tests for means, were performed to determine whether differences across states and other geographic comparisons were significant at the $\alpha=0.05$ level for both prenatal care outcome measures and predictor covariates.

Frequency tables were prepared to describe the distribution of prenatal care measures across geographies of interest, including cross-border, inter-state, border-non-border (regional and intrastate), and sister-county comparisons. The distributions of independent covariates were also calculated for the border region by state, as well as among Mexican residents delivering in the United States. Bivariate analysis was then conducted to determine crude measures of association between demographic predictor variables and low-late prenatal care utilization. To evaluate the adjusted effect of maternal state of residence on proportion of women receiving low or late prenatal care, multivariable regression models were then constructed. Dummy variables were created for all categorical indicators prior to inclusion in each model.

Given that the outcome of interest was found to be common among border populations (incidence of 10% or more), it was determined inappropriate to approximate relative risk based on odds ratios. Relative risks were estimated first using log-binomial regression models with a modified link function between independent covariates and the outcome [39]. When the adjusted log-binomial model failed to converge, risk ratios were instead estimated using a modified Poisson regression model with a robust error variance [39-41]. In order to utilize a modified Poisson approach, a subject identifier variable was created for each record. Robust error variances were calculated using the subject identifier and the repeated statement with an unstructured correlation matrix.

Binary logit models were also run to assess concordance indices for both crude and adjusted associations. Multicollinearity was assessed to eliminate potential variance inflation in the adjusted model, and immigration status was removed due to a high level of correlation with maternal nativity and state of residence. Maternal country of residence was not included in the adjusted model with state of residence due to its impact on design balance. With the exception of these variables, all demographic covariates were included in an adjusted model to control for potential confounding of the relationship between state of residence and prenatal care utilization. Crude and adjusted estimates for all measures of effect were calculated with 95% confidence intervals.

Mapping

All mapping was completed in ArcGIS 10 (Esri, 2012). Shapefiles were obtained for border states, counties, and national boundaries from the United States Geological Survey's *Border Environmental Health Initiative* [42]. Layer files for major bi-national roads, cities, and hospitals were also made available through this service. To facilitate country-specific and border mapping, additional shapefiles were created for each country, as well as for the 44 U.S. counties and 80 Mexican municipalities comprising the designated border region.

For mapping of low-late prenatal care utilization and other adequacy measures, a stand-alone attribute table was created in Microsoft Excel using SAS data tabulated by county of maternal residence. These data included total number of births in 2009, border designation, and the number and percent of records per county receiving low, late or no care based on multiple prenatal care utilization measures. Once imported into ArcGIS, the Excel file was converted to dBASE (.dbf) format for use in mapping. In turn, this file was joined with the spatial attribute table for border state counties. Graduated color ramps were applied to prenatal care outcomes of interest, which were classified by quintile for mapping. Counties with fewer than 10 births were excluded in accordance with recognized suppression standards.

Chapter 4: Results

Characteristics of the Population

Data from 1,376,123 singleton live births were analyzed in the present study. Of included records, 1,017,886 (74.0%) were births to residents of the United States. Though fewer Mexican resident births were included in the 10-state birth file (26.0%), a larger proportion of Mexican births occurred in counties along the border (54.2%). Births occurring to residents of the 144 border counties in the region comprised just under one-fifth of the complete dataset (262,248, or 19.1%).

Table 2, below, describes overall demographic characteristics of the included population of births. Hispanic mothers comprised over two-thirds (70.7%) of border resident births in the United States, and nearly one-third (30.2%) of U.S. border residents were born in Mexico. In contrast, only 0.4% of Mexican resident births were to foreign-born women. Ethnicity data is unavailable in Mexican vital records. Moreover, the proportion of births to mothers with less than high school education exceeded 25% in both countries and was further elevated along the border, approaching one-third (32.4%) of women in the Mexican border region.

Unmarried women comprised roughly 60% of Mexican live births in border counties—a rate that is nearly twenty percentage points higher than among their U.S. counterparts (41.6%). Age-related disparities were also noticeable; the proportion of Mexican border residents under the age of 18 (16.4%) was nearly twice the rate reported for births along the U.S. side of the border (8.6%). Conversely, a larger proportion of U.S. mothers gave birth at age 35 years and older (12.9%). As a result, the mean age of mothers residing in U.S. border counties was 26.8 years (±6.3), compared with 24.8 years (±6.2) among Mexican women. What's more, while Mexican women were younger and less likely to be married, a slightly larger proportion experienced a second or higher order birth (62.9%) compared with U.S. women (60.7%) in 2009.

Table 2: Descriptive overview of singleton births to residents of U.S. and Mexico border states and counties, 2009

	Border States		Border Counties	
Demographics	**MX States (n= 358,237)**	**US States (n= 1,017,886)**	**MX Border Co (n=142,224)**	**US Border Co (n=120,024)**
Birth outside Residence Co.				
Non-resident	98,559 (27.6%)	156,745 (15.4%)	10,023 (7.0%)	7,330 (6.1%)
Maternal Nativity				
Mexico	355,527 (99.7%)	224,588 (22.2%)	141,096 (99.6%)	35,897 (30.2%)
United States	561 (0.2%)	652,395 (64.5%)	286 (0.2%)	75,291 (63.3%)
Other Latin	245 (0.1%)	29,090 (2.9%)	157 (0.1%)	618 (0.5%)
Other Foreign	309 (0.1%)	104,836 (10.4%)	150 (0.1%)	7,173 (6.0%)
History of Immigration				
Immigrant	1,115 (0.3%)	358,514 (35.5%)	593 (0.4%)	43,688 (36.7%)
Maternal Ethnicity				
Hispanic	n/a	514,932 (51.1%)	n/a	82,447 (70.7%)
Maternal Age				
<=18 years	54,332 (15.3%)	71,828 (7.1%)	23,138 (16.4%)	10,297 (8.6%)
19-24 years	124,430 (34.9%)	292,487 (28.7%)	52,784 (37.4%)	37,454 (31.2%)
25-34 years	146,258 (41.1%)	505,216 (49.6%)	53,997 (38.2%)	56,782 (47.3%)
>=35 years	31,168 (8.8%)	148,355 (14.6%)	11,383 (8.1%)	15,491 (12.9%)
Mean Age (SD)	25.2 (6.3)	27.4 (6.3)	24.8 (6.2)	26.8 (6.3)
Maternal Education				
< High School	92,925 (26.4%)	259,440 (26.0%)	45,163 (32.4%)	32,714 (28.4%)
High School/=	118,198 (33.6%)	276,853 (27.7%)	46,848 (33.6%)	31,760 (27.6%)
Some College/Prep	28,781 (8.2%)	242,599 (24.3%)	12,264 (8.8%)	28,983 (25.2%)
Bachelor's Degree/=	62,294 (17.7%)	147,298 (14.8%)	21,883 (15.7%)	14,433 (12.6%)
Professional	49,140 (14.0%)	72,270 (7.2%)	13,326 (9.6%)	7,111 (6.2%)
Marital Status				
Unmarried	175,076 (49.7%)	431,846 (42.4%)	84,153 (60.2%)	49,960 (41.6%)
Parity				
1	138,569 (38.7%)	401,845 (39.5%)	52,660 (37.1%)	47,093 (39.3%)
2	111,082 (31.1%)	311,765 (30.7%)	43,584 (30.7%)	36,004 (30.0%)
3	70,487 (19.7%)	176,083 (17.3%)	28,290 (19.9%)	21,216 (17.7%)
4+	37,569 (10.5%)	126,709 (12.5%)	17,416 (12.3%)	15,620 (13.0%)
Gestation				
<37 weeks	21,380 (6.0%)	101,922 (10.0%)	7,950 (5.6%)	12,850 (10.7%)
37-38 weeks	97,545 (27.4%)	296,530 (29.2%)	33,535 (23.8%)	37,860 (31.6%)
39+ weeks	236,650 (66.6%)	618,540 (60.8%)	99,658 (70.6%)	69,269 (57.7%)

Tables 3.1 and 3.2 present the distribution of demographic characteristics for border residents, by state. Of note, the largest proportions of women delivering outside of their county of residence were found in Nuevo Leon (60.8%), New Mexico (26.9%), Coahuila (23.9%), and Sonora (14.2%). The mean age of mothers along the border ranged from 24.3 (±6.2) in Coahuila to 28.2 (±6.2) in California.

Table 3.1: Singleton births to residents of U.S. and Mexico border counties, by state, 2009

Demographics	California (n=46,481)	Baja California (n=56,669)	Arizona (n=18,208)	Sonora (n=13,220)	New Mexico (n=5,080)	Chihuahua (n=26,040)
Birth Outside Residence Co.						
Non-resident	677 (1.5%)	1,558 (2.7%)	825 (4.5%)	1,876 (14.2%)	1,367 (26.9%)	898 (3.4%)
Maternal Nativity						
Mexico	11,515 (24.8%)	56,052 (99.4%)	3,865 (22.5%)	13,135 (99.7%)	1,102 (21.7%)	25,885 (99.8%)
United States	28,334 (61.0%)	176 (0.3%)	13,302 (77.3%)	33 (0.3%)	3,813 (75.2%)	29 (0.1%)
Other Latin	370 (0.8%)	60 (0.1%)	43 (0.0%)	13 (0.2%)	158 (3.1%)	19 (0.1%)
Other Foreign	6,241 (13.4%)	117 (0.2%)				13 (0.1%)
History of Immigration						
Immigrant	18,126 (39.0%)	353 (0.6%)	3,908 (22.7%)	46 (0.3%)	1,260 (24.8%)	61 (0.2%)
Maternal Age						
<=18 years	2,378 (5.1%)	8,803 (15.6%)	1,466 (8.1%)	2,269 (17.2%)	576 (11.3%)	4,809 (18.6%)
19-24 years	12,011 (25.8%)	21,273 (37.7%)	6,004 (33.0%)	4,910 (37.2%)	2,023 (39.8%)	9,733 (37.6%)
25-34 years	24,118 (51.9%)	21,747 (38.6%)	8,741 (48.0%)	5,011 (38.0%)	2,093 (41.2%)	9,228 (35.6%)
>=35 years	7,974 (17.2%)	4,587 (8.1%)	1,997 (11.0%)	993 (7.5%)	388 (7.6%)	2,136 (8.2%)
Mean Age (SD)	28.2 (6.2)	24.8 (6.2)	26.5 (6.0)	24.6 (6.2)	25.1 (5.9)	24.5 (6.3)
Maternal Edu						
<High School	7,965 (19.1%)	18,401 (32.9%)	4,055 (22.5%)	3,447 (27.6%)	1,525 (30.1%)	9,624 (37.5%)
High School/=	10,936 (26.2%)	17,990 (32.2%)	5,946 (33.0%)	4,376 (35.0%)	1,504 (29.7%)	8,472 (33.0%)
Some College/=	10,887 (26.1%)	5,467 (9.8%)	4,238 (23.5%)	1,426 (11.4%)	1,348 (26.6%)	2,117 (8.2%)
B.A./=	7,727 (18.5%)	8,735 (15.6%)	2,097 (11.6%)	1,966 (15.7%)	496 (9.8%)	3,596 (14.0%)
Professional	4,155 (10.0%)	5,309 (9.5%)	1,693 (9.4%)	1,272 (10.2%)	193 (3.8%)	1,863 (7.3%)
Marital Status						
Unmarried	15,884 (34.2%)	35,484 (63.2%)	8,295 (45.6%)	7,556 (60.4%)	2,689 (52.9%)	17,053 (66.5%)
Parity						
1	19,956 (42.9%)	21,721 (38.4%)	7,248 (39.8%)	4,716 (35.7%)	1,887 (37.5%)	9,031 (34.7%)
2	14,759 (31.8%)	17,861 (31.6%)	5,441 (29.9%)	3,940 (29.8%)	1,527 (30.4%)	7,543 (29.0%)
3	7,261 (15.6%)	10,860 (19.2%)	3,111 (17.1%)	2,778 (21.0%)	925 (18.4%)	5,338 (20.5%)
4+	4,499 (9.7%)	6,098 (10.8%)	2,404 (13.2%)	1,783 (13.5%)	687 (13.7%)	4,097 (15.8%)
Gestation						
<37 weeks	3,795 (8.2%)	3,398 (6.0%)	1,779 (9.8%)	767 (5.9%)	590 (11.6%)	1,320 (5.1%)
37-38 weeks	11,840 (25.5%)	14,112 (25.0%)	5,026 (27.6%)	2,714 (20.7%)	1,366 (26.9%)	5,226 (20.4%)
39+ weeks	30,837 (66.4%)	38,932 (69.0%)	11,400 (62.6%)	9,622 (73.4%)	3,122 (61.5%)	19,137 (74.5%)

Table 3.2: Singleton births to residents of U.S. and Mexico border counties, by state, 2009

Demographics	Texas (n=50,255)	Coahuila (n=8,877)	Nuevo Leon (n=1,658)	Tamaulipas (n=35,760)	Mexican Res, U.S. Birth (n=5,899)
Birth Outside Res Co.					
Non-resident	4,461 (8.9%)	2,119 (23.9%)	1,008 (60.8%)	2,564 (7.2%)	5,899 (100.0%)
Maternal Nativity					
Mexico	19,415 (38.6%)	8,850 (99.8%)	1,649 (99.8%)	35,525 (99.7%)	5,758 (97.6%)
United States	29,842 (59.4%)	*	*	37 (0.1%)	107 (1.8%)
Other Latin	241 (0.5%)	*	*	63 (0.2%)	32 (0.5%)
Other Foreign	738 (1.5%)	*	*	12 (0.0%)	
History of Immigration					
Immigrant	20,394 (40.6%)	18 (0.2%)	*	112 (0.3%)	139 (2.4%)
Maternal Age					
<=18 years	5,877 (11.7%)	1,700 (19.2%)	321 (19.4%)	5,236 (14.8%)	309 (5.2%)
19-24 years	17,416 (34.7%)	3,349 (37.7%)	601 (36.3%)	12,918 (36.6%)	1,364 (23.1%)
25-34 years	21,830 (43.4%)	3,183 (35.9%)	610 (36.9%)	14,218 (40.3%)	3,362 (57.0%)
>=35 years	5,132 (10.2%)	642 (7.2%)	122 (7.4%)	2,903 (8.2%)	864 (14.6%)
Mean Age (SD)	25.8 (6.2)	24.3 (6.2)	24.4 (6.2)	25.0 (6.1)	28.1 (5.9)
Maternal Education					
< High School	19,169 (38.2%)	2,771 (31.9%)	520 (31.8%)	10,400 (29.6%)	1,415 (24.1%)
High School/=	13,374 (26.6%)	3,448 (39.7%)	612 (37.4%)	11,950 (34.0%)	1,241 (21.1%)
Some College/Prep	12,510 (24.9%)	555 (6.4%)	135 (8.3%)	2,564 (7.3%)	1,288 (21.9%)
B.A. Degree/=	4,113 (8.2%)	1,136 (13.1%)	241 (14.7%)	6,209 (17.7%)	1,367 (23.3%)
Professional	1,070 (2.1%)	768 (8.9%)	127 (7.8%)	3,987 (11.4%)	560 (9.5%)
Marital Status					
Unmarried	23,092 (45.9%)	4,194 (47.8%)	659 (40.6%)	19,207 (54.6%)	1,710 (29.0%)
Parity					
1	18,002 (35.8%)	3,238 (36.5%)	612 (36.9%)	13,342 (37.4%)	2,445 (41.5%)
2	14,277 (28.4%)	2,664 (30.0%)	516 (31.1%)	11,060 (31.0%)	2,038 (34.6%)
3	9,919 (19.8%)	1,809 (20.4%)	349 (21.1%)	7,156 (20.1%)	1,001 (17.0%)
4+	8,030 (16.0%)	1,163 (13.1%)	180 (10.9%)	4,095 (11.5%)	412 (7.0%)
Gestation					
<37 weeks	6,686 (13.3%)	505 (5.7%)	78 (4.7%)	1,882 (5.3%)	336 (5.7%)
37-38 weeks	19,628 (39.1%)	1,704 (19.3%)	410 (24.8%)	9,369 (26.5%)	1,823 (30.9%)
39+ weeks	23,910 (47.6%)	6,635 (75.0%)	1,165 (70.5%)	24,167 (68.2%)	3,738 (63.4%)

The proportion of adolescent births (age 18 and under) was highest in Coahuila (19.2%) and Nuevo Leon (19.4%), while California documented the highest proportion of women aged 35 and older (17.2%). Roughly 70% of mothers in Chihuahua, Coahuila, and Nuevo Leon reported education levels at or below high school completion. Among U.S. states, Texans reflected the lowest levels of education, with nearly two out of five women (38.2%) lacking a high school diploma or equivalent. Just 10 percent of mothers in

Texas possessed a Bachelor's degree, professional training, or other terminal degree, compared with over one-quarter of mothers in Baja California (25.1%), Sonora (25.9%), California (28.5%), and Tamaulipas (29.1%). Also, births to residents of California and Texas revealed a large proportion of women with a history of cross-border migration; first generation immigrants comprised 39.0% and 40.6% of births to border residents in these states in 2009.

The states of New Mexico and Texas reveal the highest rates of preterm birth, or 11.6% and 13.3%, respectively. Curiously, two Mexican states display a paradoxical relationship between reduced rates of preterm birth and the distribution of factors known to affect health care access. In Nuevo Leon, where women experience the lowest percent of live births prior to 37 weeks (4.7%), the proportion of mothers under the age of 18 and the proportion of women traveling outside their county of residence for delivery services were among the highest in the region, as indicated above. Similarly, residents of the state of Chihuahua display a low rate of preterm birth (5.1%), but elevated rates of less than high school education (37.5%), births occurring outside of marriage (66.5%), and women with four or more previous live births (15.8%).

Finally, women who gave birth in a U.S. border county and reported Mexican residency (n=5,899) were more likely to be older (mean age 28.1 ±5.9), married (71.0%), experiencing their first birth (41.5%), and to have at least a Bachelor's level education (32.8%). They also experience low rates of preterm birth (5.7%) which are more similar to women delivering in Mexico than among those residing in the United States.

Overall Utilization of Prenatal Care in the Population

Tables 4 – 8, beginning on the next page, provide a descriptive overview of prenatal care utilization based on several recognized measures of adequacy. These measures are based on timing of first visit; numbers of visits, including the number of visits deemed appropriate based on risk factors such as parity; and a graduated, gestation-adjusted index (R-GINDEX), also dichotomized to a new variable, *low-late utilization*.

Table 4: Comparison of prenatal care adequacy measures by country of residence, 2009

	Border States		Border Counties	
	MX States (n= 358,237)	**US States (n= 1,017,886)**	**MX Border Co (n=142,224)**	**US Border Co (n=120,024)**
Timing of entry				
1st Trimester	260,590 (74.3%)	715,904 (72.3%)	96,428 (69.2%)	81,636 (68.4%)
2nd Trimester	62,537 (17.8%)	203,243 (20.5%)	28,672 (20.6%)	24,516 (20.6%)
3rd Trimester	16,014 (4.6%)	49,383 (5.0%)	7,159 (5.1%)	7,086 (5.9%)
No care	11,820 (3.4%)	22,281 (2.2%)	7,105 (5.1%)	6,026 (5.1%)
Number of Visits				
Mean visits (SD)	7.3 (3.3)	11.0 (3.9)	7.0 (3.4)	10.2 (4.2)
Fewer than 4 visits	36,003 (10.8%)	42,131 (4.2%)	17,624 (13.0%)	8,860 (7.4%)
Fewer than 11 visits	298,448 (89.6%)	430,873 (43.1%)	123,264 (91.3%)	59,446 (49.7%)
Low visits for parity	180,040 (54.1%)	172,287 (17.2%)	77,073 (57.1%)	27,538 (23.0%)
Adapted R-GINDEX				
Early Intensive	3,038 (0.9%)	53,781 (5.5%)	1,106 (0.8%)	5,185 (4.4%)
Adequate	29,960 (9.1%)	382,145 (39.0%)	9,643 (7.2%)	41,590 (35.0%)
Intermediate	157,872 (48.0%)	423,230 (43.2%)	60,700 (45.6%	51,938 (43.7%)
T1-T2 inadequate	111,458 (33.9%)	49,161 (5.0%)	47,751 (35.9%)	7,037 (5.9%)
T3 (late) intensive	144 (0.0%)	1,424 (0.1%)	52 (0.0%)	240 (0.2%)
T3 (late) inadequate	14,361 (4.4%)	46,939 (4.8%)	6,835 (5.1%)	6,796 (5.7%)
No care	11,822 (3.6%)	22,281 (2.3%)	7,105 (5.3%)	6,026 (5.1%)
Low or Late PNC	**137,785 (41.9%)**	**119,805 (12.2%)**	**61,743 (46.4%)**	**20,099 (16.9%)**

The overall rate by which women received no prenatal care was identical among U.S. and Mexican border residents (5.1%); a total of 7,105 Mexican and 6,026 U.S. border residents reported receiving no prenatal care in 2009. Still, significant variation is reflected in the local distribution of women who lack any prenatal care services. Disparities are evident both within and across the border, with levels of no care ranging from less than one percent in San Diego County, California to nearly 30 percent in Cameron County, Texas. Mexican residents delivering in the United States tended to have the highest reported levels of no prenatal care, with a rate approaching 10 percent, overall (range: 0.7% - 61.4%).

Table 5: Comparison of prenatal care measures by maternal residence in border versus non-border counties, 2009

	All Border States		Mexico Border States		U.S. Border States	
	US/MX Border Co (n=262,248)	US/MX Non-Bord Co (n=1,107,319)	Border Co (n=142,224)	Non-border Co (n=209,475)	Border Co (n=120,024)	Non-border Co (n=897,844)
Timing of entry						
1st Trimester	178,064 (68.8%)	795,231 (73.9%)	96,428 (69.2%)	160,977 (78.5%)	81,636 (68.4%)	634,254 (72.8%)
2nd Trimester	53,188 (20.6%)	211,064 (19.6%)	28,672 (20.6%)	32,338 (15.8%)	24,516 (20.6%)	178,726 (20.5%)
3rd Trimester	14,245 (5.5%)	49,976 (4.6%)	7,159 (5.1%)	7,680 (3.7%)	7,086 (5.9%)	42,296 (4.9%)
No care	13,131 (5.1%)	20,382 (1.9%)	7,105 (5.1%)	4,128 (2.0%)	6,026 (5.1%)	16,254 (1.9%)
Number of Visits						
Mean visits (SD)	8.5 (4.1)	10.5 (4.0)	7.0 (3.4)	7.5 (3.2)	10.2 (4.2)	11.1 (3.9)
< 4 visits	26,484 (10.4%)	50,529 (4.7%)	17,624 (13.0%)	17,259 (9.0%)	8,860 (7.4%)	33,270 (3.8%)
< 11 visits	182,710 (71.7%)	541,736 (50.5%)	123,264 (91.3%)	170,317 (88.8%)	59,446 (49.7%)	371,419 (42.2%)
Low visits/ parity	104,611 (41.1%)	244,536 (22.8%)	77,073 (57.1%)	99,791 (52.1%)	27,538 (23.0%)	144,745 (16.5%)
Adapted R-GINDEX						
Early Intensive	6,291 (2.5%)	50,345 (4.8%)	1,106 (0.8%)	1,749 (0.9%)	5,185 (4.4%)	48,596 (5.6%)
Adequate	51,233 (20.3%)	359,925 (34.3%)	9,643 (7.2%)	19,379 (10.3%)	41,590 (35.0%)	340,546 (39.6%)
Intermediate	112,638 (44.7%)	465,904 (44.4%)	60,700 (45.6%	94,617 (50.0%)	51,938 (43.7%)	371,287 (43.2%)
T1-T2 inadequate	54,788 (21.7%)	104,850 (10.0%)	47,751 (35.9%)	62,726 (33.2%)	7,037 (5.9%)	42,124 (4.9%)
T3 (late) intensive	292 (0.1%)	1,239 (0.1%)	52 (0.0%)	55 (0.0%)	240 (0.2%)	1,184 (0.1%)
T3 (late) inadeq	13,631 (5.4%)	46,549 (4.4%)	6,835 (5.1%)	6,407 (3.4%)	6,796 (5.7%)	40,142 (4.7%)
No care	13,131 (5.2%)	20,384 (1.9%)	7,105 (5.3%)	4,130 (2.2%)	6,026 (5.1%)	16,254 (1.9%)
Low or Late PNC	**81,842 (32.5%)**	**173,022 (16.5%)**	**61,743 (46.4%)**	**73,318 (38.8%)**	**20,099 (16.9%)**	**99,704 (11.6%)**

Timing of Prenatal Care Entry

Only small differences were observed between women in the United States and Mexico in their timing of entry into prenatal care, with a slightly higher proportion of Mexican women receiving a visit in the first trimester (69.2%, versus 68.4% among American women). Compared with non-border residents of either country, border residents experienced slightly higher levels of third trimester entry into prenatal care (5.5%, as compared to 4.6%). The disparity between border and non-border residents was larger in Mexico than in the United States, though nominally (Table 5).

Table 6.1: Number and proportion of births by timing of entry into prenatal care and an adapted prenatal care utilization index, U.S. Mexico border region, 2009

	California (n=46,481)	Baja California (n=56,669)	Arizona (n=18,208)	Sonora (n=13,220)	New Mexico (n=5,080)	Chihuahua (n=26,040)
Timing of entry						
1st Trimester	36,842 (79.4%)	41,110 (73.6%)	12,761 (70.1%)	8,781 (68.3%)	2,871 (59.3%)	15,324 (59.8%)
2nd Trimester	7,285 (15.7%)	8,410 (15.1%)	3,731 (20.5%)	2,929 (22.8%)	1,295 (26.7%)	7,668 (29.9%)
3rd Trimester	1,742 (3.8%)	2,514 (4.5%)	1,087 (6.0%)	603 (4.7%)	**426 (8.8%)**	1,823 (7.1%)
No care	512 (1.1%)	3,832 (6.9%)	621 (3.4%)	542 (4.2%)	**253 (5.2%)**	804 (3.1%)
Number of Visits						
Mean visits (SD)	11.4 (3.8)	7.0 (3.6)	10.3 (4.0)	7.0 (3.3)	9.6 (4.4)	6.7 (2.9)
< 4 visits	**1,119 (2.4%)**	**8,144 (14.9%)**	1,159 (6.4%)	1,639 (13.1%)	487 (10.0%)	2,874 (11.5%)
< 11 visits	19,339 (41.7%)	49,575 (90.7%)	8,844 (48.6%)	11,373 (91.0%)	2,793 (57.2%)	23,622 (94.7%)
Low visits/ parity	7,321 (15.8%)	30,719 (56.3%)	4,296 (23.6%)	7,139 (57.2%)	1,446 (29.9%)	15,591 (62.5%)
Adapted R-GINDEX						
Early Intensive	3,192 (6.9%)	521 (1.0%)	681 (3.8%)	101 (0.8%)	200 (4.2%)	135 (0.6%)
Adequate	17,896 (38.7%)	4,235 (7.8%)	6,355 (35.1%)	903 (7.3%)	1,317 (27.8%)	1,062 (4.3%)
Intermediate	20,906 (45.2%)	25,169 (46.4%)	7,997 (44.2%)	5,602 (45.6%	2,098 (44.2%)	10,252 (41.8%)
T1-T2 inadequate	**2,106 (4.4%)**	**18,007 (33.2%)**	**1,372 (7.6%)**	**4,547 (37.0%)**	**454 (9.6%)**	**10,515 (42.9%)**
T3 (late) intensive	69 (0.1%)	*	19 (0.1%)	*	*	*
T3 (late) inadequate	1,663 (3.6%)	2,439 (4.5%)	1,064 (5.9%)	592 (4.8%)	412 (8.7%)	1,755 (7.2%)
No care	512 (1.1%)	3,832 (7.1%)	621 (3.4%)	542 (4.4%)	253 (5.3%)	804 (3.3%)
Low or Late PNC	**4,260 (9.2%)**	**24,280 (44.8%)**	**3,076 (17.0%)**	**5,683 (46.2%)**	**1,127 (23.8%)**	**13,080 (53.3%)**

Table 6.2: Number and proportion of births by timing of entry into prenatal care and an adapted prenatal care utilization index, U.S. Mexico border region, 2009

	Texas (n=50,255)	Coahuila (n=8,877)	Nuevo Leon (n=1,658)	Tamaulipas (n=35,760)
Timing of entry				
1st Trimester	29,162 (58.5%)	4,703 (54.6%)	1,296 (79.5%)	25,214 (72.5%)
2nd Trimester	12,205 (24.5%)	2,866 (33.3%)	280 (17.2%)	6,519 (18.7%)
3rd Trimester	**3,831 (7.7%)**	523 (6.1%)	35 (2.1%)	1,661 (4.8%)
No care	**4,640 (9.3%)**	521 (6.0%)	20 (1.2%)	1,386 (4.0%)
Number of Visits				
Mean visits (SD)	9.2 (4.3)	6.7 (3.4)	8.0 (2.7)	7.3 (3.3)
Fewer than 4 visits	6,095 (12.1%)	1,300 (16.3%)	77 (4.9%)	3,590 (10.7%)
Fewer than 11 visits	28,470 (56.8%)	7,264 (90.8%)	1,427 (90.4%)	30,003 (89.8%)
Low visits for parity	14,475 (28.9%)	4,640 (58.0%)	678 (43.0%)	18,306 (55.0%)
Adapted R-GINDEX*				
Early Intensive	1,112 (2.2%)	40 (0.5%)	13 (0.8%)	296 (0.9%)
Adequate	16,022 (32.2%)	572 (7.2%)	130 (8.3%)	2,741 (8.4%)
Intermediate	20,937 (42.1%)	3,234 (41.0%)	965 (61.5%)	15,478 (47.3%)
T1-T2 inadequate	**3,195 (6.4%)**	**3,050 (38.6%)**	**410 (26.1%)**	**11,222 (34.3%)**
T3 (late) intensive	144 (0.3%)	*	*	38 (0.1%)
T3 (late) inadequate	3,657 (7.4%	473 (6.0%)	32 (2.0%)	1,544 (4.7%)
No care	4,640 (9.3%)	521 (6.6%)	20 (1.3%)	1,386 (4.2%)
Low or Late PNC	**11,636 (23.4%)**	**4,048 (51.3%)**	**462 (29.4%)**	**14,190 (43.4%)**

Table 7.1: Comparison of adequacy measures by border versus non-border municipalities in Mexican border states, Baja California, Chihuahua and Coahuila, 2009

	Baja California	Chihuahua		Coahuila	
	Border (n=56,669)	Border (n=26,040)	Non-Border (n=32,181)	Border (n=8,877)	Non-Border (n=44,432)
Timing of entry					
1st Trimester	41,110 (73.6%)	15,324 (59.8%)	24,623 (78.2%)	4,703 (54.6%)	30,514 (69.6%)
2nd Trimester	8,410 (15.1%)	7,668 (29.9%)	5,031 (16.0%)	2,866 (33.3%)	9,359 (21.3%)
3rd Trimester	2,514 (4.5%)	1,823 (7.1%)	1,089 (3.5%)	523 (6.1%)	2,913 (6.6%)
No care	3,832 (6.9%)	804 (3.1%)	751 (2.4%)	521 (6.0%)	1,068 (2.4%)
Number of Visits					
Mean visits (SD)	7.0 (3.6)	6.7 (2.9)	7.3 (3.1)	6.7 (3.4)	7.5 (3.3)
< 4 visits	8,144 (14.9%)	2,874 (11.5%)	2,749 (9.0%)	1,300 (16.3%)	3,650 (9.7%)
< 11 visits	49,575 (90.7%)	23,622 (94.7%)	28,104 (91.7%)	7,264 (90.8%)	33,254 (88.8%)
Low visits/parity	30,719 (56.3%)	15,591 (62.5%)	17,049 (55.6%)	4,640 (58.0%)	19,516 (52.2%)
Adapted R-GINDEX					
Early Intensive	521 (1.0%)	135 (0.6%)	243 (0.8%)	40 (0.5%)	391 (1.1%)
Adequate	4,235 (7.8%)	1,062 (4.3%)	2,248 (7.5%)	572 (7.2%)	3,363 (9.1%)
Intermediate	25,169 (46.4%)	10,252 (41.8%)	15,512 (51.4%)	3,234 (41.0%)	18,199 (49.1%)
T1-T2 inadequate	18,007 (33.2%)	10,515 (42.9%)	10,362 (34.4%)	3,050 (38.6%)	12,040 (32.5%)
T3 (late) intensive	*	*	*	*	23 (0.1%)
T3 (late) inadeq	2,439 (4.5%)	1,755 (7.2%)	1,040 (3.4%)	473 (6.0%)	1,998 (5.4%)
No care	3,832 (7.1%)	804 (3.3%)	751 (2.5%)	521 (6.6%)	1,069 (2.9%)
Low or Late PNC	**24,280 (44.8%)**	**13,080 (53.3%)**	**12,157 (40.3%)**	**4,048 (51.3%)**	**15,130 (40.8%)**

Table 7.2: Comparison of adequacy measures by border versus non-border municipalities in Mexican border states, Nuevo Leon, Sonora and Tamaulipas, 2009

	Nuevo Leon		Sonora		Tamaulipas	
	Border (n=1,658)	Non-Border (n=71,932)	Border (n=13,220)	Non-Border (n=32,563)	Border (n=35,760)	Non-Border (n=28,367)
Timing of entry						
1st Trimester	1,296 (79.5%)	59,441 (84.2%)	8,781 (68.3%)	24,819 (79.2%)	25,214 (72.5%)	21,580 (77.6%)
2nd Trimester	280 (17.2%)	8,136 (11.5%)	2,929 (22.8%)	5,109 (16.3%)	6,519 (18.7%)	4,703 (16.9%)
3rd Trimester	35 (2.1%)	1,685 (2.4%)	603 (4.7%)	809 (2.6%)	1,661 (4.8%)	1,184 (4.3%)
No care	20 (1.2%)	1,366 (1.9%)	542 (4.2%)	610 (2.0%)	1,386 (4.0%)	333 (1.2%)
Number of Visits						
Mean visits (SD)	8.0 (2.7)	7.9 (3.3)	7.0 (3.3)	7.4 (3.0)	7.3 (3.3)	7.1 (2.9)
< 4 visits	77 (4.9%)	5,909 (8.8%)	1,639 (13.1%)	2,489 (8.3%)	3,590 (10.7%)	2,462 (9.3%)
< 11 visits	1,427 (90.4%)	57,052 (85.1%)	11,373 (91.0%)	27,450 (91.1%)	30,003 (89.8%)	24,457 (92.5%)
Low visits/parity	678 (43.0%)	31,106 (46.5%)	7,139 (57.2%)	16,364 (54.3%)	18,306 (55.0%)	15,756 (59.7%)
Adapted R-GINDEX						
Early Intensive	13 (0.8%)	722 (1.1%)	101 (0.8%)	241 (0.8%)	296 (0.9%)	152 (0.6%)
Adequate	130 (8.3%)	9,580 (14.4%)	903 (7.3%)	2,425 (8.1%)	2,741 (8.4%)	1,763 (6.9%)
Intermediate	965 (61.5%)	33,403 (50.3%)	5,602 (45.6%	15,400 (51.6%)	15,478 (47.3%)	12,103 (47.2%)
T1-T2 inadequate	410 (26.1%)	19,727 (29.7%)	4,547 (37.0%)	10,442 (35.0%)	11,222 (34.3%)	10,155 (39.6%)
T3 (late) intensive	*	*	*	*	38 (0.1%)	*
T3 (late) inadeq	32 (2.0%)	1,537 (2.3%)	592 (4.8%)	719 (2.4%)	1,544 (4.7%)	1,113 (4.3%)
No care	20 (1.3%)	1,366 (2.1%)	542 (4.4%)	610 (2.0%)	1,386 (4.2%)	334 (1.3%)
Low or Late PNC	**462 (29.4%)**	**22,643 (34.1%)**	**5,683 (46.2%)**	**11,777 (39.5%)**	**14,190 (43.4%)**	**11,611 (45.3%)**

Table 8.1: Comparison of adequacy measures by border versus non-border counties in U.S. border states, California and Arizona, 2009

	Arizona		California	
	Border (n=18,208)	Non-border (n=71,997)	Border (n=46,481)	Non-border (n=463,738)
Timing of entry				
1st Trimester	12,761 (70.1%)	59,470 (82.8%)	36,842 (79.4%)	362,940 (81.4%)
2nd Trimester	3,731 (20.5%)	9,432 (13.1%)	7,285 (15.7%)	67,700 (15.2%)
3rd Trimester	1,087 (6.0%)	1,883 (2.6%)	1,742 (3.8%)	12,963 (2.9%)
No care	621 (3.4%)	1,062 (1.5%)	512 (1.1%)	2,054 (0.5%)
Number of Visits				
Mean visits (SD)	10.3 (4.0)	11.2 (3.9)	11.4 (3.8)	12.0 (3.7)
Fewer than 4 visits	1,159 (6.4%)	2,386 (3.3%)	1,119 (2.4%)	6,558 (1.5%)
Fewer than 11 visits	8,844 (48.6%)	33,633 (46.8%)	19,339 (41.7%)	144,261 (32.1%)
Low visits for parity	4,296 (23.6%)	10,883 (15.2%)	7,321 (15.8%)	44,185 (9.8%)
Adapted R-GINDEX				
Early intensive	681 (3.8%)	4,299 (6.0%)	3,192 (6.9%)	31,161 (7.1%)
Adequate	6,355 (35.1%)	30,198 (42.2%)	17,896 (38.7%)	202,600 (46.3%)
Intermediate	7,997 (44.2%)	29,917 (41.8%)	20,906 (45.2%)	175,770 (40.2%)
T1-T2 inadequate	1,372 (7.6%)	4,229 (5.9%)	2,106 (4.4%)	13,141 (3.0%)
T3 (late) intensive	19 (0.1%)	47 (0.1%)	69 (0.1%)	537 (0.1%)
T3 (late) inadequate	1,064 (5.9%)	1,825 (2.5%)	1,663 (3.6%)	11,931 (2.7%)
No care	621 (3.4%)	1,062 (1.5%)	512 (1.1%)	2,054 (0.5%)
Low or Late PNC	**3,076 (17.0%)**	**7,163 (10.0%)**	**4,260 (9.2%)**	**27,663 (6.3%)**

Table 8.2: Comparison of adequacy measures by border versus non-border counties in U.S. border states, New Mexico and Texas, 2009

	New Mexico		Texas	
	Border (n=5,080)	Non-border (n=23,248)	Border (n=50,255)	Non-border (n=338,861)
Timing of entry				
1st Trimester	2,871 (59.3%)	13,662 (67.9%)	29,162 (58.5%)	198,182 (59.4%)
2nd Trimester	1,295 (26.7%)	4,842 (24.1%)	12,205 (24.5%)	96,752 (29.0%)
3rd Trimester	426 (8.8%)	1,209 (6.0%)	3,831 (7.7%)	26,241 (7.9%)
No care	253 (5.2%)	394 (2.0%)	4,640 (9.3%)	12,744 (3.8%)
Number of Visits				
Mean visits (SD)	9.6 (4.4)	10.6 (4.4)	9.2 (4.3)	10.0 (4.0)
Fewer than 4 visits	487 (10.0%)	1,150 (5.1%)	6,095 (12.1%)	23,176 (6.9%)
Fewer than 11 visits	2,793 (57.2%)	11,953 (53.3%)	28,470 (56.8%)	181,572 (53.9%)
Low visits for parity	1,446 (29.9%)	5,265 (24.0%)	14,475 (28.9%)	84,412 (25.1%)
Adapted R-GINDEX				
Early intensive	200 (4.2%)	1,449 (7.4%)	1,112 (2.2%)	11,687 (3.5%)
Adequate	1,317 (27.8%)	5,830 (29.6%)	16,022 (32.2%)	101,918 (30.7%)
Intermediate	2,098 (44.2%)	9,174 (46.6%)	20,937 (42.1%)	156,426 (47.2%)
T1-T2 inadequate	454 (9.6%)	1,663 (8.4%)	3,195 (6.4%)	23,091 (7.0%)
T3 (late) intensive	*	55 (0.3%)	144 (0.3%)	545 (0.2%)
T3 (late) inadequate	412 (8.7%)	1,141 (5.8%)	3,657 (7.4%	25,245 (7.6%)
No care	253 (5.3%)	394 (2.0%)	4,640 (9.3%)	12,744 (3.8%)
Low or Late PNC	**1,127 (23.8%)**	**3,253 (16.5%)**	**11,636 (23.4%)**	**61,625 (18.6%)**

By state, New Mexico (8.8%) and Texas (7.7%) were home to the largest proportion of border residents delaying care to third trimester. In contrast, Nuevo Leon and California exhibited the highest levels of first trimester entry (79.5% and 79.4%, respectively), and fewer than five percent of women in these states received either no care or care beginning in the third trimester (Table 6). Significant variation was also observed between border and non-border counties by state, particularly in Mexico but also among residents of Arizona and New Mexico in the United States (Tables 7 and 8). Much lower disparities were observed between border and non-border counties in California (similarly high) and Texas (similarly low).

Additionally, though race and ethnicity data were unavailable in Mexican natality files, it is evident from the literature that Hispanic women may experience differential levels of care and subsequent health outcomes. Table 9, below, displays rates of prenatal care adequacy among border residents, dichotomized by Hispanic ethnicity.

Table 9: Comparison of adequacy measures among singleton births to residents of the U.S.-Mexico border region, by Hispanic ethnicity, 2009

	Hispanic Ethnicity (missing=3,486)	
	Hispanic (n=82,447)	Non-Hispanic (n=34,110)
Timing of entry		
1st Trimester	51,427 (62.8%)	27,495 (81.0%)
2nd Trimester	19,035 (23.2%)	4,937 (14.5%)
3rd Trimester	5,801 (7.1%)	1,152 (3.4%)
No care	5,610 (6.9%)	361 (1.1%)
Number of Visits		
Mean visits (SD)	10.7 (4.0)	11.3 (4.0)
Fewer than 4 visits	7,920 (9.6%)	830 (2.4%)
Fewer than 11 visits	44,074 (53.6%)	14,056 (41.3%)
Low visits for parity	21,386 (26.0%)	5,609 (16.5%)
Adapted R-GINDEX		
Early intensive	3,039 (3.7%)	1,949 (5.8%)
Adequate	26,521 (32.5%)	13,582 (40.2%)
Intermediate	35,354 (43.3%)	15,165 (44.9%)
T1-T2 inadequate	5,285 (6.5%)	1,606 (4.8%)
T3 (late) intensive	205 (0.3%)	30 (0.1%)
T3 (late) inadequate	5,552 (6.8%)	1,116 (3.3%)
No care	5,610 (6.9%)	361 (1.1%)
Low or Late PNC	**16,652 (20.4%)**	**3,113 (9.2%)**

Tables 10.1 – 10.8, below, compare timing of entry and other measures of prenatal care adequacy among residents in 15 sister communities along the border. In these communities, rates of third trimester entry or no care range from 3.1% in Maverick County, Texas and the Chihuahua municipality of Ojinaga to over one-third of all mothers (34.6%) in Presidio County, Texas.

Table 10.1: Cross-border comparison of prenatal care adequacy measures in sister counties of California and Baja California, 2009

	Tijuana (BC)-San Diego (CA)			**Mexicali (BC)-Imperial (CA)**		
	Tijuana (n=29,545)	San Diego (n=43,414)	MX births in San Diego Co. (n=709)	Mexicali (n=15,891)	Imperial (n=3,067)	MX births in Imperial Co (n=100)
Timing of entry						
1st Trimester	20,874 (71.2%)	35,236 (81.3%)	586 (82.7%)	12,140 (78.2%)	1,606 (53.3%)	32 (32.7%)
2nd Trimester	3,965 (13.5%)	6,455 (14.9%)	109 (15.4%)	2,534 (16.3%)	830 (27.6%)	22 (22.5%)
3rd Trimester	1,468 (5.0%)	1,405 (3.2%)	14 (2.0%)	**431 (2.8%)**	**337 (11.2%)**	18 (18.4%)
No care	**2,995 (10.2%)**	**274 (0.6%)**		**425 (2.7%)**	**238 (7.9%)**	26 (26.5%)
Number of Visits						
Mean visits (SD)	6.9 (3.9)	11.5 (3.7)	12.9 (4.3)	7.3 (3.2)	9.6 (4.7)	6.4 (5.3)
Fewer than 4 visits	5,335 (18.5%)	800 (1.8%)	5 (0.7%)	1,480 (9.9%)	319 (10.6%)	31 (31.3%)
Fewer than 11 visits	26,083 (90.3%)	17,426 (40.2%)	208 (29.3%)	13,406 (89.9%)	1,913 (63.2%)	80 (80.8%)
Low visits/parity	15,919 (55.2%)	6,408 (14.8%)	56 (7.9%)	8,112 (54.5%)	913 (30.2%)	64 (64.7%)
Adapted R-GINDEX						
Early Intensive	317 (1.1%)	2,989 (6.9%)	**113 (15.9%)**	143 (1.0%)	203 (6.8%)	*
Adequate	2,206 (7.7%)	17,225 (39.8%)	309 (43.6%)	1,345 (9.2%)	671 (22.4%)	22 (22.5%)
Intermediate	13,412 (46.7%)	19,579 (45.3%)	251 (35.4%)	7,137 (48.6%)	1,327 (44.3%)	21 (21.4%)
T1-T2 inadequate	8,378 (29.1%)	1,794 (4.2%)	22 (3.1%)	5,229 (35.6%)	222 (7.4%)	11 (11.2%)
T3 (late) intensive	*	64 (0.2%)	*	*	*	*
T3 (late) inadequate	1,436 (5.0%)	1,331 (3.1%)	*	415 (2.8%)	332 (11.1%)	18 (18.4%)
No care	2,995 (10.4%)	274 (0.6%)	*	425 (2.9%)	238 (7.9%)	26 (26.5%)
Low or Late PNC	**12,811 (44.6%)**	**3,463 (8.0%)**	**36 (5.1%)**	**6,069 (41.3%)**	**797 (26.6%)**	**55 (56.1%)**

Table 10.2: Cross-border comparison of prenatal care adequacy measures in sister counties of western Arizona and Sonora, 2009

	S. Luis Rio CO (SO)-Yuma (AZ)			Nogales (SO)-Santa Cruz (AZ)		
	San Luis Rio CO (n=2,814)	Yuma (n=3,164)	Mexican births in Yuma Co. (n=200)	Nogales (n=3,996)	Santa Cruz (n=726)	Mexican births in Santa Cruz Co. (n=245)
Timing of entry						
1st Trimester	1,568 (58.8%)	1,881 (59.5%)	14 (7.0%)	2,545 (64.5%)	491 (67.6%)	77 (31.4%)
2nd Trimester	798 (29.9%)	729 (23.1%)	54 (27.0%)	944 (23.9%)	154 (21.2%)	47 (19.2%)
3rd Trimester	151 (5.7%)	324 (10.3%)	67 (33.5%)	211 (5.4%)	62 (8.5%)	121 (49.4%)
No care	151 (5.7%)	226 (7.2%)	65 (32.5%)	243 (6.2%)	19 (2.6%)	
Number of Visits						
Mean visits (SD)	6.8 (3.5)	9.0 (4.1)	4.5 (3.8)	6.5 (3.2)	10.4 (3.9)	5.1 (3.3)
< 4 visits	419 (15.9%)	369 (11.7%)	79 (39.5%)	591 (15.5%)	66 (9.1%)	106 (43.3%)
< 11 visits	2,352 (89.5%)	1,919 (60.8%)	190 (95.0%)	3,618 (94.8%)	533 (73.4%)	230 (93.9%)
Low visits/parity	1,539 (58.6%)	1,062 (33.6%)	155 (77.5%)	2,361 (61.9%)	298 (41.1%)	183 (74.7%)
Adapted R-GINDEX						
Early Intensive	26 (1.0%)	49 (1.6%)	*	29 (0.8%)	13 (1.8%)	*
Adequate	182 (7.1%)	810 (25.8%)	*	184 (4.9%)	139 (19.2%)	12 (4.9%)
Intermediate	1,017 (39.8%)	1,464 (46.6%)	44 (22.0%)	1,647 (43.5%)	352 (48.6%)	59 (24.1%)
T1-T2 inadequate	1,033 (40.4%)	271 (8.6%)	20 (10.0%)	1,473 (38.9%)	139 (19.2%)	53 (21.6%)
T3 (late) intensive	*	*	*	*	*	*
T3 (late) inadequate	148 (5.8%)	320 (10.2%)	66 (33.0%)	207 (5.5%)	62 (8.6%)	115 (46.9%)
No care	151 (5.9%)	226 (7.2%)	65 (32.5%)	243 (6.4%)	19 (2.6%)	*
Low or Late PNC	**1,332 (52.1%)**	**819 (26.1%)**	**152 (76.0%)**	**1,924 (50.9%)**	**220 (30.4%)**	**174 (71.0%)**

Table 10.3: Cross-border comparison of prenatal care adequacy measures in Pima regional sister counties, 2009

	Caborca-Puerto Penasco-G. Plutarco Elias Calles (SO)-Pima (AZ)				
	Caborca (n=1,797)	Puerto Penasco (n=1,214)	Gen. Plutarco Elias Calles (n=235)	Pima (n=12,523)	Mexican births in Pima Co. (n=285)
Timing of entry					
1st Trimester	1,334 (76.8%)	886 (73.4%)	164 (70.7%)	8,954 (71.5%)	83 (29.1%)
2nd Trimester	303 (17.4%)	245 (20.3%)	52 (22.4%)	2,601 (20.8%)	76 (26.7%)
3rd Trimester	59 (3.4%)	54 (4.5%)	4 (1.7%)	649 (5.2%)	57 (20.0%)
No care	41 (2.4%)	22 (1.8%)	12 (5.2%)	315 (2.5%)	69 (24.2%)
Number of Visits					
Mean visits (SD)	7.5 (3.1)	7.5 (3.2)	6.5 (3.0)	10.4 (3.9)	5.5 (4.6)
< 4 visits	141 (8.2%)	121 (10.0%)	32 (13.9%)	637 (5.1%)	108 (38.0%)
< 11 visits	1,541 (89.5%)	1,075 (89.1%)	220 (95.7%)	5,972 (47.7%)	242 (85.2%)
Low visits/parity	920 (53.4%)	585 (48.5%)	146 (63.5%)	2,728 (21.8%)	197 (69.4%)
Adapted R-GINDEX					
Early Intensive	12 (0.7%)	12 (1.0%)	*	563 (4.5%)	*
Adequate	138 (8.2%)	91 (7.6%)	*	4,323 (34.7%)	24 (8.5%)
Intermediate	843 (50.3%)	620 (51.8%)	99 (43.6%)	5,707 (45.8%)	77 (27.1%)
T1-T2 inadequate	582 (34.8%)	398 (33.3%)	104 (45.8%)	899 (7.2%)	53 (18.7%)
T3 (late) intensive	*	*	*	12 (0.1%)	*
T3 (late) inadequate	59 (3.5%)	53 (4.4%)	*	635 (5.1%)	56 (19.7%)
No care	41 (2.4%)	22 (1.8%)	12 (5.3%)	315 (2.5%)	69 (24.3%)
Low or Late PNC	**682 (40.7%)**	**473 (39.6%)**	**120 (52.9%)**	**1,861 (14.9%)**	**179 (63.0%)**

Table 10.4: Cross-border comparison of prenatal care adequacy measures in sister counties of Arizona, Sonora, New Mexico and Chihuahua, 2009

	Agua Prieta-Naco (SO)-Cochise (AZ)		Ascension (CH)-Luna (NM)		
	Agua Prieta-Naco (n=1,090)	Cochise (n=1,795)	Ascension (n=362)	Luna (n=405)	Mexican births in Luna Co (n=89)
Timing of entry					
1st Trimester	798 (76.1%)	1,435 (79.9%)	218 (61.6%)	215 (60.1%)	25 (35.7%)
2nd Trimester	177 (16.9%)	247 (13.8%)	75 (21.2%)	67 (18.7%)	
3rd Trimester	45 (4.3%)	52 (2.9%)	38 (10.7%)	33 (9.2%)	45 (64.3%)
No care	28 (2.7%)	61 (3.4%)	23 (6.5%)	43 (12.0%)	
Number of Visits					
Mean visits (SD)	6.9 (3.1)	12.1 (3.8)	5.5 (2.8)	8.6 (5.4)	3.5 (4.3)
Fewer than 4 visits	131 (14.6%)	87 (4.9%)	86 (24.9%)	55 (17.7%)	50 (58.1%)
Fewer than 11 visits	835 (93.1%)	420 (23.4%)	334 (96.8%)	195 (62.7%)	81 (94.2%)
Low visits/parity	520 (58.0%)	208 (11.6%)	258 (74.8%)	126 (40.7%)	68 (79.1%)
Adapted R-GINDEX					
Early Intensive	*	56 (3.1%)	*	17 (5.7%)	*
Adequate	61 (6.9%)	1,083 (60.5%)	11 (3.3%)	73 (24.6%)	*
Intermediate	448 (50.6%)	474 (26.5%)	100 (29.7%)	105 (35.4%)	11 (16.4%)
T1-T2 inadequate	298 (33.6%)	63 (3.5%)	165 (49.0%)	31 (10.4%)	10 (14.9%)
T3 (late) intensive	*	*	*	*	*
T3 (late) inadeq	44 (5.0%)	47 (2.6%)	38 (11.3%)	26 (8.8%)	*
No care	28 (3.2%)	61 (3.4%)	23 (6.8%)	43 (14.5%)	43 (64.2%)
Low or Late PNC	**370 (41.8%)**	**176 (9.8%)**	**226 (67.1%)**	**102 (34.3%)**	**55 (82.1%)**

Table 10.5: Cross-border comparison of prenatal care adequacy measures in sister counties of New Mexico, Texas and Chihuahua, 2009

	Juarez (CH)-Dona Ana (NM)-El Paso (TX)				Ojinaga (CH)-Presidio (TX)	
	Juarez (n=23,729)	Dona Ana (n=3,235)	El Paso (n=13,637)	MX births in El Paso/DA Co (n=2,573)	Ojinaga (n=352)	Presidio (n=138)
Timing of entry						
1st Trimester	13,710 (58.7%)	1,767 (55.7%)	8,061 (59.4%)	1,213 (47.3%)	288 (82.8%)	47 (34.6%)
2nd Trimester	7,240 (31.0%)	924 (29.1%)	3,850 (28.4%)	732 (28.5%)	49 (14.1%)	42 (30.9%)
3rd Trimester	1,689 (7.2%)	311 (9.8%)	1,146 (8.5%)	537 (20.9%)	**6 (1.7%)**	**23 (16.9%)**
No care	723 (3.1%)	171 (5.4%)	510 (3.8%)	83 (3.2%)	**5 (1.4%)**	**24 (17.7%)**
Number of Visits						
Mean visits (SD)	6.7 (2.9)	9.6 (4.3)	9.5 (3.8)	7.7 (3.6)	7.0 (2.3)	6.8 (4.2)
Fewer than 4 visits	2,580 (11.3%)	339 (10.6%)	970 (7.1%)	281 (11.0%)	23 (7.2%)	30 (21.9%)
Fewer than 11 visits	21,502 (94.5%)	1,821 (56.8%)	7,681 (56.4%)	2114 (82.7%)	316 (98.8%)	113 (82.5%)
Low visits/parity	14,171 (62.3%)	956 (29.9%)	3,853 (28.3%)	1,324 (51.8%)	195 (60.9%)	69 (50.4%)
Adapted R-GINDEX						
Early Intensive	131 (0.6%)	119 (3.8%)	355 (2.6%)	41 (1.6%)	*	*
Adequate	999 (4.5%)	875 (27.6%)	4,087 (30.2%)	182 (7.1%)	*	17 (12.7%)
Intermediate	9,310 (41.6%)	1,396 (44.1%)	6,353 (46.9%)	1251 (49.1%)	182 (57.4%)	60 (44.8%)
T1-T2 inadequate	9,584 (42.8%)	295 (9.3%)	1,092 (8.1%)	468 (18.4%)	116 (36.6%)	12 (9.0%)
T3 (late) intensive	*	*	17 (0.1%)	25 (1.0%)	*	*
T3 (late) inadequate	1,625 (7.3%)	304 (9.6%)	1,120 (8.3%)	499 (19.6%)	11 (3.5%)	21 (15.7%)
No care	723 (3.2%)	171 (5.4%)	510 (3.8%)	83 (3.3%)		24 (17.9%)
Low or Late PNC	**11,938 (53.4%)**	**776 (24.5%)**	**2,739 (20.2%)**	**1,075 (42.2%)**	**127 (40.1%)**	**57 (42.5%)**

Table 10.6: Cross-border comparison of prenatal care adequacy measures in sister counties of Texas and Coahuila, 2009

	Acuña (CO)-Jimenez (CO)-Val Verde (TX)			Piedras Negras (CO)-Maverick (TX)		
	Acuña-Jimenez (n=2,863)	Val Verde (n=881)	Mexican births in Val Verde Co (n=241)	Piedras Negras (n=3,262)	Maverick (n=1,034)	Mexican births in Maverick Co (n=249)
Timing of entry						
1st Trimester	932 (34.6%)	332 (38.1%)	94 (39.3%)	1,923 (59.6%)	832 (80.9%)	162 (65.6%)
2nd Trimester	1,397 (51.9%)	294 (33.8%)	60 (25.1%)	835 (25.9%)	165 (16.0%)	45 (18.2%)
3rd Trimester	136 (5.1%)	115 (13.2%)	33 (13.8%)	263 (8.1%)	32 (3.1%)	40 (16.2%)
No care	232 (8.6%)	130 (14.9%)	52 (21.8%)	207 (6.4%)		
Number of Visits						
Mean visits (SD)	5.9 (3.0)	7.1 (4.3)	5.3 (3.9)	6.6 (3.7)	12.7 (3.2)	12.7 (3.2)
Fewer than 4 visits	423 (18.0%)	190 (21.6%	88 (36.8%)	647 (20.6%)	28 (2.7%)	*
Fewer than 11 visits	2,310 (98.2%)	685 (77.9%)	213 (89.1%)	2,783 (88.6%)	181 (17.5%)	51 (20.5%)
Low visits/parity	1,532 (65.1%)	447 (50.9%)	157 (65.7%)	1,899 (60.5%)	81 (7.8%)	18 (7.2%)
Adapted R-GINDEX						
Early Intensive	*	12 (1.4%)	*	19 (0.6%)	19 (1.8%)	10 (4.0%)
Adequate	31 (1.3%)	110 (12.7%)	10 (4.2%)	304 (10.0%)	733 (71.3%)	142 (57.5%)
Intermediate	785 (34.0%)	366 (42.2%)	81 (34.2%)	1,149 (9.8%)	206 (20.0%)	55 (22.3%)
T1-T2 inadequate	1,162 (50.3%)	136 (15.7%)	63 (26.6%)	1,181 (37.9%)	38 (3.7%)	*
T3 (late) intensive	*	*	*	*	*	*
T3 (late) inadequate	97 (4.2%)	113 (13.0%)	31 (13.1%)	256 (8.2%)	23 (2.2%)	35 (14.2%)
No care	232 (10.0%)	130 (15.0%)	52 (21.9%)	207 (6.6%)	*	*
Low or Late PNC	**1,493 (64.6%)**	**380 (43.8%)**	**146 (61.6%)**	**1,645 (52.8%)**	**70 (6.8%)**	**40 (16.2%)**

Table 10.7: Cross-border comparison of prenatal care adequacy measures in sister counties of Texas and Tamaulipas, 2009

	Nuevo Laredo (TA)-Webb (TX)			Camargo-Miguel Aleman (TA)-Starr (TX)		
	Nuevo Laredo (n=7,906)	Webb (n=5,661)	Mexican births in Webb Co (n=261)	Camargo (n=253)	Miguel Aleman (n=345)	Starr (n=1,382)
Timing of entry						
1st Trimester	5,400 (69.4%)	3,752 (68.2%)	71 (27.3%)	155 (67.4%)	258 (76.3%)	781 (56.9%)
2nd Trimester	1,628 (20.9%)	933 (17.0%)	68 (26.2%)	42 (18.3%)	48 (14.2%)	383 (27.9%)
3rd Trimester	422 (5.4%)	200 (3.6%)	27 (10.4%)	22 (9.6%)	25 (7.4%)	134 (9.8%)
No care	**331 (4.3%)**	**618 (11.2%)**	94 (36.2%)	11 (4.8%)	7 (2.1%)	75 (5.5%)
Number of Visits						
Mean visits (SD)	6.9 (3.1)	9.0 (3.8)	5.4 (4.7)	7.1 (3.6)	8.9 (4.1)	9.8 (3.8)
Fewer than 4 visits	788 (11.2%)	671 (11.9%)	101 (38.8%)	33 (15.5%)	21 (6.5%)	110 (8.0%)
Fewer than 11 visits	6,503 (92.3%)	3,840 (67.9%)	218 (83.8%)	194 (91.1%)	245 (76.1%)	627 (45.5%)
Low visits/parity	4,055 (57.9%)	1,504 (26.6%)	164 (63.3%)	115 (54.0%)	120 (37.3%)	330 (24.0%)
Adapted R-GINDEX						
Early Intensive	45 (0.6%)	22 (0.4%)	*	*	12 (3.8%)	11 (0.8%)
Adequate	478 (6.9%)	1,633 (29.7%)	23 (8.9%)	14 (6.6%)	41 (12.9%)	572 (41.8%)
Intermediate	3,084 (44.4%)	2,835 (51.6%)	87 (33.6%)	96 (45.3%)	176 (55.5%)	516 (37.7%)
T1-T2 inadequate	**2,631 (37.9%)**	**182 (3.3%)**	28 (10.8%)	67 (31.6%)	58 (18.3%)	62 (4.5%)
T3 (late) intensive	373 (5.4%)	200 (3.7%)	27 (10.4%)	20 (9.5%)	30 (9.4%)	133 (9.7%)
T3 (late) inadequate						
No care	331 (4.8%)	618 (11.3%)	94 (36.3%)	11 (5.2%)		75 (5.5%)
Low or Late PNC	**3,335 (48.0%)**	**1,000 (18.2%)**	**149 (57.5%)**	**98 (46.2%)**	**88 (27.8%)**	**270 (19.7%)**

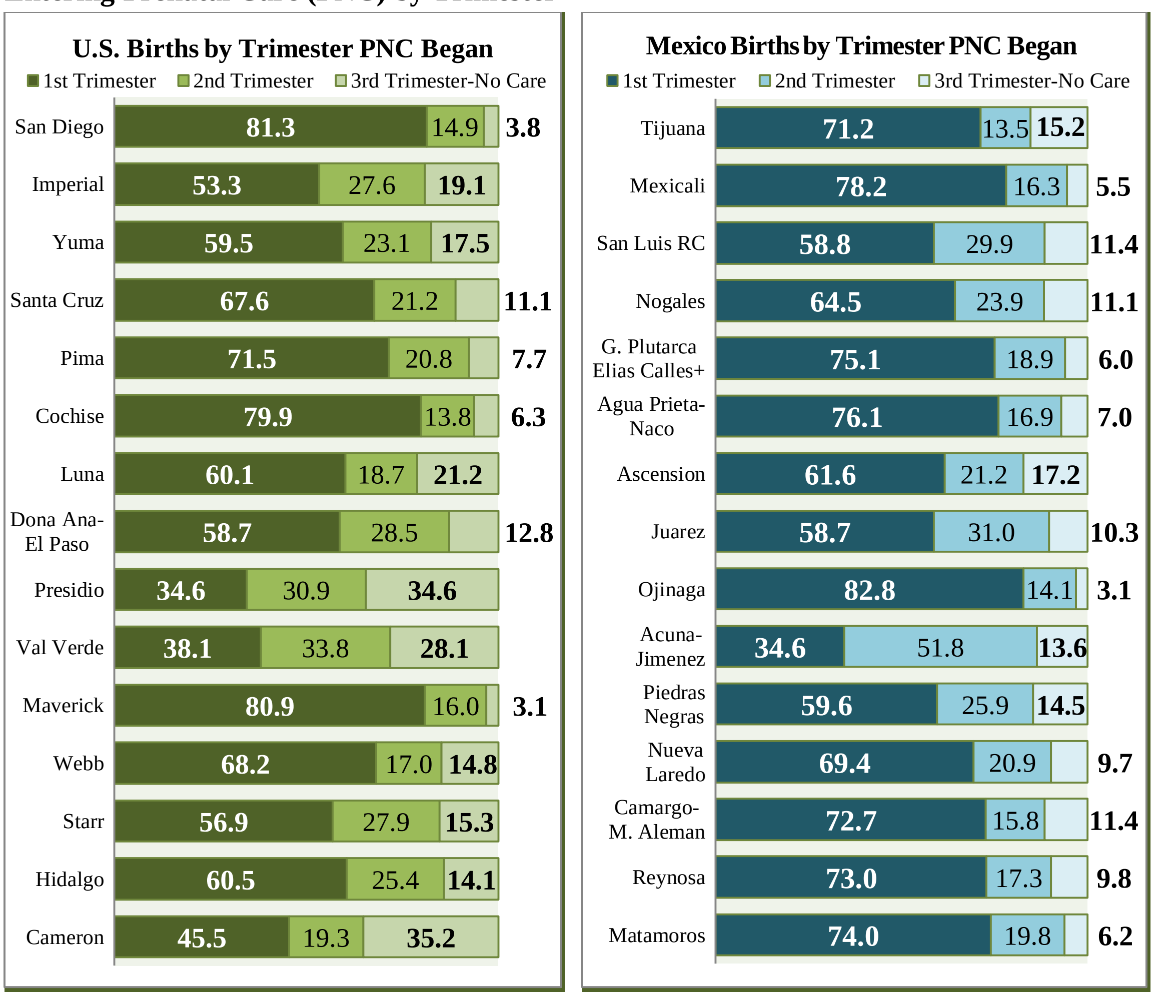
Table 10.8: **Cross-border comparison of prenatal care adequacy measures in sister counties of East Texas and Coahuila, 2009**

	Reynosa (TA)-Hidalgo (TX)			Matamoros (TA)-Cameron (TX)		
	Reynosa (n=14,074)	Hidalgo (n=16,532)	MX births in Hidalgo Co (n=644)	Matamoros (n=9,685)	Cameron (n=7,846)	MX births in Cameron Co (n=242)
Timing of entry						
1st Trimester	9,922 (73.0%)	9,936 (60.5%)	178 (28.0%)	6,989 (74.0%)	3,563 (45.5%)	104 (43.2%)
2nd Trimester	2,356 (17.3%)	4,163 (25.4%)	189 (29.8%)	1,871 (19.8%)	1,514 (19.3%)	36 (14.9%)
3rd Trimester	715 (5.3%)	1,512 (9.2%)	225 (35.4%)	321 (3.4%)	436 (5.6%)	22 (9.1%)
No care	608 (4.5%)	810 (4.9%)	43 (6.8%)	260 (2.8%)	2,313 (29.6%)	79 (32.8%)
Number of Visits						
Mean visits (SD)	7.1 (3.0)	9.7 (3.8)	7.5 (3.9)	7.2 (3.2)	7.5 (5.7)	5.8 (4.9)
Fewer than 4 visits	1,451 (10.9%)	1,386 (8.4%)	115 (17.9%)	934 (10.0%)	2,452 (31.3%)	90 (37.2%)
Fewer than 11 visits	12,416 (93.1%)	8,220 (49.8%)	474 (73.9%)	8,409 (90.4%)	5,278 (67.4%)	205 (84.7%)
Low visits/parity	7,416 (55.7%)	4,043 (24.5%)	326 (50.9%)	5,255 (56.5%)	3,287 (41.7%)	151 (62.4%)
Adapted R-GINDEX						
Early Intensive	69 (0.5%)	272 (1.7%)	*	81 (0.9%)	316 (4.1%)	*
Adequate	825 (6.4%)	6,135 (37.5%)	85 (13.4%)	679 (7.4%)	1,803 (23.1%)	31 (12.9%)
Intermediate	6,763 (52.1%)	6,470 (39.5%)	230 (36.3%)	4,098 (44.8%)	2,697 (34.6%)	75 (31.1%)
T1-T2 inadequate	4,024 (31.0%)	1,195 (7.3%)	49 (7.7%)	3,718 (40.6%)	239 (3.1%)	30 (12.4%)
T3 (late) intensive	*	88 (0.5%)	*	*	12 (0.2%)	*
T3 (late) inadequate	694 (5.3%)	1,412 (8.6%)	217 (34.3%)	316 (3.5%)	422 (5.4%)	22 (9.1%)
No care	608 (4.7%)	810 (4.9%)	43 (6.8%)	260 (2.8%)	2,313 (29.6%)	79 (32.8%)
Low or Late PNC	**5,331 (41.1%)**	**3,505 (21.4%)**	**315 (49.8%)**	**4,295 (46.9%)**	**2,986 (38.3%)**	**131 (54.4%)**

Figure 3, below, illustrates both cross-border (horizontal, sister-county comparison) and domestic (vertical, inter-county) disparities in trimester of first visit. As this figure illustrates, rates of first trimester prenatal care are highly variability throughout the region, both within and across the border. For example, Presidio County, Texas exhibits the lowest rate of prenatal care use in the first trimester (34.6%), while located directly adjacent to the municipality of Ojinaga, Chihuahua, one of only three sister communities in the region to exceed a goal of 80% first trimester enrollment into prenatal care. In contrast, initiation rates were the same or similar for the sister communities of El Paso, Texas (Doña Ana, New Mexico) and Juarez, Chihuahua (58.7%), as well as for Luna County, New Mexico and the municipality of Ascension, Chihuahua (60.1%, 61.6%).

Even if cross-border rates were similar, disparities were observed along the border. For example, women in Webb County, Texas and the municipality of Nueva Laredo, Tamaulipas entered care much earlier (68.2%, 69.4%) than women in the sister communities of Val Verde County, Texas and Acuña Municipality, Coahuila (38.1%, 34.6%). Moreover, rates of late (third trimester) and no care are lower among Mexican residents in 11 of the 15 sister communities, above. Women in these municipalities display prevalence of late or no prenatal care that is up to 91% lower than that of U.S. sister counties.

Figure 3: Proportion of 2009 Births in U.S.-Mexico Sister Counties & Municipalities Entering Prenatal Care (PNC) by Trimester

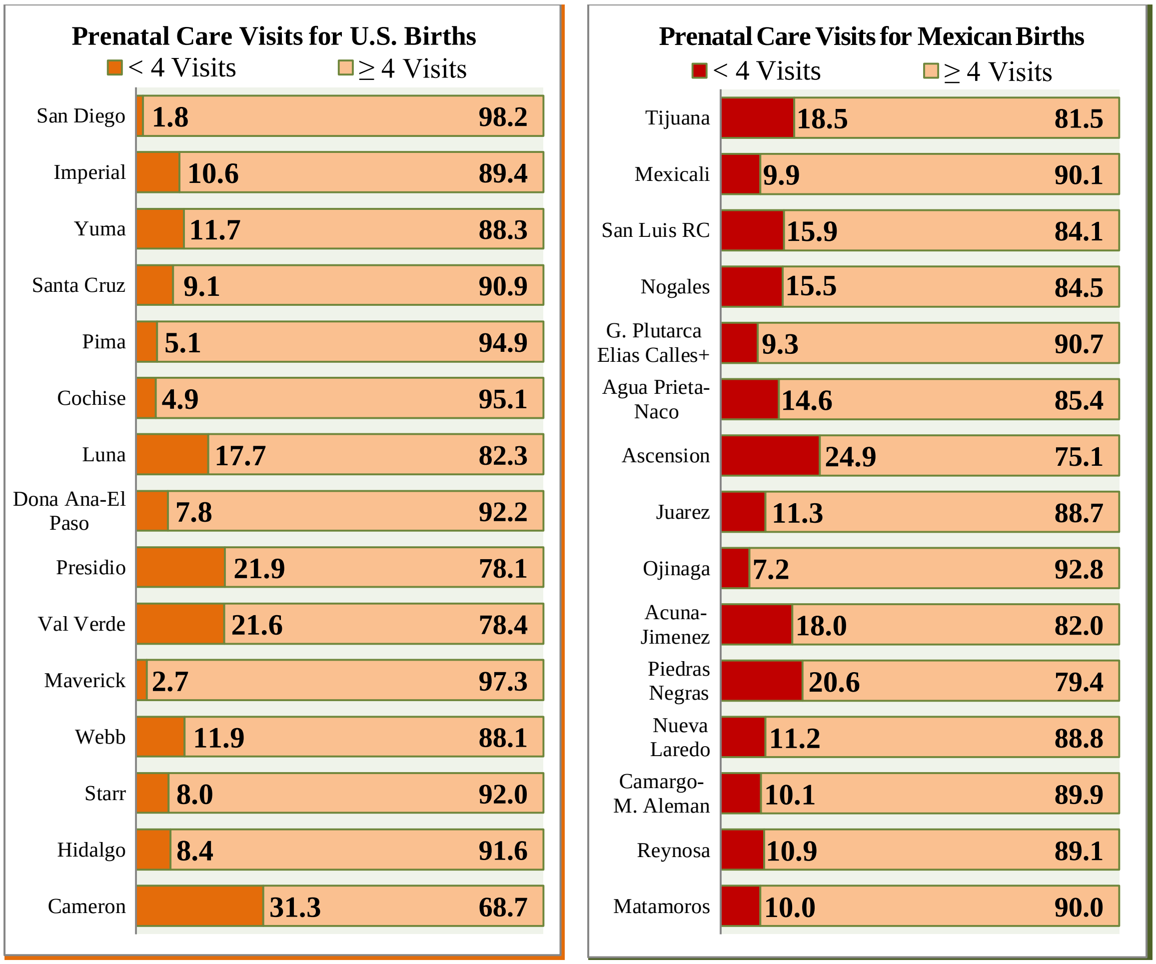


Number of Prenatal Care Visits

In 2009, American women in the border region, on average, received 10.2 (±4.2) visits per pregnancy, while Mexican women received only 7.0 (±3.4). The distributions of mothers achieving numbers of visits consistent with standard visits schedules for low-risk women are reported in Tables 4 – 10. Of importance, levels of adequacy change dramatically depending on the standard adopted. For example, while 87 percent of Mexican border residents receive at least four visits—adequate according to WHO recommendations, an even larger percentage (91.3%) *fail* to achieve adequate care according to an 11-visit schedule. When recommending visits based on parity, just over half (57.1%) of Mexican border residents receive an adequate quantity of care. The same standard-specific utilization rates vary less for American women, though the range of estimates of inadequate care remains wide—from 7.4% inadequate based on a 4 visit schedule to 49.7% inadequate based on an 11 visit schedule. Similar trends were observed for rates among border residents by state (Table 6).

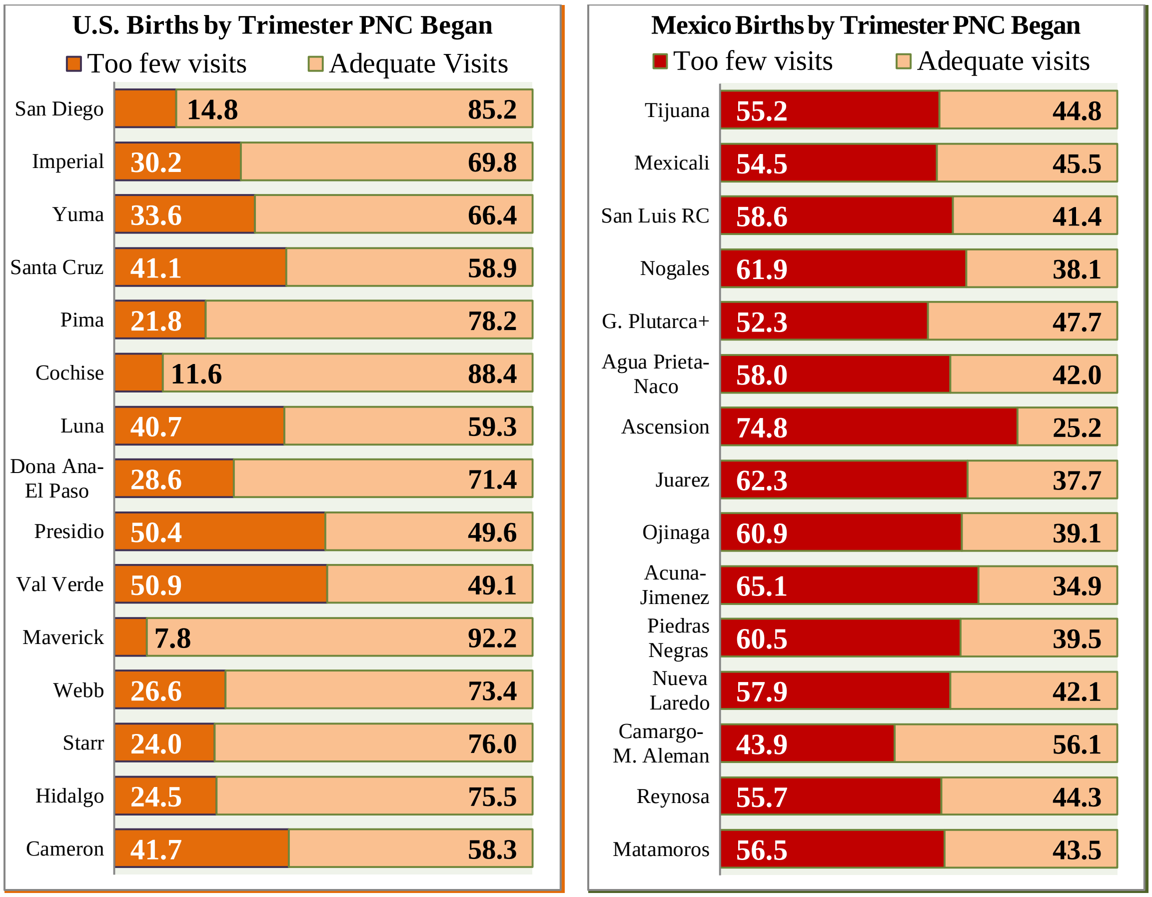
Figures 4 and 5, below, apply specifically to mothers living in recognized sister communities along the U.S.-Mexico border. Each presents prenatal care inadequacy rates based on the reported numbers of visits received. Adherence to the WHO minimum four-visit schedule is described in figure 3. Once again, a great deal of inter- and intra-community variation was observed. In 10 communities, the percent of Mexican women receiving fewer than four visits (9.3 - 24.9%) exceeded rates among American women in the sister county or counties across the border. Illustrating the magnitude of disparities, women in Tijuana, Baja California were 10.3 times as likely to receive less than four visits compared with mothers across the border in San Diego County. Mothers in Cameron and Presidio Counties, and those in the Mexican municipality of Piedras Negras were over three times as likely to receive fewer than four visits when compared to women in their closest neighboring county across the border.

Figure 4: Proportion of 2009 Births in U.S.-Mexico Sister Counties Receiving Fewer than Four Prenatal Care (PNC) Visits



In comparison, figure 5 illustrates the distribution of women who received inadequate numbers of visits according to a parity-based schedule recommended by the UK Royal College of Obstetricians and Gynaecologists (RCOG), whereby primiparous women require 10 visits and multiparous women require a reduced seven visits. Greater variability is evident across U.S. border counties than among Mexico municipalities. However, with the increased visit requirement, *all* Mexican municipalities have exceeded U.S. inadequacy levels. Two sister county pairs experienced an increased disparity in prevalence when using the higher visit requirements, including Cochise County, Arizona and the municipalities of Agua Prieta and Naco, Sonora (PR=5.0); as well as Maverick County, Texas and the municipality of Piedras Negras in Coahuila State (PR=7.8).

Figure 5: Proportion of 2009 Births in U.S.-Mexico Sister Counties Receiving Low Prenatal Care (PNC) Visits for Parity



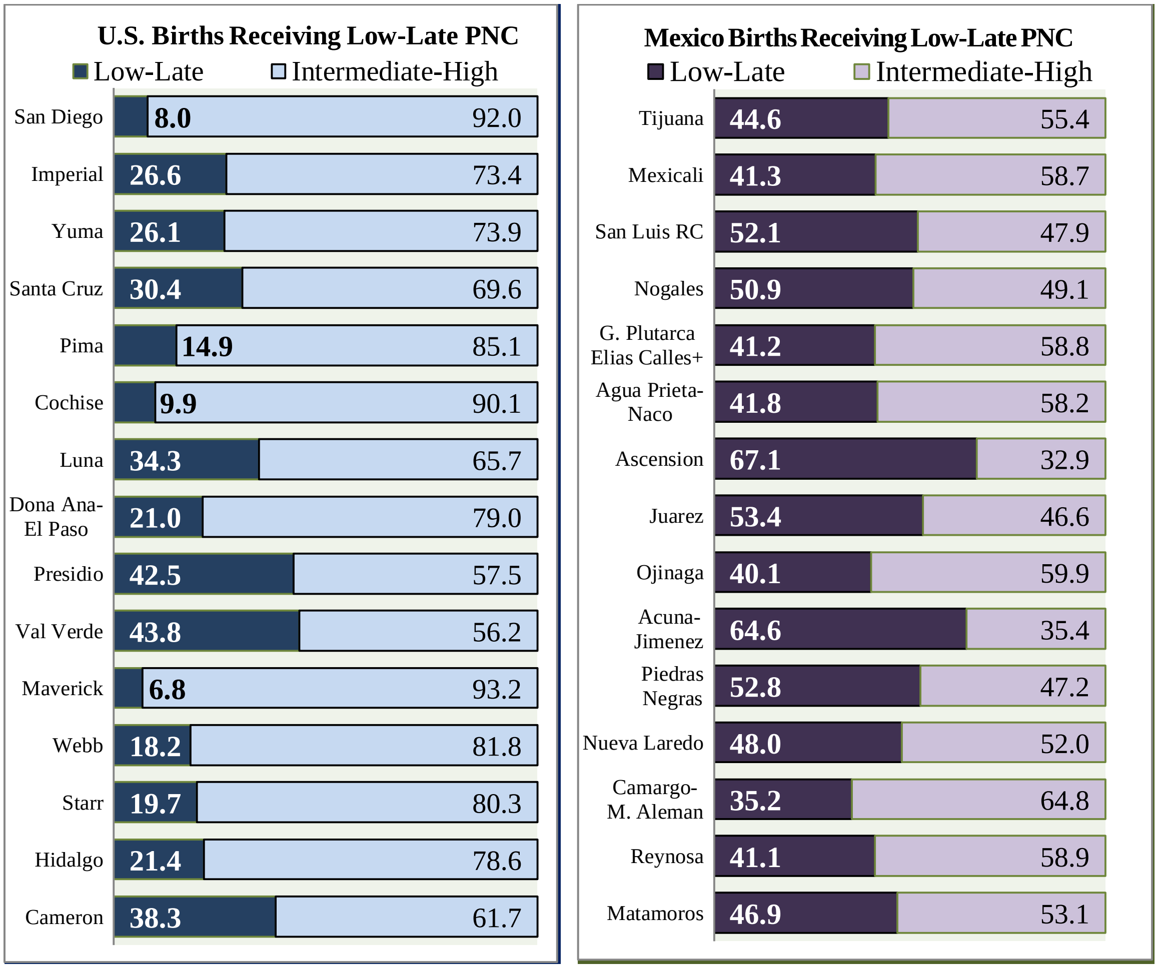
Low or Late Prenatal Care

The final measure used to document adequacy of prenatal care among border residents, the R-GINDEX, also produced low estimates of prenatal care adequacy throughout the border region. Due to the high number of visits required, the disparity between Mexican and American women was increased through the use of this measure. Nearly half (46.4%) of border residents in Mexico received inadequate prenatal care according to this index; Mexican women were 2.7 times as likely as American women to be classified as low-late utilizers of prenatal care (Table 10). Border communities, by state, reflect similar or higher cross-border prevalence ratios.

With the exception of Nuevo Leon, where 29.4% of mothers receive low or late care, border residents in Mexican states exhibit rates of low-late utilization in excess of 40 percent (43.3 – 53.3%). High levels of early (first or second trimester) but inadequate care were strongly correlated with overall low-late utilization rates among Mexican women. Conversely, among American women, rates of early inadequate care were universally low (4.4 – 9.6%). Rather, among U.S. mothers, rates of low-late utilization were elevated relative to rates of third trimester entry and/or no prenatal care.

Rates of low-late utilization are illustrated in figure 6, below, for sister communities along the U.S.-Mexico border. As observed for both timing and quantity of prenatal care use, significant variation exists both within and across the border. However, the relative prevalence of low-late utilization in Mexican municipalities compared with neighboring U.S. sister counties appears more related to number of visits than timing of entry into care. For example, in the municipalities of Acuña and Jimenez in the Mexican state of Coahuila, residents are nearly 50% less likely to enter prenatal care in the third trimester than women across the border in Val Verde County, Texas. Yet, they experience a 50% higher likelihood of low-late utilization.

Figure 6: Proportion of 2009 Births in U.S.-Mexico Sister Counties Receiving Low-Late PNC according to the R-GINDEX



Spatial Analysis of Prenatal Care Distribution

Maps were created to illustrate the quintile distribution of prenatal care adequacy in U.S. border counties and Mexican municipalities according to the measures described above. All maps are provided in Appendix B. An initial map, *A*, displays for the 10 border states the percent of women receiving low-late prenatal care by county. Rates of low-late care are mapped by quintile, with the darkest shade used to represent those counties comprising the fifth, or lowest, quintile for this measure. A second map, *B*, highlights the same distribution, but with a specific focus on the 124 border counties of the region. Counties are labeled using a local FIPS code classification by state.

Subsequently, maps *C* and *D* display the Mexican distribution, also by quintile, of four potential prenatal care measures, first at the state extent, then limited to the 80 border municipalities. As these maps illustrate, six municipalities perform poorly on all indicators, including Tubutama (Sonora); Janos, Ascension and Praxedis G. Guerrero (Chihuahua); and Acuña and Jimenez (Coahuila). In the same way, maps *E* and *F* display the quintile distribution of prenatal care adequacy for U.S. border counties, again for both the state and border-level extents. Six U.S. counties also perform consistently within the fifth quintile regardless of measure. These include Luna County, New Mexico; and Presidio, Val Verde, Duval, Brooks and Cameron Counties in Texas.

Bivariate Analysis and Relative Risk of Low-Late Utilization

Table 11 on the following page displays the results of bivariate and multivariable regression modeling, including both crude and adjusted risk ratios. Overall, Mexican border residents were 2.7 times more likely to utilize low or late levels of prenatal care, compared with American mothers in the border region. State of maternal residence displayed the strongest unadjusted association with low-late utilization of prenatal care (RR=1.84 – 5.79; p<0.001). That is, when compared with mothers in California border counties, risk of low-late prenatal care utilization was 84% higher for women in Arizona and more than 2.5 times as high for women in New Mexico and Texas. Women in Mexican states experienced an increased risk of low-late prenatal care utilization that was 3.2 to 5.8 times as high as among Californians.

Table 11: Crude and adjusted risk ratios for independent risk factors associated with low-late utilization of prenatal care *(missing=22,566, or 8.6%)*

Independent Risk Factors	**Overall Border** (n=262,248)	**Low-Late Utilization** (n=81,842)	**Crude Relative Risk (95% CI)**	**Adjusted Relative Risk (95% CI)**
Maternal Country of Res.				
Mexico	142,224 (54.2%)	61,743 (75.4%)	2.74 (2.70 - 2.78)	NA
U.S.	120,024 (45.8%)	20,099 (24.6%)	1.00	NA
Maternal State of Res.				
Arizona, US	18,208 (6.9%)	3,076 (3.8%)	1.84 (1.77 - 1.93)	1.73 (1.66 - 1.81)
Baja California, MX	56,669 (21.6%)	24,280 (29.7%)	4.86 (4.72 - 5.01)	2.82 (2.73 - 2.92)
California, US	46,481 (17.7%)	4,260 (5.2%)	1.00	1.00
Chihuahua, MX	26,040 (9.9%)	13,080 (16.0%)	5.79 (5.61 - 5.97)	3.15 (3.04 - 3.26)
Coahuila, MX	8,877 (3.4%)	4,048 (5.0%)	5.57 (5.37 - 5.77)	3.33 (3.20 - 2.46)
New Mexico, US	5,080 (1.9%)	1,127 (1.4%)	2.58 (2.43 - 2.74)	2.27 (2.14 - 2.41)
Nuevo Leon, MX	1,658 (0.6%)	462 (0.6%)	3.20 (2.94 - 3.47)	2.06 (1.89 - 2.24)
Sonora, MX	13,220 (5.0%)	5,683 (6.9%)	5.02 (4.85 - 5.20)	2.87 (2.76 - 2.98)
Tamaulipas, MX	35,760 (13.6%)	14,190 (17.3%)	4.71 (4.57 - 4.86)	2.84 (2.74 - 2.94)
Texas, US	50,255 (19.2%)	11,636 (14.2%)	2.54 (2.46 - 2.63)	2.00 (1.93 - 2.07)
Birth Outside Res Co.				
Non-resident	17,353 (6.7%)	4,996 (6.1%)	0.93 (0.91 - 0.95)	0.89 (0.87 - 0.91)
Maternal Nativity				
Mexico	176,993 (67.9%)	70,476 (86.5%)	3.08 (3.02 - 3.14)	1.71 (1.66 - 1.75)
U.S.	75,577 (29.0%)	10,195 (12.5%)	1.00	1.00
Other Latin	775 (0.3%)	219 (0.3%)	2.12 (1.89 - 2.37)	1.83 (1.65 - 2.04)
Other Foreign	7,323 (2.8%)	577 (0.7%)	0.58 (0.54 - 0.63)	1.16 (1.07 - 1.26)
History of Immigration				
Immigrant	44,281 (17.0%)	10,159 (12.5%)	0.67 (0.66 - 0.68)	NA
Maternal Age				
<=18 years	33,435 (12.8%)	15,532 (19.1%)	1.87 (1.84 - 1.90)	1.49 (1.46 - 1.52)
19-24 years	90,238 (34.5%)	32,011 (39.3%)	1.41 (1.40 - 1.43)	1.28 (1.27 - 1.30)
25-34 years	110,779 (42.4%)	27,971 (34.4%)	1.00	1.00
>=35 years	26,874 (10.3%)	5,906 (7.3%)	0.87 (0.85 - 0.89)	0.90 (0.88 - 0.92)
Maternal Education				
Less than High School	77,877 (30.5%)	33,467 (41.7%)	1.27 (1.25 - 1.28)	1.13 (1.12 - 1.15)
High School /=	78,608 (30.8%)	26,713 (33.3%)	1.00	1.00
Some College/Prep	41,247 (16.2%)	8,601 (10.7%)	0.60 (0.59 - 0.62)	0.85 (0.84 - 0.87)
Bachelor's Degree/=	36,316 (14.2%)	8,445 (10.5%)	0.68 (0.67 - 0.70)	0.79 (0.78 - 0.81)
Professional+	20,437 (8.0%)	3,031 (3.8%)	0.44 (0.42 - 0.45)	0.56 (0.54 - 0.58)
Marital Status				
Unmarried	134,113 (51.1%)	53,539 (66.3%)	1.86 (1.84 - 1.88)	1.32 (1.30 - 1.33)
Parity				
1	99,753 (38.1%)	28,990 (35.5%)	1.00	1.00
2	79,588 (30.4%)	23,766 (29.1%)	1.03 (1.01 - 1.04)	1.12 (1.11 - 1.14)
3	49,506 (18.9%)	15,916 (19.5%)	1.11 (1.09 - 1.13)	1.22 (1.20 - 1.24)
4+	33,036 (12.6%)	13,086 (16.0%)	1.36 (1.34 - 1.39)	1.50 (1.47 - 1.53)

Missing data was pervasive in the available datasets, and as such, these data were considered prominently in the analysis. Outcome variables of interest were among the most prone to missing data, in particular, the number of visits. Nationally, 25,014 (7.0%) Mexican birth records were missing a reported number of prenatal care visits received;

7,150 records (5.0%) from Mexican border residents were missing this variable. In contrast, data on timing of entry were missing for 2.0% of Mexican border residents. In the United States, overall levels of missingness for these variables constituted 0.3% (n=381) and 0.6% (760), respectively. Table 12, below, reflects the distribution of missing prenatal care data according to population demographics.

Table 12: Distribution of missing data for either number of visits, timing of prenatal care entry or gestational age at birth.

Variable	Overall Border Population (n=262,248)	Missing Prenatal Variables (n=10,244)
Maternal Country of Residence		
Mexico	142,224 (54.2%)	9,032 (88.2%)
U.S.	120,024 (45.8%)	1,212 (11.8%)
Maternal State of Residence		
Arizona, US	18,208 (6.9%)	99 (1.0%)
Baja California, MX	56,669 (21.6%)	2,464 (24.1%)
California, US	46,481 (17.7%)	227 (2.2%)
Chihuahua, MX	26,040 (9.9%)	1,511 (14.8%)
Coahuila, MX	8,877 (3.4%)	983 (9.6%)
New Mexico, US	5,080 (1.9%)	338 (3.3%)
Nuevo Leon, MX	1,658 (0.6%)	88 (0.9%)
Sonora, MX	13,220 (5.0%)	931 (9.1%)
Tamaulipas, MX	35,760 (13.6%)	3,055 (29.8%)
Texas, US	50,255 (19.2%)	548 (5.3%)
Birth Outside County of Residence		
Missing	1 (0.0%)	1 (0.0%)
Non-resident	17,353 (6.7%)	884 (8.6%)
Maternal Nativity		
Missing	1,580 (0.6%)	113 (1.1%)
Mexico	176,993 (67.9%)	9,186 (89.7%)
U.S.	75,577 (29.0%)	845 (8.2%)
Other Country (Latino)	775 (0.3%)	18 (0.2%)
Other Country (non-Latino)	7,323 (2.8%)	82 (0.8%)
History of Immigration		
Missing	1,580 (0.6%)	113 (1.1%)
Resides outside country of origin	44,281 (17.0%)	419 (4.1%)
Maternal Age		
Missing	922 (0.4%)	174 (1.7%)
<=18 years	33,435 (12.8%)	1,645 (16.1%)
19-24 years	90,238 (34.5%)	3,715 (36.3%)
25-34 years	110,779 (42.4%)	3,867 (37.7%)
>=35 years	26,874 (10.3%)	843 (8.2%)
Maternal Education		
Missing	7,763 (3.0%)	667 (6.5%)
Less than High School	77,877 (30.5%)	3,203 (31.3%)
High School or equivalent	78,608 (30.8%)	3,121 (30.5%)
Some College/Preparatory	41,247 (16.2%)	1,038 (10.1%)
Bachelor's Degree or equivalent	36,316 (14.2%)	1,396 (13.6%)
Professional+	20,437 (8.0%)	819 (8.0%)
Marital Status		
Missing	2,378 (0.9%)	456 (4.5%)
Unmarried	134,113 (51.1%)	5,517 (53.9%)
Parity		
Missing	365 (0.1%)	163 (1.6%)
1	99,753 (38.1%)	3,819 (37.3%)
2	79,588 (30.4%)	2,946 (28.8%)
3	49,506 (18.9%)	2,030 (19.8%)
4+	33,036 (12.6%)	1,286 (12.6%)

Other demographic characteristics were also associated with low-late prenatal care utilization. Compared with women 25-34 years old, risk of low-late utilization was increased 41% among women ages 19-24 and 87% among women age 18 or younger. Women age 35 years and older exhibited a 13% reduced risk of low-late utilization. Likewise, compared with mothers who had completed high school or the equivalent, women with less education were 27% less likely to receive low-late utilization, and risk was reduced among mothers with higher levels of education. Unmarried women displayed an 86% increased risk in low-late utilization, while also risk increased gradually with higher parity. Women who delivered outside their county of residence displayed a small but significant 7% reduced risk of low-late care. Those who reported current residence in a country other than their country of origin displayed a 67% reduce risk of low-late utilization.

Adjusted Measures of Effect based on Multivariable Regression Modeling

The primary effect variable, *maternal state of residence*, remained the strongest predictor of low-late utilization of prenatal care in the adjusted model (Adjusted RRs: 1.73 – 3.33). Magnitude of the adjusted relative risk declined slightly but remained significant after the inclusion of all independent covariates within the model, including maternal nativity, non-residency in the county of birth, age, education, marital status, and parity. Main effects and all adjusted covariates resulting from multivariable analysis are also included in Table 11, above.

Chapter 5: Discussion, Conclusions & Public Health Implications

Current levels of prenatal care utilization in the U.S.-Mexico border region

This study provides a first complete look at the distribution of prenatal care adequacy throughout the U.S.-Mexico border region, based on a binational dataset of 2009 births to residents of both countries. A considerable strength of the study was the comprehensive manner in which adequacy was approached, basing conclusions on multiple recognized measures of prenatal care utilization. Chief among adopted measures was a dichotomous variable, low-late utilization, constructed from an existing adequacy index in use since the mid-1990s (R-GINDEX). Use of this variable enabled an evaluation of adequacy based on total visits, adjusted for both trimester of first visit and gestational age at birth. The distribution of this variable and important implications for its use are outlined in greater depth, below, following an initial discussion of adequacy based on more traditional measures: 1) any care, and 2) timing of first visit.

While binational disparities in access might be expected for measures of timing or any care, women residing in the United States and Mexico appear to fare equally well. For example, in both countries, roughly five percent (5.1%) of women reported receiving no prenatal care during their pregnancy. A minimal amount of variation *is* observed, however, across states and in comparing border to non-border residents. Consider, for example, the nine-fold increase in prevalence of no care between Texas (9.3%) and California (1.1%), or the contrast between Texas border (9.3%) and non-border (3.8%) counties. One potential explanation might pertain purely to data quality, discussed more fully at the end of this chapter. In short, border county residents may be more likely to transfer their care across the border during the course of their pregnancy. This, in turn, introduces the possibility that initial care will go undocumented on the birth certificate due to a lack of complete information in the final prenatal record. Regarding variation across states, this may be explained by factors outside of this analysis, but influenced by state-level policies, priorities and community demographics, such as population density; provider reimbursement rates; socioeconomic status and relative affluence; and eligibility criteria for public funding. No modeling was performed to evaluate an association between *any* care and state of residence, but it is assumed that many of the same demographic factors contribute to varying levels of any care as did in relation to LLU.

Once any care is achieved, trimester of first visit becomes an important indicator as well, in that early care provides the greatest opportunity for timely intervention to prevent or mediate risk factors for maternal and perinatal morbidity. It is interesting to note that despite considerable differences between the United States and Mexico in observed demographic characteristics, cross-border rates of women entering care in the first trimester are quite similar (68.4% in the U.S. and 69.2% in Mexico). A higher degree of disparity at the state level, coupled with variation in the relative size of state populations, results in absolute numbers of border residents failing to receive first trimester care that range from 335 (20.5%) in Nuevo Leon and 1,974 (40.7%) in New Mexico to more than 20,205 (41.5%) in Texas and 14,756 (26.4%) in Baja California. It is hoped that local-level estimates of the absolute numbers of pregnancies with late or no care, particularly those presented for sister communities along the border, will prove useful in resource allocation and policy decisions made in local jurisdictions.

The degree to which Mexican states have met and exceeded Healthy Border 2010 targets is remarkable—over two-thirds of Mexican mothers residing in the border region reported an initial visit in the first 12 weeks of pregnancy, with nearly 90 percent reporting care in either the first or second trimester. As demonstrated above, this indicator is subject to variation both along and across the border; however, at the aggregate level, all Mexican states well-exceed the target of 70% coverage in the first six months. In both the U.S. and Mexico, the greatest amount of variation in this indicator appears to occur between border and non-border counties or municipalities within states (more than a two-fold difference in each country), and this ongoing disparity should be considered when establishing future targets.

Based on the current findings, it is unclear why Mexico and the United States established such different targets for the proportion of women receiving early care. Unlike Mexico, the United States was unable to attain its target of 85 percent first trimester visits, at least by 2009. Granted, vital records practices had changed by 2006 for two of the four U.S. border states (California and Texas), with New Mexico following suit shortly thereafter—each of these states adopted modified data collection processes after established border targets were set. Importantly, more rigorous reporting criteria implemented with the 2003 version of the U.S. birth certificate has been shown to reduce documented rates of prenatal care by as much as 10 percent in some early adopting states [33]. This might, in large part, explain the seemingly aggressive target established for U.S. border counties by the year 2010. Still, Arizona, the only U.S. border state yet to adopt the revised certificate, was capable only of 70 percent early initiation in border counties in 2009 (non-border counties approached the goal, achieving 82.8 percent first trimester entry). Once again, based on the results of this analysis, targets established for first trimester prenatal care entry in U.S. border counties should more closely align with Mexican border targets, rather than those for non-border counties.

Relatively low cross-border variation in the proportions of women receiving an early first visit provides an opportunity to consider domestic disparities. In particular, lowest levels of first trimester care were found in the U.S. counties of Presidio, Val Verde and Cameron in Texas, as well as in the Mexican municipalities of Acuña and Jimenez. The additional cross-border disparity observed in Presidio County, given its relatively small total population, might signal either a disproportionate lack of access to services in the county or might indicate a larger proportion of cross-border health seeking resulting in undocumented care. In contrast, rates were universally low on both sides of the border in Val Verde County and the paired municipalities of Acuna-Jimenez. The slightly larger population here might advocate greater resource allocation to these jurisdictions.

In contrast to timing of initial visit, a low-late utilization measure based on Alexander and Kotelchuck's R-GINDEX illuminates vastly different rates of inadequacy in Mexico (46.4%) and the United States (16.9%). When comparing sister cities across the border, a nearly two-fold difference or greater was observed in all but five communities. In the community displaying the most extreme disparities, women in the Mexican municipality of Piedras Negras were classified as receiving low or late care at a rate six times that of women in Maverick County across the border. Though Piedras Negras experienced three times the births in 2009, the absolute difference in numbers of women receiving low-late care remains conspicuous: 70 mothers in Maverick, compared with over 1,600 in Piedras Negras. In contrast, when communities shared similar rates of low-late utilization (i.e., Presidio-Ojinaga and Cameron-Matamoros), an inflated county rate in the United States tended to serve as the equalizing factor. No Mexican municipality enjoyed a rate of low-late utilization below 30%, and more than one-third displayed rates in excess of 50% prevalence.

In applying a measure of low-late utilization, the disparities it projects across the border clearly indicate the need for a review of its component parts. Doing so may illuminate factors driving the rates in each country. Based on the results of this study, it is clear that in the United States, highest levels of low-late utilization appear to be closely related to a high proportion of women reporting either an absence of care or first visit in the third trimester (primarily, those receiving no care). However, when rates of no care are low, as is the case in most Mexican border states, the difference appears to be driven instead by an inadequate number of visits, or fewer than eight visits for a 40-week pregnancy beginning care in the first trimester (8-12 visits is considered 'intermediate' care at 40 weeks). For example, "adequate" care requires entry in the first trimester, but it also calls for a proportionately larger number of visits based on the total time between start of care and delivery. Rates of "intermediate" care, requiring fewer visits, were much more similar across states, but the numbers of women receiving this level of care were insufficient to offset differences between the countries. After all, when compared to the average number of visits among Mexican women, 7.0 (SD 3.4), an 11-visit schedule represents over one standard deviation from the mean. Thus, among Mexican women, even where rates of first trimester entry are high, levels of low-late care appear disproportionate in comparison with American women due to a low number of total visits. More interesting is the fact that U.S. women entering care late still tend to receive an adequate *number* of visits—and more visits than Mexican women entering early.

Implications for variation across adequacy indicators—lessons for future measurement

It is clear from the results of this study that estimates of adequacy vary greatly when comparing timing- versus visit-driven measures of utilization. Given similar cross-border levels of first trimester entry (slightly improved, in fact, among Mexican mothers), it is obvious that the relative difference between adequacy rates observed in the United States and Mexico lies in an emphasis on number of visits. In considering the policy implications for this finding, it may be useful to reflect on the current literature surrounding prenatal care delivery. That is, which of these elements, timing or quantity, is more critical in achieving healthy maternal and perinatal outcomes? This study set out to produce a descriptive, binational assessment of prenatal care adequacy in the border region, as measured primarily according to an index variable of low-late utilization. More important, however, the findings tend to support conclusions of previous authors, questioning the validity of such existing measures. That is, do they result in an accurate understanding of the quality and levels of care women receive? Why, if the measures are valid, do the women classified as receiving low care often experience similar or improved health outcomes? One concern is that efforts to improve rates of low-late care may result in a push for increased visits at the expense of efforts to improve rates of early care.

Each measure of prenatal care adequacy is imbued with certain strengths and weaknesses. Timing of entry is a measure frequently used given its utility in identifying those women who have been precluded from early screening, health promotion, and management of pre-pregnancy risk factors. First trimester initiation serves as a useful benchmark since the majority of early screening and risk identification occurs in this period; and the majority of national and border-specific objectives have framed measurement of first visit timing in this way. Similarly, late entry into care or measurement of any care (versus no care) accomplishes the aim of identifying women receiving the least beneficial (or no) levels of service, who are most likely to miss critical opportunities for screening and early management of risk factors. However, measures that exclusively consider timing of entry into the care system fail to adequately capture the amount of care a woman ultimately receives; that is, even if she enters care early, her opportunities to receive the full benefit of screening—the intervention—may be limited if she discontinues or delays further care. Also compromised are her opportunities for risk identification when such factors appear later in pregnancy.

Based on an indicator of low-late utilization, Mexican residents tended to receive a lower *quantity* of care, overall. That is, U.S. women tended to enter prenatal care at the same time or later than their Mexican counterparts and still managed to obtain higher amounts of care when measured in number of discrete visits. Given this distinction, the question remains as to whether or not the present findings should influence policy aimed at improving numbers of visits in Mexican municipalities along the border. Certainly, there is value in ensuring that adequate content is covered throughout visits received, and in ensuring that this content is delivered sufficiently early. It appears, however, that receiving a particular number of visits is less meaningful.

Importantly, there is no way to distinguish between eight visits received at recommended intervals, as compared with eight visits received in the final month of pregnancy as a result of complications. If the latter were the case, it wouldn't be surprising to find high *quantities* of prenatal care associated with poor birth outcomes, as some studies have found in the United States.

In the same vein, it is also possible that a portion of the disparities between the United States and Mexico are due to disparities in the rates of preterm delivery. Alexander and Kotelchuck note that women delivering at earlier gestational ages require a lower number of visits to exceed thresholds for both adequacy and intensive use of care [35]. This was particularly the case in application of the APNCU index. However, the same presumably applies to use of the R-GINDEX as well, given its similar adjustment of recommended visits based on gestational age at birth.

Assuming providers adhere to one of the several established content guidelines, timing and spacing of visits may be much more important than quantity; yet, no mechanism for documenting the adequacy of spacing is currently available. Further research is needed to understand the spacing and content of visits before policy priorities are established for numbers of visits. There is also a need to integrate spacing into the indices currently used to *classify* adequacy of care.

Implications for binational practice standards & consensus building to improve continuity of care along the border

Indicators available to classify adequacy of care are dependent on accepted standards that define appropriate levels of education, screening, monitoring and treatment. Given projected levels of cross-border movement to obtain obstetric and other health services, the need for common standards which facilitate continuity of pregnancy care are as essential as integrated reproductive health surveillance systems. Yet, in the process of determining appropriate measures for the current study, more than a dozen prenatal care schedules and guidelines were identified, which differentially quantify and categorize levels of necessary care.

Aside from the obvious inequities in clinical standards of care that result, variability in measures can have several other implications. For example, a lack of comparability across studies evaluating the impact of prenatal care on birth outcomes impacts our ability to generalize findings to broader practice. Conflicting standards of care may also impact the levels of health coverage made available to women, as well as the personal and social burden of pregnancy-related health expenditures resulting from excess numbers of required visits (e.g., direct expense, transportation, work leave, childcare). Additionally, in communities with low health literacy, confusion resulting from poorly communicated expectations of pregnancy care behaviors may also result in further under-utilization of available services.

Thus, in order to improve prenatal care utilization in the border region, as well as to measure the impacts of increased service delivery, it will be necessary to address the variations currently observed in available guidelines and care standards. Building on current collaboration and initial steps toward binational reproductive health surveillance, partners in the border region are in a unique position to bridge this critical gap.

Study Limitations

Though not precluding the application of these findings to policy decisions and practice along the border, several important limitations must be considered when interpreting the results of this study. These include five key issues: 1) combined analysis of birth records not directly comparable due to variation in inter-state and inter-national data collection tools and methods; 2) high levels of missing data; 3) the potential for under-reporting of outcome variables as a result of cross-border care seeking patterns; 4) absence of important covariates which were not common to each dataset; and 5) the questionable utility of prenatal care measures, given their ability (or inability) to inform the efficacy of prenatal care, generally. These limitations are discussed in turn, below.

It is of foremost importance to acknowledge the impact that variation in data collection methods—both in terms of question format and documentation standards—may influence the reported findings. State and county-level comparisons of prenatal indicators and explanatory variables may result in considerable bias due to substantive differences in the collection of data [33]. For example, the 2003 revision of the U.S. standard birth certificate now collects the actual date of first prenatal care visit based on the mother's prenatal care records, while the previous 1989 version requests only self-reported timing of entry.

In addition, missing data was pervasive throughout records in the analyzed dataset. Though largely missing at random, several variables displayed comparatively high levels of missingness or slight variation across to strata, and these should be noted. Of primary concern were substantial levels of missingness among outcome variables, namely number of visits, with missingness in the combined R-GINDEX variable also impacted by data missing for timing of entry and gestational age at birth. Among covariate data, maternal education and marital status appeared most problematic. In closer review, California reported a disproportionately large amount of missing data on maternal education (n=4,811), accounting for 96 percent of missing U.S. values, and nearly two-thirds of values missing for the entire population of births. Missing education data for Mexico, though substantial, was more evenly distributed across border states, and is assumed not to be the result of any systematic reporting bias.

Additionally, cross-border care seeking has important implications for accurate documentation of prenatal care utilization. As has been previously mentioned, inaccurate reporting may result if a woman changes providers during the course of her pregnancy or if she seeks services across the border, where no mechanism of follow-up or visit confirmation is available for recording in the prenatal record.

Fourthly, had *domestic* regression models been developed to assess the independent association of maternal state of residence and prenatal care utilization, they might have adjusted for several additional covariates. That is, the combined, binational model was limited to potential confounders common to both datasets. To ensure comparability of measures of effect, it was necessary to exclude several variables known in the literature to be associated with health care seeking. Socioeconomic status measures, for example, were not available within the 2009 U.S. data set; measures of preconception health status and race were not captured in the Mexican data set.

Finally, it is important to remember that data on the distribution, or spacing, of subsequent visits throughout pregnancy were unavailable when restricted to vital statistics records. Rather, current data collection is founded on the assumption that the earlier the initiation of prenatal care and the larger the number of visits, the greater the provider capacity for early screening and behavioral intervention.

Recommendations for future research

Despite these limitations, one important accomplishment of the study was affirmation that maternal state of residence remains the strongest predictor of low or late prenatal care utilization after controlling for other independent risk factors, such as maternal age and marital status. Given this finding, further investigation is warranted into the state-level factors influencing access to adequate prenatal care. Specifically, models should be built to explore in greater depth characteristics such as provider coverage levels; wealth and income distribution; payor sources and public assistance eligibility; population density and urbanity; preconception service utilization; and a more sophisticated understanding of immigration status and its impact on both service delivery and utilization. Indeed, the non-uniform distribution of disparities observed across all measures of care in the present study appear to indicate that local-level variations in policy and socio-cultural attributes also play an important role in achieving high levels of prenatal care utilization.

It will also be important to link natality files to data sources which provide more detailed information on the location, spacing and content of prenatal care received. While this research successfully serves to provide a population-level assessment of current care patterns for state and local planning purposes, and while this assessment has been based on well-established measures of prenatal care, discrepancies in apparent need across various indicators should raise some concern. Perhaps there is a need to increase the frequency of prenatal visits among Mexican women; but it is also possible that spacing and content of visits are more appropriate in Mexico despite a lower number of visits. Current tools available to measure adequacy are insufficient to address these questions. New indices of adequacy are therefore needed to ensure that the prenatal care patterns described are valid reflections of the most vulnerable populations in the border region—that is, those most benefited by programs aimed at expansion of access to care.

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Appendix A: Municipalities, Counties & Sister Cities of the U.S.-Mexico Border Region

A-1. Mexican Border Municipalities, by State

A-2. United States Border Counties, by State

A-3. Sister County (City) Pairs along the U.S.-Mexico Border

A-1. Mexican Border Municipalities, by State

	Municipality	FIPS
Baja California	Ensenada	001
	Mexicali	002
	Tecate	003
	Tijuana	004
	Playas de Rosarito	005
Coahuila	Acuna	002
	Allende	003
	Guerrero	012
	Hidalgo	013
	Jimenez	014
	Juarez	015
	Morelos	019
	Nava	022
	Ocampo	023
	Piedras Negras	025
	Sabinas	028
	Villa Union	037
	Zaragoza	038
Chihuahua	Ahumada	001
	Ascension	005
	Coyame del Sotol	015
	Guadalupe	028
	Janos	035
	Juarez	037
	Manuel Benavides	042
	Nuevo Casas Grandes	050
	Ojinaga	052
	Praxedis G. Guerrero	053
Nuevo Leon	Agualeguas	002
	Aldamas, Los	003
	Anahuac	005
	Cerralvo	011
	China	013
	Doctor Coss	015
	Doctor Gonzalez	016
	General Bravo	020
	General Trevino	023
	Herreras, Los	027
	Higueras	028
	Lampazos de Naranjo	032
	Marin	034
	Melchor Ocampo	035
	Paras	040
	Ramones, Los	042
	Sabinas Hidalgo	044
	Vallecillo	050

	Municipality	FIPS
Sonora	Agua Prieta	002
	Altar	004
	Arizpe	006
	Atil	007
	Bacoachi	011
	Bavispe	015
	Caborca	017
	Cananea	019
	Cucurpe	022
	Fronteras	027
	Imuris	035
	Magdalena	036
	Naco	039
	Nacozari de Garcia	041
	Nogales	043
	Oquitoa	046
	Puerto Penasco	048
	San Luis Rio Colorado	055
	Santa Ana	058
	Santa Cruz	059
	Saric	060
	Tubutama	065
	General Plutarco Elias Calles	070
Tamaulipas	Camargo	007
	Guerrero	014
	Gustavo Diaz Ordaz	015
	Matamoros	022
	Mendez	023
	Mier	024
	Miguel Aleman	025
	Nuevo Laredo	027
	Reynosa	032
	Rio Bravo	033

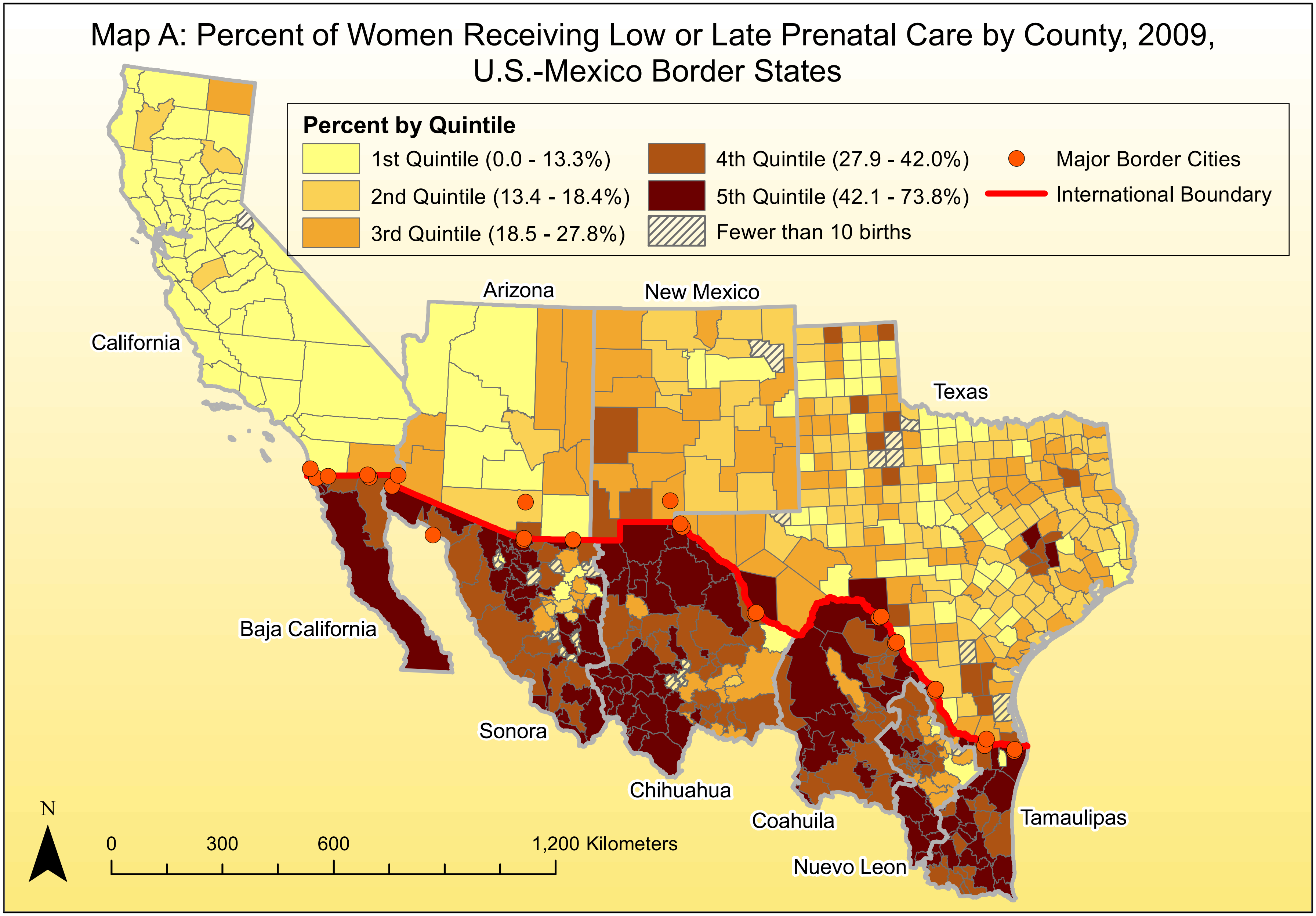
A-2. United States Border Counties, by State

	County	FIPS
Arizona	Cochise	003
	Pima	019
	Santa Cruz	023
	Yuma	027
California	Imperial	025
	San Diego	073
New Mexico	Dona Ana	013
	Grant	017
	Hidalgo	023
	Luna	029
	Otero	035
	Sierra	051
Texas	Brewster	043
	Brooks	047
	Cameron	061
	Crockett	105
	Culberson	109
	Dimmit	127
	Duval	131
	Edwards	137
	El Paso	141
	Frio	163
	Hidalgo	215
	Hudspeth	229
	Jeff Davis	243
	Jim Hogg	247
	Kenedy	261
	Kinney	271
	La Salle	283
	McMullen	311
	Maverick	323
	Pecos	371
	Presidio	377
	Real	385
	Reeves	389
	Starr	427
	Sutton	435
	Terrell	443
	Uvalde	463
	Val Verde	465
	Webb	479
	Willacy	489
	Zapata	505
	Zavala	507

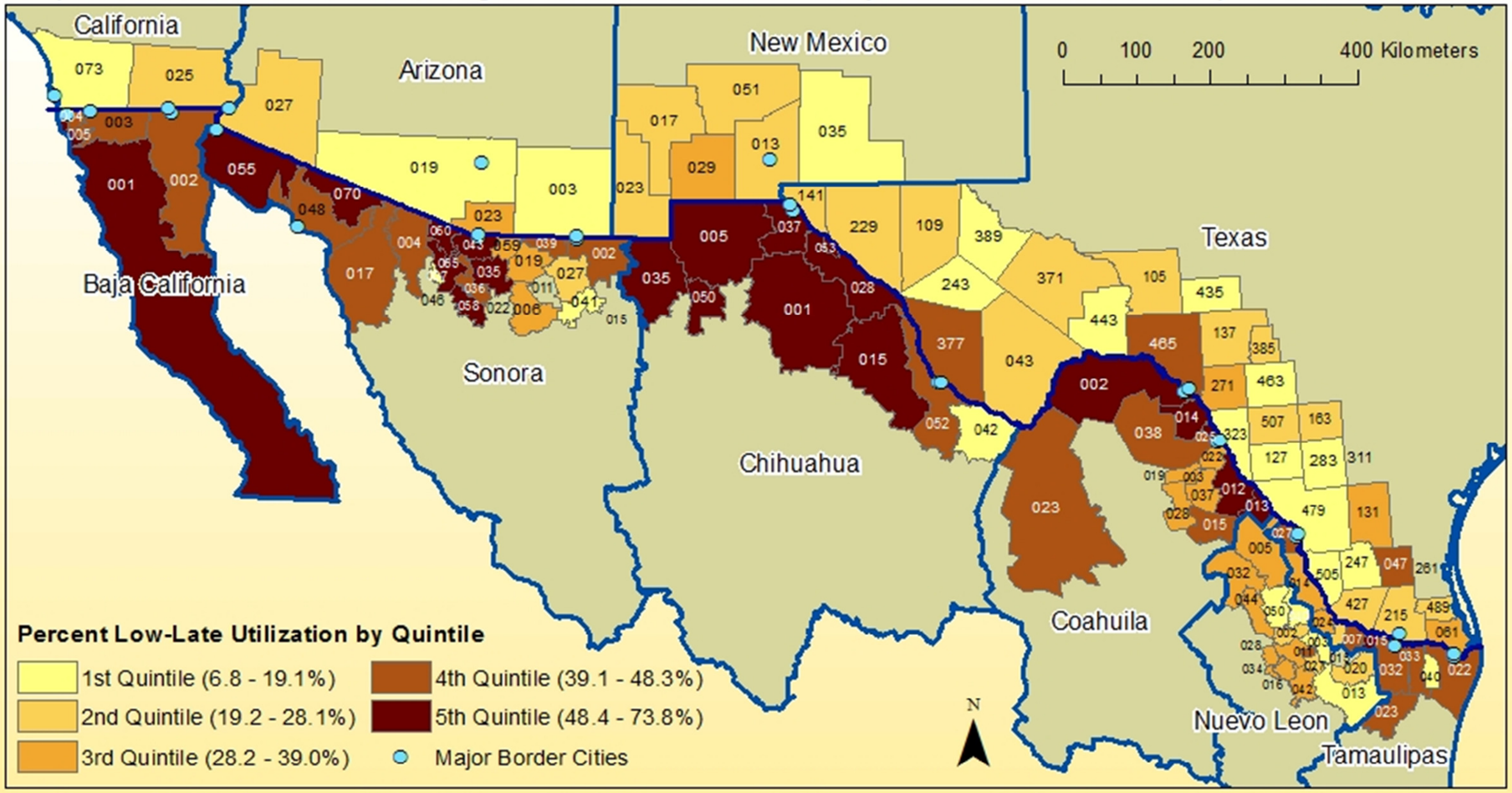
A-3. Sister County (City) Pairs

1. San Diego (San Diego), California – Tijuana, Baja California
2. Imperial (Calexico), California – Mexicali, Baja California
3. Yuma (Yuma), Arizona – San Luis Rio Colorado, Sonora
4. Pima (Tuscon), Arizona – General Plutarco Elias Calles/Caborca/Puerto Penasco, Sonora
5. Santa Cruz (Nogales), Arizona – Nogales, Sonora
6. Cochise (Douglas), Arizona – Agua Prieta/ Naco, Sonora
7. Luna (Columbus), New Mexico – Ascension (Las Palomas), Chihuahua
8. El Paso (El Paso), Texas/ Doña Ana (Las Cruces), New Mexico – Juarez (Ciudad Juarez), Chihuahua
9. Presidio (Presidio), Texas – Ojinaga, Chihuahua
10. Val Verde (Del Rio), Texas – Acuña (Ciudad Acuña), Coahuila
11. Maverick (Eagle Pass), Texas – Piedras Negras, Coahuila / Kickapoo Nation
12. Webb (Laredo), Texas – Nuevo Laredo, Tamaulipas
13. Starr, Texas – Camargo/ Miguel Aleman, Tamaulipas
14. Hidalgo (McAllen), Texas – Reynosa, Tamaulipas
15. Cameron (Brownsville), Texas – Matamoros, Tamaulipas

Appendix B: Spatial Mapping of Prenatal Care Indices in the U.S.-Mexico Border Region


Map A: Percent of Women Receiving Low or Late Prenatal Care by County, 2009, U.S.-Mexico Border States
Percent by Quintile
1st Quintile (0.0 - 13.3%)
2nd Quintile (13.4 - 18.4%)
3rd Quintile (18.5 - 27.8%)
4th Quintile (27.9 - 42.0%)
5th Quintile (42.1 - 73.8%)
Fewer than 10 births
Major Border Cities
International Boundary
California
Arizona
New Mexico
Texas
Baja California
Sonora
Chihuahua
Coahuila
Nuevo Leon
Tamaulipas
N
0
300
600
1,200 Kilometers

Map B: Percent of Women Receiving Low or Late Prenatal Care by Border Counties & Municipalities, 2009



Arizona
003 Cochise
019 Pima
023 Santa Cruz
027 Yuma

Baja California
001 Ensenada
002 Mexicali
003 Tecate
004 Tijuana
005 Playas de Rosarito

California
025 Imperial
073 San Diego

Chihuahua
001 Ahumada
005 Ascension
015 Coyame del Sotol
028 Guadalupe
035 Janos
037 Juarez
042 Manuel Benavides
050 N. Casas Grandes
052 Ojinaga
053 Praxedis G. Guerrero

Coahuila
002 Acuna
003 Allende
012 Guerrero
013 Hidalgo

Coahuila (cont)
014 Jimenez
015 Juarez
019 Morelos
022 Nava
023 Ocampo
025 Piedras Negras
028 Sabinas
037 Villa Union
038 Zaragoza

New Mexico
013 Dona Ana
017 Grant
023 Hidalgo
029 Luna
035 Otero
051 Sierra

Nuevo Leon
002 Agualeguas
003 Los Aldamas
005 Anahuac
011 Cerralvo
013 China
015 Doctor Cross
016 Doctor Gonzalez
020 Gen Bravo
023 Gen Trevino
027 Herreras, Los
028 Higueras
032 Lampazos de Naranjo
034 Marin
035 Melchor Ocampo
040 Paras
042 Ramones, Los
044 Sabinas Hidalgo
050 Vallecillo

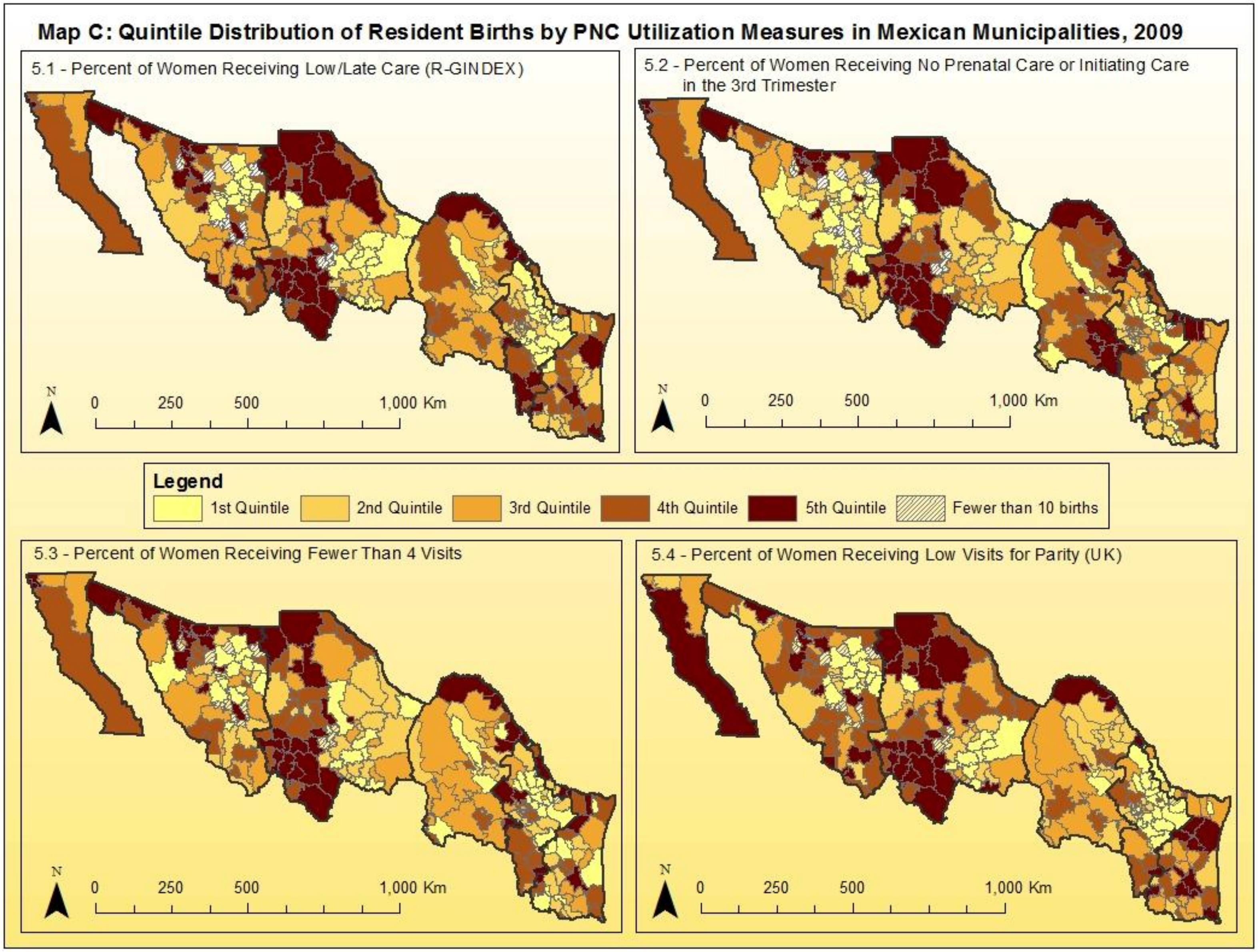
Sonora
002 Agua Prieta
004 Altar
006 Arizpe
007 Atil
011 Bacoachi
015 Bavispe
017 Caborca
019 Cananea
022 Cucurpe
027 Fronteras
035 Imuris
036 Magdalena
039 Naco
041 Nacozari de Garcia
043 Nogales
046 Oquitoa
048 Puerto Penasco
055 San Luis Rio Colorado

Sonora (cont)
058 Santa Ana
059 Santa Cruz
060 Saric
065 Tubutama
070 Gen Plutarco Elias

Tamaulipas
007 Camargo
014 Guerrero
015 Gustavo Diaz Ordaz
022 Matamoros
023 Mendez
024 Mier
025 Miguel Aleman
027 Nuevo Laredo
032 Reynosa
033 Rio Bravo
040 Valle Hermoso

Texas
043 Brewster
047 Brooks
061 Cameron
105 Crockett
109 Culberson
127 Dimmit
131 Duval
137 Edwards
141 El Paso
163 Frio
215 Hidalgo
243 Jeff Davis
247 Jim Hogg
261 Kenedy
271 Kinney
283 La Salle
311 McMullen
323 Maverick

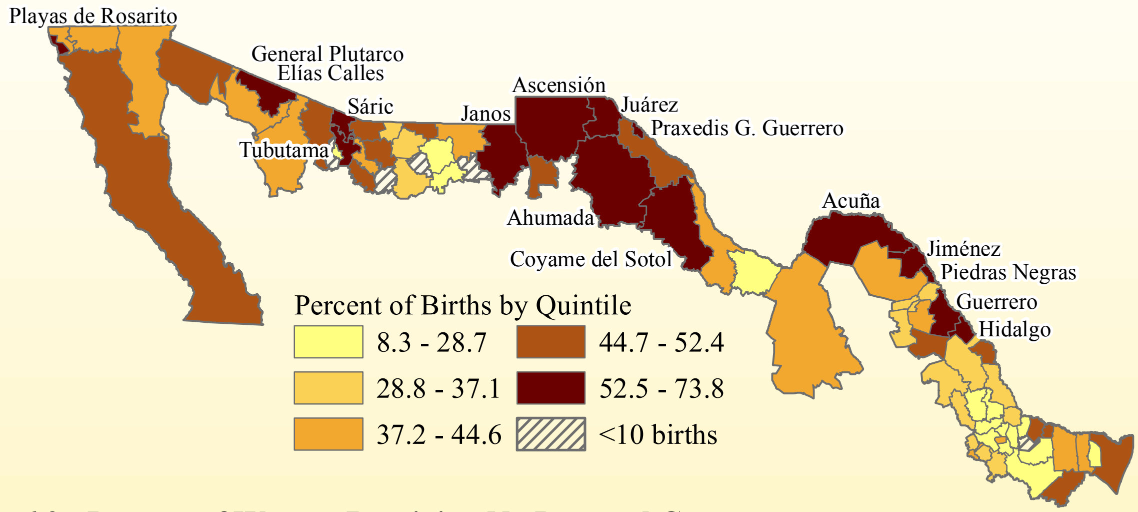
Texas (cont)
371 Pecos
377 Presidio
385 Rea
389 Reeves
427 Starr
435 Sutton
443 Terrell
463 Uvalde
465 Val Verde
479 Webb
489 Willacy
505 Zapata
507 Zavala



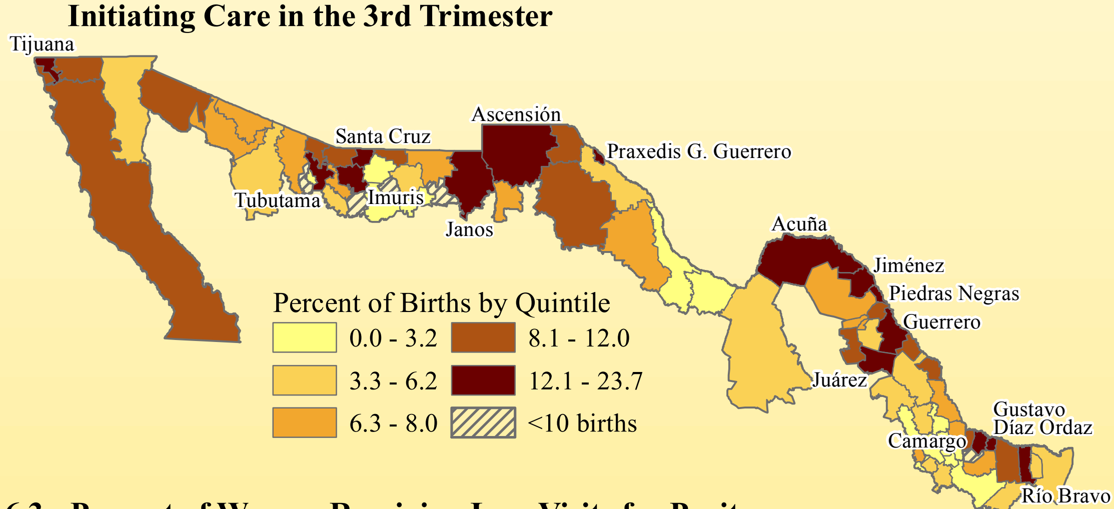
Map C: Quintile Distribution of Resident Births by PNC Utilization Measures in Mexican Municipalities, 2009
5.1 - Percent of Women Receiving Low/Late Care (R-GINDEX)
5.2 - Percent of Women Receiving No Prenatal Care or Initiating Care in the 3rd Trimester
Legend
1st Quintile
2nd Quintile
3rd Quintile
4th Quintile
5th Quintile
Fewer than 10 births
5.3 - Percent of Women Receiving Fewer Than 4 Visits
5.4 - Percent of Women Receiving Low Visits for Parity (UK)
N
0
250
500
1,000 Km

Map D: Quintile Distribution of Resident Births by Prenatal Care Utilization Measures in Mexico Border Municipalities, 2009

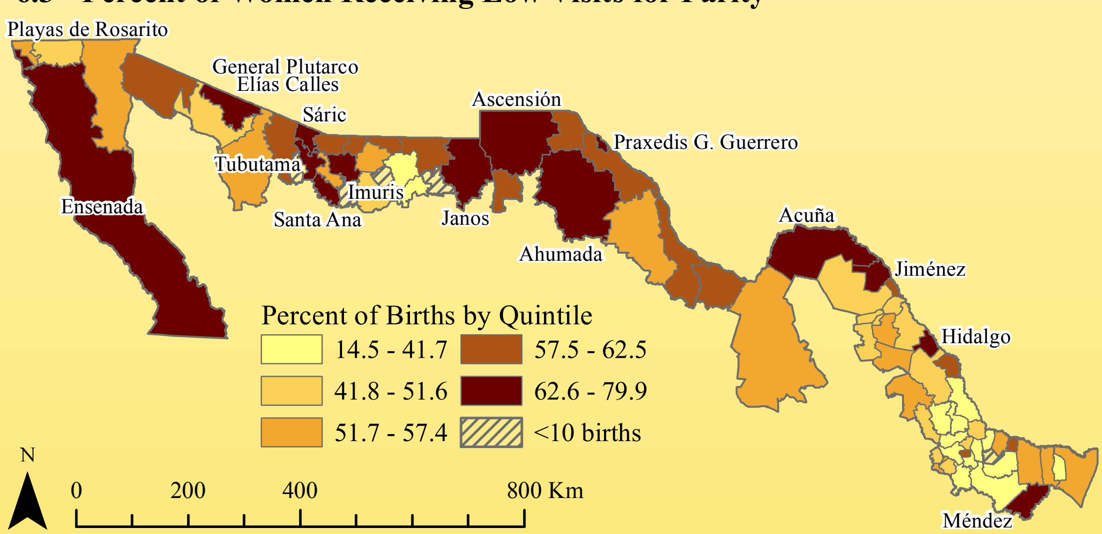
6.1 - Percent of Women Receiving Low/Late Care (R-GINDEX)

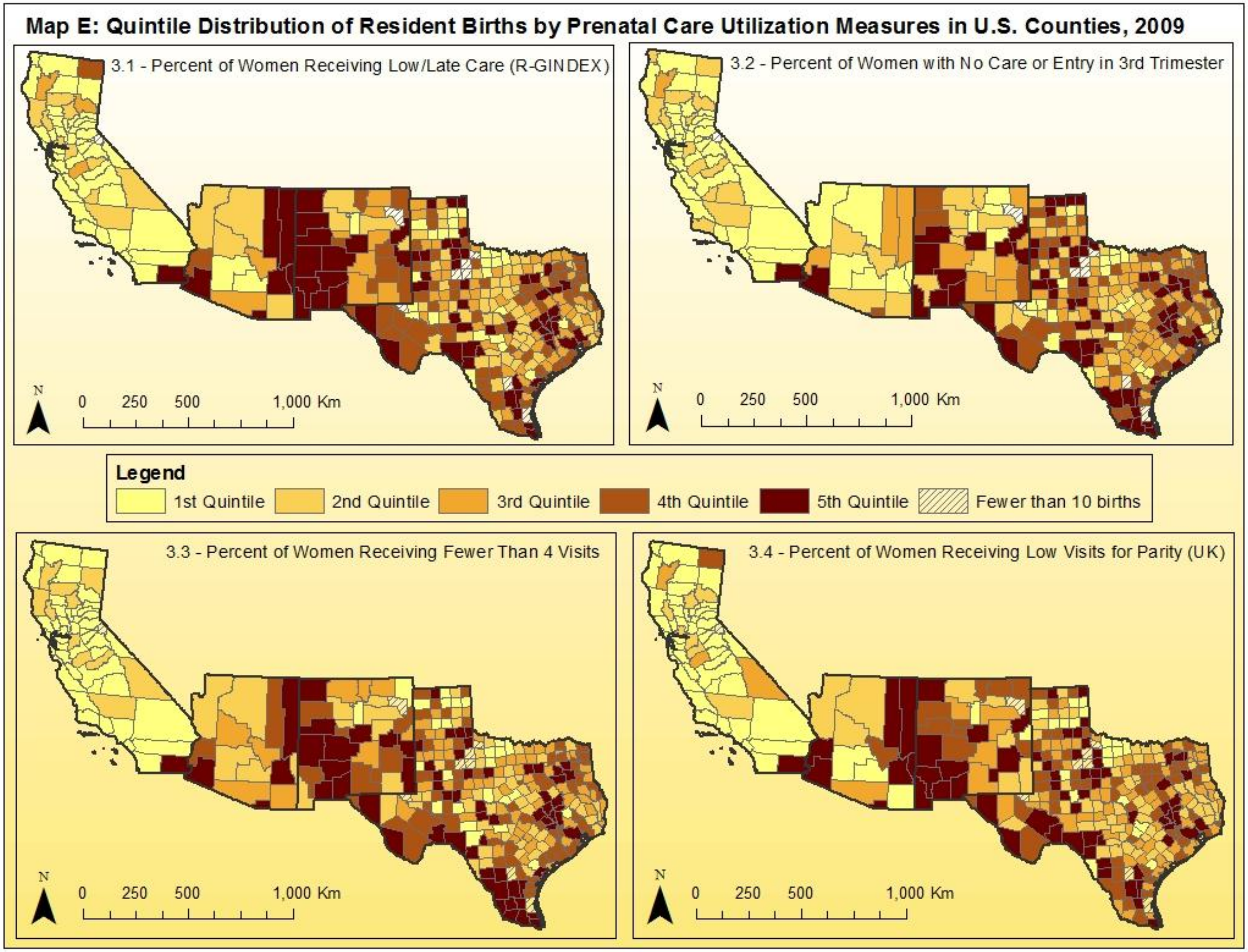


6.2 - Percent of Women Receiving No Prenatal Care or Initiating Care in the 3rd Trimester



6.3 - Percent of Women Receiving Low Visits for Parity

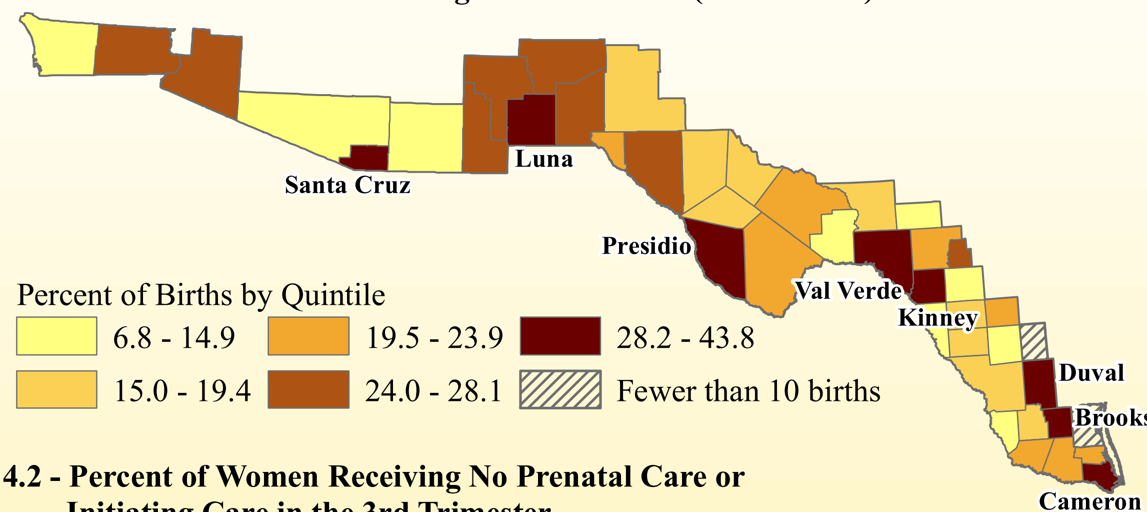




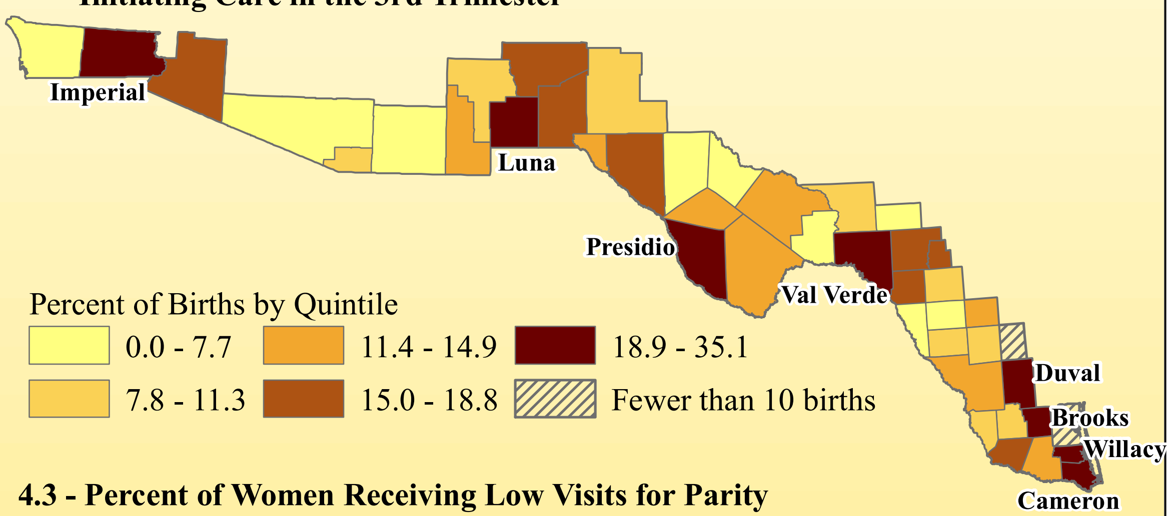
Map E: Quintile Distribution of Resident Births by Prenatal Care Utilization Measures in U.S. Counties, 2009
3.1 - Percent of Women Receiving Low/Late Care (R-GINDEX)
3.2 - Percent of Women with No Care or Entry in 3rd Trimester
3.3 - Percent of Women Receiving Fewer Than 4 Visits
3.4 - Percent of Women Receiving Low Visits for Parity (UK)
N
0 250 500 1,000 Km
Legend
1st Quintile
2nd Quintile
3rd Quintile
4th Quintile
5th Quintile
Fewer than 10 births

Map F: Quintile Distribution of Resident Births by Prenatal Care Utilization Measures in U.S. Border Counties, 2009

4.1 - Percent of Women Receiving Low/Late Care (R-GINDEX)



4.2 - Percent of Women Receiving No Prenatal Care or Initiating Care in the 3rd Trimester



4.3 - Percent of Women Receiving Low Visits for Parity