Timeliness, frequency and content of antenatal care: which is most important to reducing indigenous disparities in birth weight in Mexico?

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ABSTRACT

This article examines the role of components of adequate antenatal care (ANC) in disparities in birth weight between indigenous and non-indigenous women in Mexico. We estimate the potential for added weight gain among indigenous infants if their mothers received timely, frequent (≥4 visits) and complete ANC (≥75% of recommended processes of care). We used population-based survey data (2012; N = 6612 women 12–49). We applied quantile regression to examine heterogeneity of the association between adequate ANC, indigenous ethnicity and birth weight across quantiles of the birth weight distribution. A greater proportion of indigenous women reported a low-birth weight infant (<2.5 kg) at last delivery (14 vs 8% among non-indigenous women). Coverage of adequate ANC (timely, frequent and complete care) is lower among indigenous (59%, CI:53;65) than non-indigenous (68%, CI:66;70) women. Indigenous ethnicity is associated with a lower birth weight across quantiles of the observed birth weight distribution: between 300 g in the 0.05, 0.10 and 0.25 quantiles. Among indigenous women, greater newborn weight gains are achieved in the lowest quantiles if they have access to ≥75% of the content of ANC compared with those that did not have access: ~180 and 260 g are gained in both quantiles 0.05 and 0.10, respectively. This means that the smallest indigenous newborns could potentially reach 2.36 kg (from 1.86 kg), close to the normal weight threshold. The frequency of ANC was positively associated with birth weight for all women but complete ANC appears to differentially affect indigenous women at the bottom of the birth weight distribution. The marginal gains obtained among indigenous newborns that received complete ANC compared with indigenous/non-indigenous newborns did not receive it, is particularly important in low-birth weight quantiles. Delivering basic processes of ANC may therefore have the potential to impact the highest risk women and help them to overcome the low-birth weight threshold.

Key words: Antenatal care, disparities, indigenous, low-birth weight, Mexico
Introduction

Birth weight is a key determinant of infant morbidity, mortality, growth and development (McCormick 1985; MacDorman and Atkinson 1999; McIntire et al. 1999; Dashe et al. 2002). Low-birth weight (LBW), defined as fewer than 2.5 kg at birth, contributes to 60–80% of all neonatal deaths globally. Ninety-seven percent of the 20 million LBW infants born each year (16% of all births) are in developing countries (WHO 2014). Within regions and countries, large disparities exist in LBW by race and ethnicity, education and poverty (Glei and Goldman 2000; Kramer et al. 2000b; Rauh et al. 2001; Leslie et al. 2003; Pallikadavath et al. 2004; Stewart et al. 2007). In Mexico, the prevalence of LBW is between 7 and 8.5% (OECD 2014; UNICEF 2014).

A large literature documents that LBW is associated with neonatal death, chronic degenerative diseases and alterations in mental development, learning and language, motor and auditory impairments, and behaviour problems in childhood (Barker et al. 1989; Barker 1990; Ashworth 1998; Bang et al. 2005; Lawn et al. 2005). LBW can be categorized into very LBW (<1.5 kg) and moderately LBW (1.5–2.49 kg). Although more evidence exists for adverse outcomes associated with very LBW, moderately LBW is known to be associated with higher rates of health problems compared with normal weight infants (Stein et al. 2006). In addition to increased risk for mortality and immediate morbidities (Kramer et al. 2000a; Tison et al. 2002), moderately LBW infants are at increased risk for learning and behavioural problems, attention deficit and asthma, among other health problems (Resnick et al. 1999; Breslau and Chikota 2000; Breslau et al. 2001; Brooks et al. 2001; Elgen et al. 2002). Moderately LBW infants also tend to require hospital-related infant services during perinatal and subsequent periods (Petrou et al. 2003; Wang et al. 2004), which implies higher costs of care for the health system.

Correlates of LBW include maternal biological, nutritional and obstetric history, and premature birth or intrauterine growth retardation (Kligman et al. 1990; Alkaly et al. 1998; Newburn and Onyiski 2005; Beck et al. 2010; Lawn et al. 2010). Socioeconomic factors such as poverty and geographical isolation (Glei and Goldman 2000; Kramer et al. 2000b; Glei et al. 2003; Pallikadavath et al. 2004; Adam et al. 2005) are also associated with LBW.

The large health, economic and social disparities between indigenous and non-indigenous populations is well-documented (World Bank 2006; Servan-Mori et al. 2014) and include disparities in reproductive and infant health. In Mexico, maternal mortality is 9-fold higher in highly marginalized and geographically isolated indigenous areas compared with those with better infrastructure (CDI and PNUD 2010), the child mortality rate is nearly double that of non-indigenous areas (PNUD 2010) and LBW is much more prevalent among indigenous infants (CDC/NCHS 2013). Indigenous women are more vulnerable to complications during pregnancy and childbirth (Kestler 1995; Farmer 2000; Montenegro and Stephens 2006) partly explained by higher pregnancy risk factors related to their reproductive health history (e.g. high fertility, short inter-pregnancy intervals, young age at first pregnancy), life style (e.g. strenuous physical work throughout pregnancy) and lack of adequate access to reproductive health services (Gracey 2009; King et al. 2009).

The World Health Organization (WHO) recommends timely, sufficient and high-quality antenatal care (ANC) to improve maternal and neonatal health outcomes (Coimbra et al. 2003; Sánchez et al. 2005; Cano et al. 2006; CONAPO 2011). The key characteristics of ANC are: Timeliness (the first consultation should preferably during the first trimester of pregnancy), frequency (≥ 4 ANC visits by qualified staff), and content or quality (must be based on the use of standardized guidelines and clinical protocols) (MPS/WHO 2007). If prenatal care meets these three attributes, it is considered ‘adequate’ (MPS/WHO 2007). Meeting these basic standards of ANC is widely accepted to improve infant health; evidence suggests that approximately two-thirds of infant deaths could be prevented with adequate ANC coupled with interventions along a continuum of care during childbirth and the postpartum period (Ronsmans et al. 2010). Projections to 2035 also suggest that an expansion of coverage of these interventions (during antenatal, childbirth, and postpartum periods) up to 90% could reduce mortality in children below 5 years by ~70% compared with 2010 levels (Walker et al. 2013; Zulfiqar et al. 2013). Delivering effective ANC thus has great potential to contribute to progress to Millennium Development Goals 4 (reduce child mortality) and 5 (reduce maternal mortality).

Despite widespread agreement that utilization of timely, frequent and quality ANC can improve maternal and infant health, we have limited evidence about the link of ANC to specific maternal and infant health outcomes or on which components of ANC are most important to improving health. Most studies in Latin America have focused on timely care and frequency of visits (Rous et al. 2004; Smith and Deb 2005; Celik and Younis 2007; Jewell 2007; Jewell and Rous 2009; Wehby et al. 2009; Habibov 2011). Less is known about the content or quality of ANC and infant health but evidence suggests that additional processes of care are associated with increased birth weight (Habibov 2011). Furthermore, most research focuses on average treatment effects and there is little data to guide interventions to target the highest risk women and infants.

In sum, there is limited evidence about the relationship between indigenous ethnicity, access to and utilization of adequate ANC, and birth weight. There is also little data to guide ANC interventions—we do not know which aspect of adequate ANC—timely initiation, frequency or content—to identify which is the most important component. To develop efficient and effective health system responses to improve birth outcomes among disadvantaged
women, we need to identify which aspects of ANC are likely to make the most difference. The purpose of this study is to test the association of indigenous ethnicity and the components of adequate ANC and birth weight. We explore the heterogeneous effects of adequate ANC by indigenous ethnicity and across the birth weight distribution. In particular, we estimate the potential for added weight gain among the highest risk indigenous infants if their mothers received timely, sufficient and a high quality (75% of recommended care) of ANC.

Materials and methods
Data and study population
We used the 2012 National Health and Nutrition Survey (ENSANUT), which is nationally representative (by state and urban/rural stratum) and provides data on health and nutrition status, health services utilization, insurance and health system performance. The 2012 ENSANUT includes 50,528 households (194,758 individuals). Taking the complex survey design into account, the full sample represents 115,170,278 Mexicans (Romero-Martinez et al. 2013). We used data from ENSANUT’s household, adolescent and adult survey modules for our analysis. Data on reproductive health were collected from a random sample of 6612 women in two age ranges, 12–19 and 20–49 years of age, who had a live birth since 2006. After excluding women without information about the weight of their last child born alive or the process of prenatal care, the final analytical sample included with 5386 women (12.5% missing). We examined potential differences in important covariates that could be associated with our independent or dependent variables between our analytical sample and those excluded due to missing data and found no significant differences (see Supplementary Appendix S1).

Variables
Our primary outcome is birth weight (in kg), measured by reviewing the official certificate (9.5% of observations) or self-reported (90.5%) by the mother or guardian of the child. Following WHO recommendations (Fescina et al. 2011), we categorized birth weight as very low (<1.5 kg), moderately low (1.5–2.49 kg), normal (2.5–4.0 kg) and overweight (≥4.0 kg). We also examined continuous birth weight by quantiles (we analysed the sample birth weight distribution using quantiles [5, 10, 15, 25, 50, 75%]). However, we could not classify LBW as being preterm vs small for gestational age (SGA) because we lack data on gestational age. Our key independent variable is adequate ANC, based on the WHO criteria: a woman received adequate prenatal care if she had her first antenatal visit within the first trimester of pregnancy, had ≥4 ANC visits, and if the content of her ANC included ≥75% of recommended care (out of 11 processes of care classified as essential: measurement of height, weight and blood pressure, urinalysis, blood examination, blood sugar examination, syphilis detection-Venereal Disease Research Laboratory (VDRL) ultrasound, tetanus vaccine, folic acid, vitamins/iron/food supplement). Following our previous work, we assumed that each of the processes of care is equally important (Heredia-Pi et al. 2013).

We classified women as indigenous or not according to the official definition in Mexico (CDI 2009), whereby a household is considered indigenous if the head of the family, a spouse and/or an older relative (e.g. grandmother) self-identifies as and/or speaks an indigenous language. Following this official definition, we created a binary variable at the household level. We included the following sociodemographic variables: schooling (continuous years); health insurance (Social Security, employment based insurance, Seguro Popular, health insurance for the poor and none) and an Asset and housing index as a socioeconomic status proxy. We constructed this index using principal components analysis with polychoric correlation matrices (Kolenikov 2004; McKenzie 2005), based on household-level assets and infrastructure such as owning a television, and roof and floor materials. The range of the asset and housing index was [−5.23–1.88]; more positive scores indicate higher socioeconomic status, while lower socioeconomic status households have more negative scores. We also included an indicator for being a part of a beneficiary household of the Oportunidades program (formerly PROGRESA), a marker of poverty. Locality-level variables include the size of the place of residence (metropolitan/urban or ≥2300 inhab. and rural or <2300 inhab.) and a marginalization index (expressed as a percentage; range: 1.1–37.1%, and based on locality-level access to basic public services, housing conditions and wage earnings) (CONAPO 2010).

We also included maternal characteristics at the time of the most recent birth: Age (12–19, 20–29 and 30–49 years.), parity (0, 1 and ≥2), having had at least one stillborn child or a child who died before the first year of life, history of abortion or miscarriage and the type of ANC provider (Social Security, the Ministry of Health, private and Midwife/home). We measured maternal risk factors with a binary indicator of any reported pregnancy risk factor and individual indicators for high blood pressure, vaginal bleeding, anaemia, threat of miscarriage, preeclampsia or eclampsia, gestational diabetes, or infections during pregnancy. Finally, we include a binary variable that identifies women who reported any complication (preeclampsia or eclampsia, haemorrhage, miscarriage, threat of miscarriage, obstructed delivery and wrong position of the fetus, premature childbirth or some complication due to a previous disease) at the time of delivery.

Analysis
We first describe sociodemographic differences, access to health services, ANC, and birth weight by indigenous ethnicity. We used bivariate regression models accounting for the complex survey design to compare the groups and permit population-level estimates. Next, we used quantile regression to identify associations between adequate ANC, indigenous status and birth weight. Quantile regression is one approach to identify heterogeneity of treatment effects. We used quantile regression to be able to differentiate marginal gains in birth weight along the newborn weight distribution in our sample. This method provides a richer characterization of the data, allowing us to identify differential effects of covariates across our distribution, not merely its conditional mean (Koenker 1978; Koenker 2001; Fenske et al. 2013). Thus, we were able to focus our analysis on the highest risk infants at the bottom of the birth weight distribution. We included all variables described earlier in our models; our basic model form is

\[ \text{Birth weight} = Q(\beta_{Q \cdot ANC, \gamma} \cdot X) \]

Where \( \beta \) is the quantile effect of adequate ANC on quantile qth of birth weight and \( \gamma \) is a vector of the quantile (qth) effect of a vector X that includes socioeconomic characteristics, women’s characteristics and health risks across the distribution of birth weight. That is to say conditioned on X vector, \( \beta \) measures the change in birth weight that corresponds to a specific quantile when there is a unit change in ANC.

Finally, we estimated the marginal expected gains in newborn weight if indigenous and non-indigenous women receive adequate
ANC (timely, sufficiency and 75% of recommended processes) compared with those that did not receive adequate ANC; we also estimated associations between specific components of ANC (e.g. timely only, frequency only, processes of care only) and the birth weight. We used Stata 13.1 for all analyses (StataCorp 2013).

**Results**

### Descriptive results

Nine percent of the women in our sample reside in indigenous households (Table 1). Indigenous women report on average 2 fewer years of schooling (7.2 vs 9.5 among non-indigenous), higher parity (46% with two or more children vs 34%) and lower socioeconomic status (as measured by household-level Oportunidades enrollment and locality-level marginalization index). A greater proportion of indigenous women (65%) are covered by public insurance (Seguro Popular) that targets the poor compared with non-indigenous women (46%). Indigenous women are also more likely to reside in rural areas (47% compared with 19%).

A greater proportion of indigenous women reported LBW at last delivery (Table 2; 14 vs 8% among non-indigenous women). The distribution of birth weight in the sample (Figure 1) highlights the similarity of the distributions among indigenous and non-indigenous infants except for a greater proportion of moderately LBW (1.5–2.49 kg) indigenous newborns (dotted line). A smaller proportion of indigenous women reported a diagnosis of some health problem during the index pregnancy compared with non-indigenous women (47.1 vs 60.9%). The proportion of vaginal deliveries was greater among indigenous woman compared with non-indigenous woman (66.1 vs 52.2%) and a lower proportion of indigenous women reported a planned cesarean delivery compared with non-indigenous woman (12.4 vs 21.9%).

### Quantile regression results

Table 3 shows results of the quantile regression model that estimates the association between birth weight and adequate ANC (timely, frequent and includes at least 75% of the ANC components). Panel A of Table 3 shows results of the association between being indigenous, access to adequate ANC and the interaction of both variables (being indigenous and adequate ANC) with the weight of the baby. Each column presents results of different quantiles along the observed distribution of Birth weight (BW) (0.05, 0.10, 0.25, 0.50).
Table 2. Birth weight and ANC during the last pregnancy by Indigenous status

<table>
<thead>
<tr>
<th>Component</th>
<th>Indigenous</th>
<th>Non-indigenous</th>
<th>P value corrected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (median and interquartile rank [IQR])</td>
<td>3.05 [2.70;3.50]</td>
<td>3.20 [2.82;3.05]</td>
<td>0.00</td>
</tr>
<tr>
<td>Very low birth weight (&lt;1.5 kg) (%)</td>
<td>0.42 [0.10;1.82]</td>
<td>0.75 [0.41;1.37]</td>
<td>0.39</td>
</tr>
<tr>
<td>Moderate birth weight (1.5–&lt;2.5 kg) (%)</td>
<td>13.1 [8.79;19.0]</td>
<td>7.19 [6.07;8.48]</td>
<td>0.03</td>
</tr>
<tr>
<td>Normal birth weight (2.5–&lt;4.0 kg) (%)</td>
<td>82.7 [76.8;87.4]</td>
<td>87.2 [85.7;88.6]</td>
<td>0.10</td>
</tr>
<tr>
<td>Over birth weight (&gt;4.0 kg) (%)</td>
<td>3.79 [2.08;6.81]</td>
<td>4.84 [4.04;5.78]</td>
<td>0.38</td>
</tr>
<tr>
<td>Access to ANC (%)</td>
<td>95.8 [93.0;98.5]</td>
<td>99.0 [98.7;99.3]</td>
<td>0.02</td>
</tr>
<tr>
<td>Frequent (At least four consultations) (A) (%)</td>
<td>84.7 [80.2;89.1]</td>
<td>92.3 [91.0;93.5]</td>
<td>0.00</td>
</tr>
<tr>
<td>Timely (first ANC visit during the first quarter) (B) (%)</td>
<td>77.1 [72.1;82.1]</td>
<td>83.8 [82.2;85.4]</td>
<td>0.01</td>
</tr>
<tr>
<td>Content of ANC consultation (C) (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥50%*</td>
<td>92.6 [89.4;95.8]</td>
<td>95.9 [94.9;96.8]</td>
<td>0.05</td>
</tr>
<tr>
<td>≥75%*</td>
<td>74.2 [69.0;79.4]</td>
<td>81.2 [79.1;83.2]</td>
<td>0.01</td>
</tr>
<tr>
<td>Measure</td>
<td>94.2 [91.3;97.1]</td>
<td>93.8 [92.6;94.9]</td>
<td>0.79</td>
</tr>
<tr>
<td>Weighed</td>
<td>97.0 [95.1;98.8]</td>
<td>97.4 [96.6;98.2]</td>
<td>0.68</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>97.9 [96.4;99.3]</td>
<td>97.4 [96.4;98.3]</td>
<td>0.58</td>
</tr>
<tr>
<td>Urinalysis</td>
<td>86.2 [82.6;89.8]</td>
<td>89.0 [87.4;90.7]</td>
<td>0.18</td>
</tr>
<tr>
<td>Blood examination</td>
<td>83.5 [79.7;87.4]</td>
<td>88.4 [86.8;90.0]</td>
<td>0.03</td>
</tr>
<tr>
<td>Blood sugar examination</td>
<td>69.6 [64.6;74.7]</td>
<td>72.2 [70.0;74.4]</td>
<td>0.36</td>
</tr>
<tr>
<td>Syphilis detection (VDRL)</td>
<td>37.9 [31.7;44.0]</td>
<td>43.1 [40.8;45.5]</td>
<td>0.13</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>85.6 [82.1;89.0]</td>
<td>94.2 [93.1;95.3]</td>
<td>0.00</td>
</tr>
<tr>
<td>Tetanus vaccine</td>
<td>95.3 [93.0;97.6]</td>
<td>90.0 [88.5;91.6]</td>
<td>0.00</td>
</tr>
<tr>
<td>Folic acid</td>
<td>96.8 [95.1;98.5]</td>
<td>97.8 [97.1;98.5]</td>
<td>0.30</td>
</tr>
<tr>
<td>Vitamins/iron/food supplement</td>
<td>88.1 [83.0;93.2]</td>
<td>93.0 [91.6;94.3]</td>
<td>0.07</td>
</tr>
<tr>
<td>(A)+[(B)+[(C)] ≥ 50%* (%)</td>
<td>71.7 [66.2;77.1]</td>
<td>79.0 [77.1;80.9]</td>
<td>0.01</td>
</tr>
<tr>
<td>Adequate ANC: (A)+(B)+(C) ≥ 75%* (%)</td>
<td>59.0 [53.0;65.0]</td>
<td>68.1 [65.9;70.3]</td>
<td>0.00</td>
</tr>
<tr>
<td>Diagnosis of some health problem during pregnancy*b (%)</td>
<td>47.1 [40.0;54.1]</td>
<td>60.9 [58.8;63.1]</td>
<td>0.00</td>
</tr>
<tr>
<td>Any complication during childbirth*c (%)</td>
<td>16.7 [12.5;20.9]</td>
<td>20.4 [18.5;22.3]</td>
<td>0.14</td>
</tr>
<tr>
<td>Vaginal delivery (%)</td>
<td>66.1 [60.0;72.1]</td>
<td>52.2 [50.1;54.3]</td>
<td>0.00</td>
</tr>
<tr>
<td>Urgent cesarean (%)</td>
<td>21.6 [16.6;26.6]</td>
<td>25.9 [23.9;27.9]</td>
<td>0.15</td>
</tr>
<tr>
<td>Planned cesarean (%)</td>
<td>12.4 [8.34;16.4]</td>
<td>21.9 [20.0;23.9]</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Note: * refers to the test of equality or similar medians or percentages, and values lower than 0.05 signifies that distributions are statistically different. IQR, interquartile rank. Estimations performed considering the effect of the survey design.

*Include High blood pressure, vaginal bleeding, threat of miscarriage, preeclampsia or eclampsia, gestational diabetes, or infections.

**Refers to the percentage of medical procedures received.

*bInclude preeclampsia or eclampsia, haemorrhage, miscarriage, threat of miscarriage, obstructed delivery, wrong position of the fetus, premature childbirth or some complication due to a previous disease.

...the interaction between being indigenous is marginally significant at the 10th quantile of birth weight and similar to some upper quantiles of birth weight (q.25): Infants born to indigenous mothers with an adequate ANC are 130 g bigger than infants born to non-indigenous or indigenous mothers with inadequate ANC.

Table 3, Panel B shows the association between disaggregated components that indicate adequate ANC (content, timely and frequency) and the weight of the newborn and suggests which component of ANC may be most important to improving newborn weight. The first part of Panel B shows principal associations of each components of ANC and the indigenous ethnicity with birth weight: results clearly show that being indigenous is associated with a lower birth weight, of ~300 g, than infants born to non-indigenous women in quantities 10th, 15th and 25th. The first part of Panel B also shows the association of the disaggregated ANC components and birth weight. Babies born to mothers who had at least four ANC visits have 140 and 120 g more in the 10th and 5th quantiles, respectively, than babies born to mothers who had <4 prenatal visits. This gain in weight by the frequency in visits seems to be lower in upper quantities.

The second part of Panel B shows the interaction of disaggregated ANC components and indigenous ethnicity: compared with infants born to indigenous women who had 75% of the ANC components, infants born to indigenous or non-indigenous women who received <75% of the ANC components prenatal care weigh more, especially in the lower quantiles of the birth weight distributions: the birth weight of indigenous infants with access to at least 75% of the ANC components in quantities 0.05 and 0.10 is 180 and 260 g more, respectively, than birth weight of indigenous/non-indigenous infants that had access to <75% of the ANC components.
Table 3. Quantile Regression: association between birth weight and ANC among Mexican indigenous people

<table>
<thead>
<tr>
<th></th>
<th>Dependent variable: birth weight (kg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>q = 0.05</td>
</tr>
<tr>
<td>Panel A: Association of adequate ANC with birth weight</td>
<td></td>
</tr>
<tr>
<td>Adequate ANC</td>
<td>0.05*</td>
</tr>
<tr>
<td>Indigenous</td>
<td>[−0.01,0.11]</td>
</tr>
<tr>
<td>Indigenous × Adequate ANC</td>
<td>[−0.33,−0.06]</td>
</tr>
<tr>
<td>Intercept</td>
<td>2.33b</td>
</tr>
<tr>
<td>Panel B: Association of ANC components with birth weight</td>
<td></td>
</tr>
<tr>
<td>Content of ANC consultation (≥75%)</td>
<td>0.18a</td>
</tr>
<tr>
<td></td>
<td>0.04(0.24)</td>
</tr>
<tr>
<td>Indigenous</td>
<td>[0.04,0.08]</td>
</tr>
<tr>
<td>Timely (first ANC visit during the first quarter)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>[−0.06,0.08]</td>
</tr>
<tr>
<td>Frequent (At least four consultations)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.14b</td>
</tr>
<tr>
<td>Indigenous</td>
<td>[0.04,0.24]</td>
</tr>
<tr>
<td>Intercept</td>
<td>2.33b</td>
</tr>
<tr>
<td>Observations</td>
<td>5287</td>
</tr>
</tbody>
</table>

Note: * indicates statistical significance at 1, 5 and 10% error levels, respectively. CI95% in brackets. Covariates include: all variables showed in Table 1, and the diagnosis of some health problem during pregnancy, any complication during childbirth and type of delivery (vaginal, urgent or planned cesarean).

dAdequate ANC is defined according to WHO criteria: pregnant woman had her first antenatal visit within the first trimester of pregnancy, had ≥4 ANC visits, and if the content of her antenatal care included ≥75% of the list of recommend care.
Additionally, infants born to indigenous women that had a timely access to ANC are significantly 150 g more than indigenous/non-indigenous infants that did not have timely access in the lowest quantile (q.05). This association was not significant in upper quantiles. In the interaction with ethnicity, there is not a significant association between the frequency of visits and birth weight along the lower quantiles of weight.

Discussion

We found that indigenous women have a greater proportion of LBW (<2.5 kg) newborns compared with non-indigenous women in Mexico. We also found significant disparities in reported utilization of timely ANC and the minimum number of recommended prenatal visits (four). The gap between indigenous and non-indigenous women in utilization of ANC processes of care was greater in the components that require more health resources: blood laboratory examination, ultrasound and vitamins and food-supplements. We found that in the lower quantiles of birth weight distribution, ultrasound and vitamins and food-supplements were less frequently used among indigenous women. This was associated with increased risk of giving birth at low birth weight (i.e., below the 5th percentile) and lower frequency of visits among indigenous women compared to non-indigenous women. The frequency of ANC (≥4 visits) was associated with increases in birth weight for all women (controlling for indigenous ethnicity) but content (achieving ≥75% of recommended processes of care) appears to differentially affect indigenous women at the bottom of the birth weight distribution. The marginal gains obtained among indigenous newborns who received at least 75% of processes of care compared with indigenous/non-indigenous newborns who received <75% of ANC content is important particularly in low-birth-quantiles, ~180 g for those newborns located at q.05, 260 g for those in the q.10 and 120 g for those in the q.15. Delivering basic processes of ANC may therefore have the potential to impact the highest risk women and help them to overcome the LBW threshold. This implies that indigenous women need not only timely and frequent ANC but also care that covers basic processes of care to monitor healthy pregnancies and identify at-risk pregnancies.

Previous work suggested that timely ANC is associated with an increase in birth weight of up to 200 g. (Smith and Debb 2005). Delayed access to care has also been found to be associated with reductions in birth weight of up to ~300 g. (Jewell and Rous 2009). In Uruguay, timely ANC was associated with increases in birth weight of 506 g (Jewell and Triundo 2006; Jewell and Rous 2009). Frequency of care has shown to be linked to increases in birth weight (Celik and Younis 2007; Wehby et al. 2009; Habibov and Fan 2011) but marginal effects diminish after a threshold number of eight visits (Rous et al. 2004). A randomized trial by the WHO found that an ANC model with fewer visits but higher intensity and quality at each visit was as effective and saved money compared with more frequent visits (Villara et al. 2001). It is only recently that the content and quality of ANC has received more attention. Wehby et al. (2009) found a positive effect of adequate ANC on birth weight, measured through the Kessner index, which includes timeliness and frequency of care (Kessner 1973; Kotelchuck 1994), while Habibov and Fan (2011) showed that an additional unit of ANC quality (measured by utilization of antenatal procedures such as weight and blood pressure measurement, blood sample, urine examination and identification and management of pregnancy complications) was associated with small but significant (41 g) increases in birth weight. These findings are consistent with our results; however, we also show heterogeneous effects among indigenous women and at the lower end of the birth weight distribution, while previous studies have estimated only average effects.

Ensuring provision and utilization of timely and frequent or sufficient ANC has long been standard policy across low- and middle-income countries (Carroli et al. 2001; PMNCH 2006). The content of ANC, now included in WHO recommendations, is a different challenge that requires improving health system functioning and quality of care (Marchant et al. 2015). Our results suggest that achieving 75% of recommended processes of care could have a disproportionate impact on indigenous women at the bottom of the birth weight distribution—exactly the women we hope to reach with ANC interventions to accelerate progress towards Millennium Development Goals 4 and 5.

Our findings have important implications for policies and programs to increase birth weight among women at most risk of delivering low-weight infants and to eliminating well-documented ethnic disparities in maternal and infant health in Mexico. In the last 15 years, the Mexican government has focused on increasing utilization of antenatal health services among poor women living in rural areas through the provision of conditional cash transfer in the Oportunidades program and other health programs such as Arranque Parejo (SSa 2008) and Seguro Popular (Frenk et al. 2009). Women enrolled in the Oportunidades program are required to initiate ANC in the first 3 months of the pregnancy and attend a minimum of five antenatal visits during the pregnancy period to receive cash transfers (Gertler 2000). The program contributed to an increase the average number of prenatal visits from 2.9 [C95%: 2.5;3.4] in 1998 (before the implementation of the program) to 4.7 [C95%:4.5;4.9] in 2007 among women living in high poverty rural areas. However, the indigenous population is still without access to adequate ANC, as reflected in worst levels of child morbidity and mortality compared with non-indigenous group of population. This means that although social programs such as Oportunidades and others (social insurance for the poor ‘Seguro Popular’, Arranque Parejo, etc.) have contributed to the increased use of ANC services, the most deprived women have still limited access to qualified care during the prenatal period (Sosa-Rubi et al. 2011).

Our study has several limitations. Although the ENSANUT is a high-quality population-based survey, it is a cross-sectional study and we report associations, not causal effects. Second, although our measure of birth weight was self-reported, which could potentially be a source of bias, when we examined the distribution of the self-report birth weight in the analytical sample and compared it with the distribution of birth weights from vital statistics data (called SNAC in Mexico) (SSa 2015), we found that the self-reported birth weight closely mirror the vital statistics data (see Supplementary Appendix S2). Additionally, we examined differences by source of birth weight data by year to assess whether as time passes, recall bias grows, compared with documentation. We did not find significant differences in the report of the mean of the birth weight by year of delivery (results not shown). We also acknowledge that recall bias could be present in other variables such as the recall of components of ANC or the presence of health problems during pregnancy. If differential recall bias exists by ethnicity, then we are unable to determine if observed differences in ANC and health problems are due to actual differences in ANC received and/or health problems, differential detection and diagnosis of health problems or differential recall of ANC received and/or health problems diagnosed. Third, the survey does not contain gestational age in consequence we cannot identify if the LBWs reported are due to pre-term births or small for gestational age term deliveries. Nor can we assess whether gestational age differs by indigenous ethnicity.
Undertook additional analyses to examine the relationship between the visit in which women received each of the procedures. We found that the probability of receiving each individual component of ANC utilization and obstetric outcomes across provider types and levels of care. Although it would be ideal to have detailed clinical data, strengths of our study include a comprehensive measure of ANC and our focus on heterogeneity of treatment effects, which allows decision makers to target programs where they are likely to have the greatest impact (Gakidou et al., 2007).

In conclusion, we contribute to evidence which suggests that access to adequate prenatal care, including timely care, frequency of use and content of care, can contribute to reducing ethnic disparities in birth weight. Reaping benefits from adequate ANC likely will require both demand and supply-side interventions. Women need to know that what happens during a care encounter (processes of care) is as important as entering care early and the frequency of care. The Mexican government must focus on expanding access to timely and frequent care as well as to improving the content and quality of care delivered to indigenous women.

**Ethics Statement**

This study is a secondary data analysis of the Mexican National Health and Nutrition Survey (ENSA NUT) 2012. The data for the analysis were requested and obtained from the survey public repository hosted at the National Institute of Public Health webpage at: http://ensanut.insp.mx/. This repository has the data already de-identified; thus it is not possible to trace any of the data to the actual individual. In accordance to the Internal Regulation of the Research Ethics Committee of the National Institute of Public Health, this secondary analysis was considered exempt of approval.

**Supplementary Data**

Supplementary data are available at HEAPOL online.

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**Conflict of interest statement.** None declared.

**References**


Fourth, regarding the information used to construct the quality index, the survey does not provide information neither about the frequency in which these procedures were performed nor the number of the visit in which women received each of the procedures. We undertook additional analyses to examine the relationship between content and frequency of care. *Supplemental Appendix S1–S3 (online-only) reports the probability of receiving each antenatal component based on the number of antenatal visits. In general, we found that the probability of receiving each individual component or \(\geq 50\%\) and \(\geq 75\%\) of the total components is positively associated with the number of prenatal visits, in other words women with a greater number of antenatal consultations have more access to more components to ANC.

Fifth, the temporalities of our covariates, such as asset and housing index, were measured at the time of the survey and not at the time of the occurrence of the last obstetric event. However, our key independent variable, indigenous status, is not time-varying. Finally, although it would be ideal to rely on clinical data to evaluate receipt and content of ANC, obstetric outcomes and birth weight, in Mexico such a dataset does not exist. Mexico has electronic hospital discharge data that contains International classification of diseases 10th edition codes for relevant diagnoses but limited sociodemographic information. Furthermore, such data do not exist for the outpatient setting, where the vast majority of ANC occurs. Mexico, like many countries, has a fragmented health system, and there is not a comprehensive health information system for all care providers. We rely on the ENSANUT survey precisely because it is the most comprehensive source of information about population-level ANC utilization and obstetric outcomes across provider types and levels of care. Although it would be ideal to have detailed clinical data, strengths of our study include a comprehensive measure of ANC and our focus on heterogeneity of treatment effects, which allows decision makers to target programs where they are likely to have the greatest impact (Gakidou et al., 2007).

In conclusion, we contribute to evidence which suggests that access to adequate prenatal care, including timely care, frequency of use and content of care, can contribute to reducing ethnic disparities in birth weight. Reaping benefits from adequate ANC likely will require both demand and supply-side interventions. Women need to know that what happens during a care encounter (processes of care) is as important as entering care early and the frequency of care. The Mexican government must focus on expanding access to timely and frequent care as well as to improving the content and quality of care delivered to indigenous women.


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