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## Traditional and biomedical maternal and neonatal care practices in a rural Indigenous population of the Bolivian Amazon

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### Abstract

In recent decades, Bolivia has expanded maternal and child health insurance coverage to improve access to prenatal and early life health care. Nationally, however, maternal and child health disparities persist along a rural-urban divide. Research is needed among rural populations to better understand local barriers to health care access and usage. Particularly among Indigenous populations, disparities may be compounded by differences in preferences for and access to traditional versus biomedical health care. We examined prenatal care and birth practices among Tsimane forager-farmers of El Beni, Bolivia. From 2012–2013, we interviewed 151 Tsimane mothers (0–35 months postpartum) from nine villages about birth and neonatal care practices, prenatal care, and pharmaceutical usage during labour and postpartum recovery. Results demonstrate local disparities in biomedical care usage by ease of access (e.g. proximity to market town, Spanish fluency), and maternal experience (e.g. parity and prior offspring death or miscarriage). While 59% of interviewed mothers had received at least one prenatal screening, services performed in screenings were limited. Nearly all women continue to birth at home with family assistance. Inconsistent access to health care services may be exacerbated by regional, generational, and educational disparities within the population.

### Keywords

Indigenous health; traditional medicine; prenatal care; birth practices; health disparities

### Introduction

Policies that expand prenatal care access and insurance coverage for health services may reduce ethnic disparities in maternal and infant outcomes (Wehby et al., 2018), especially for marginalised Indigenous populations (Valeggia & Snodgrass, 2015). Since 2000, Bolivia has implemented several national programmes to improve access to maternal and child health care services (Silva & Batista, 2010; Smith et al., 2014). Since then, national maternal

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and under-5 mortality rates have decreased, while the institutional birth rate and number of women receiving four or more prenatal check-ups has increased (Pan American Health Organization, 2017). However, disparities across different ethnic groups may persist due to local variation in health care access and preferences, fertility patterns and practices, and other health risks (Wehby et al., 2018).

While rural and Indigenous populations in Bolivia are more likely to live in extreme poverty and lack access to high-quality health services (Durie, 2003; Pan American Health Organization, 2017), health disparities across demographics are influenced by both macro-level health care policy and infrastructure and micro-level circumstances affecting individuals' relationships with, and ability to navigate, health care systems (Brunson & Suh, 2020). Many Indigenous populations freely combine local traditions with biomedical practice (de Bourmont et al., 2020; Garro, 1998; Hoyler et al., 2018; Young, 1980) – a fact explicitly recognised and legitimised in the 2003 Bolivian Universal Maternal and Child Insurance Law. However, comprehensive intercultural health initiatives have had limited success (Torri & Hollenberg, 2013). More research is needed to better understand how traditional and biomedical practices affecting maternal and infant health are accessed, utilised, and integrated.

The Tsimane are a high-fertility, high-mortality forager-farming Indigenous population residing in the rural lowland Amazonian region of El Beni, Bolivia. On average, Tsimane women have nine children, with first births before age 19 and interbirth intervals of 2–3 years (McAllister et al., 2012), and a miscarriage rate of 55.1/1000 births (Gurven, 2012). The infant mortality rate, though declining since 1990, ranges from 10–20% – significantly higher than Bolivian national rates – largely owing to respiratory and gastrointestinal illness (Gurven et al., 2007). However, despite research examining Tsimane reproductive patterns, breastfeeding, and infant morbidity and mortality (Gurven et al., 2016; Martin et al., 2016; Veile et al., 2014), there has been limited research documenting Tsimane prenatal and birth practices. Similarly, while the Tsimane have been reported to freely mix biomedical and traditional ethnobotanical and shamanistic therapies to treat a variety of illnesses (Calvet-Mir et al., 2008) – with treatment preferences influenced by symptom severity and perceived efficacy and cost (Bethancourt, 2008) – no research has examined the extent of or factors associated with plurality in prenatal and birth practices.

The aim of this paper, therefore, is to describe current Tsimane prenatal and birth practices, and to examine how these practices vary with regional access to biomedical care and maternal factors that may influence familiarity with or preference for biomedical vs. traditional practices. Data on prenatal, birth, and postpartum practices were collected as part of a study on infant feeding practices and maternal reproductive and infant health outcomes among 151 Tsimane mother-infant dyads from 2012–2013 (Martin et al., 2016). Free services covered by a national health plan and regularly available at the time of data collection included prenatal care and child vaccinations, growth measurements, and nutritional supplements. These services were provided by mobile health care providers, a hospital in the town of San Borja, a clinic ~5 km outside of San Borja (Galilea), and a clinic on the outskirts of San Borja (HOREB). Tsimane women have traditionally given birth at home. At the time of data collection, there were no professional midwives working

in villages, and the extent of hospital births was unknown. Pharmaceuticals used during labour and postpartum (including antibiotics and Pitocin) are available for purchase without a prescription in San Borja pharmacies; antibiotics are sometimes given out by mobile health care providers.

Mother-infant participants in the study resided in nine villages differing in access to San Borja, the largest proximate market town (population ~41,000, 2012). Tsimane villages closer to San Borja have easier access to clinics and pharmacies and lower morbidity and mortality indices compared to more remote villages (Gurven, 2012; Gurven, 2012; Gurven et al., 2016). Villages near town also have better economic and educational opportunities, which further influence health behaviours (Blackinton et al., 2007; Blackwell et al., 2017; Godoy et al., 2007; Gurven et al., 2017). However, recent research (Alami et al., 2018) found that residing closer to town was not associated with greater biomedical treatment uptake for adult illnesses. Rather, adults residing farther from town were more likely to believe in their ability to control their own health, which may promote biomedical health seeking despite reduced access. Similarly, greater inequality and ethnic discrimination experienced by residents closer to town may inhibit biomedical health seeking (Alami et al., 2018). Thus, biomedical care access and individual therapeutic preference or experience may be heterogeneous in remote and near town villages.

Specifically, we examine the influence of maternal schooling, Spanish fluency, and parity in relation to biomedical and traditional prenatal and birth practices. Most Tsimane women are not fluent in Spanish and have limited formal education. Mothers with more schooling and/or more fluent in Spanish may be more comfortable communicating with healthcare professionals, and therefore more accepting of biomedicine and more likely to seek out biomedical prenatal and infant care services. Adolescent mothers may have had more exposure to, and be more accepting of biomedicine, but may be more uncomfortable interacting with predominantly male and/or non-Tsimane health care providers. Mothers with more dependents are less likely to travel (Miner et al., 2014), and may therefore be less likely to obtain a prenatal screening. On the other hand, older mothers may be more likely to have had a previous birth trauma (i.e. miscarriage or stillbirth) and/or better able to detect problems with current pregnancies – which may increase motivation to seek out care.

## Materials and methods

### Study population:

There are over 100 Tsimane villages in the Beni Department of Bolivia. Tsimane families are traditionally semi-nomadic and subsist primarily from subsistence-scale farming, hunting, and fishing. Few villages have access to electricity, plumbing, or clean water (Sobolewski et al., 2017). Most villages now have schools, but schools in smaller and more remote villages have more limited resources and more frequent educational disruptions (Godoy et al., 2007). Families live among extended kin networks with both patrilocal and matrilineal residence observed. Tsimane marriages, while not formalised, are mostly monogamous and stable; with a polygyny rate of 5–10% and separation rate of about 20% (Stieglitz et al., 2011). From here on, references to marriage and spouses refer to long standing monogamous relationships.

At the time of data collection (2012–2013), there were two national initiatives in place that could have promoted prenatal care usage among Tsimane mothers. The *Seguro Universal Materno Infantil* (SUMI), implemented in 2003, is a national insurance plan that provides health care for pregnant women until six months postpartum and for children up to age five. The *Bono Juana Azurduy* programme, implemented in 2009, offers additional cash incentives (up to 1,820 Bolivianos, \$268 US) for women to access four prenatal visits, institutional births, and postpartum and child wellness visits. Services covered under these programmes are provided through a mix of health clinics, hospitals, and mobile outreach services administered by the public and private sector (Silva & Batista, 2010). However, these programmes frequently generated demand without equivalent investment in infrastructure (Smith et al., 2014). SUMI has been criticised for removing coverage of reproductive health and family planning services, and for prioritising availability of advanced level services in urban areas. By 2008, or five years after SUMI was implemented, national infant mortality rates decreased overall, but rates in rural and Indigenous provinces actually increased (Silva & Batista, 2010).

While prenatal and birth customs among the Tsimane have not been extensively documented, preoccupations with the health of pregnant mothers and infants are evident from ethnographic accounts. Following birth, mothers rest with neonates in a mosquito net (*sajaja*) for 1–4 weeks and are cared for by their spouses and relatives (Melgar, 2009). They customarily apply a black plant dye (*bi*) to neonates as a protective coating within the first few days after birth, which remains on the skin for about a week (Reyes-García, 2001). The use of *bi* is thought to render the baby invisible to malevolent spirits (Gurven et al., 2007), ensure that he or she will have dark skin, and/or protect against skin infections (Reyes-García, 2001). Breastfeeding is universal and on-demand, with mothers exclusively breastfeeding for about four months and weaning at 27 months on average (Martin et al., 2016).

The Tsimane do not discourage prenatal sexual intercourse, as they believe that a foetus is protected in the womb (Ellis, 1996). Intercourse is discouraged for three to six months postpartum, as it is thought to harm the mother's healing womb and imbues mothers and infants with an odour that displeases forest spirits (Huanca, 1999). Paternal extramarital sex during pregnancy is believed to harm the foetus and lead to deformities (Ellis, 1996), while paternal absence and extramarital affairs postpartum may be blamed for severe vomiting and diarrhoea in infants (Gurven, 2012). Pregnancy taboos reflect beliefs that characteristics of certain foods can be transferred to the foetus – i.e. meat from animals with antlers or spines can harm the baby; fused plantains (*pe're epoj*) can lead to twins, which are considered dangerous and unlucky (Ellis, 1996). Ritual familial consumption of peach palm fruit (*väjij*) during the rainy season is believed to protect pregnant women and babies; however the flowering plants are deemed dangerous to women and children (Huanca, 2008).

#### Data collection:

Research was conducted in association with the Tsimane Health and Life History Project (THLHP), which has provided primary care while collecting epidemiological and anthropological information from participants across villages for nearly two decades

(Gurven et al., 2017). THLHP physicians may treat pregnant women and children as needed, but are not official providers of prenatal and paediatric preventative care services. For the present study, author MM interviewed 151 Tsimane mothers in nine villages between July 2012 – April 2013, as part of a larger study examining relationships between breastfeeding practices and maternal and infant health outcomes (Martin et al., 2016). All mothers with children aged 0–35 months were invited to participate; one mother declined, and interviews were not successfully coordinated with another 13 mothers. The final sample represented 92% of all eligible families in the study villages. All mothers in the study were monogamously married. Study villages were selected because of their population size (100–300 residents each) and variation in accessibility to San Borja.

Author MM conducted initial structured interviews and collected anthropometric measures from all participating mothers and infants. Initial interviews (lasting approximately 1 h) included short answer questions about maternal reproductive history and household demographics, and prenatal, birth, postpartum care, breastfeeding, complementary feeding, and illness history of the youngest child. A subset of mothers in six proximately located villages were followed prospectively: these included 48 mothers with infants less than one year of age and 11 mothers who were in their third trimester of pregnancy at the start of data collection. The present study analyses only data from the initial interviews and postpartum interviews (conducted at 1–28 days postpartum with the pregnant mothers). All interviews were conducted in participants' homes in the Tsimane language (with responses translated in situ to Spanish), with the help of two Tsimane research assistants. MM also conducted unassisted initial interviews in Spanish with 10 mothers who were native Spanish speakers and of mixed-Tsimane ethnicity (9 of whom lived in one near town village). A descriptive summary of participant characteristics is given in Table 1.

Among the 151 participants interviewed, 149 were asked if they had received a prenatal screening documented on a *Carnet de Salud de la Madre* (from here on *Carnet*). *Carnets* are given to patients on their first prenatal screening and kept by patients, who then present them to medical providers to update after each successive prenatal screening. Information from available *Carnets* were recorded with participant consent. Participants were also asked about their most recent pregnancy and birth, including emergencies experienced during the pregnancy, where they gave birth, who assisted during labour, and what, if any, over-the-counter and traditional medicines they took or administered to neonates. Sample sizes for some questions related to birth and postpartum care varied due to interviewer omission and timing of sample collection; total sample sizes per outcome are reported in text and tables.

### **Ethics Statement:**

All study protocols were approved by the University of California Santa Barbara Institutional Review Board. Participant consent and approvals to conduct the research in Bolivia were obtained at multiple levels. The THLHP maintains formal agreements with the municipal government of San Borja and the *Gran Consejo Tsimane* to work with Tsimane communities. Author MM further arranged independent agreements for the present study with the *Gran Consejo* and leaders of study communities, the Estación Biológica del Beni, and the Ministerio del Medio Ambiente y Agua. MM explained the purpose of the study

to study villages in community meetings held prior to data collection, and in visits with participants before arranging interviews. Participants gave verbal informed consent before each interview for themselves and their infants. Participants were compensated with small care packages that included household goods (e.g. yarn, thread, combs) and over-the-counter medicines (e.g. paracetamol, salve).

Initial and follow-up interviews were conducted independently of THLHP services and medical care. There was no THLHP presence in seven of the nine villages during data collection. The other two villages were visited concurrently with semi-annual THLHP medical team visits, however all consent procedures and interviews were conducted by MM independently of the THLHP team, and in participants' homes. In all villages, participants were informed that MM was not a THLHP medical doctor, and that consent or refusal to participate would not affect their ability to receive THLHP care at present or in the future.

### Statistical methods:

Descriptive statistics were generated for frequencies of prenatal screenings, emergency prenatal visits, mothers birthing at home or in-hospital, sex and relationship of birth assistants, and use of traditional and pharmaceutical medicines during birth and postpartum recovery. Logistic regression was used to explore the effects of different factors on the likelihood of receiving at least one prenatal screening, and of using traditional and pharmaceutical medicines during birth or postpartum recovery. Baseline models include village region, maternal parity, and whether or not a mother reported any previous infant death or miscarriage. Subsequent models additively considered Spanish fluency (none vs. conversational or fluent), highest level of schooling completed, and interaction terms. Final models were selected using AIC and evaluated for multicollinearity using variance inflation factors (VIF). VIF cut-off was set at 3.5, or a squared GVIF<sup>(1/2\*Df)</sup> term for categorical variables.

Village region reflects accessibility to San Borja. Villages categorised as 'near town' ( $n = 5$ ) are located < 20 km from San Borja and accessible year-round by road or river; villages categorised as 'remote' ( $n = 4$ ) are > 30 km from San Borja and only accessible via river. Maternal parity was counted as all live births, documented from self-reported reproductive history in initial interviews, and checked against THLHP census and demographic records. In initial interviews, mothers reported their highest grade level completed and Spanish fluency. Spanish fluency was reported as 'none', 'a little', 'good', but is referred to here, respectively, as 'none', 'conversational', and 'fluent'.

To account for non-linear parity effects on birth risks and breastfeeding outcomes (Martin et al., 2016), parity was grouped into four categories: primiparous (1 birth), low parity (2–3 births), prime parity (4–8 births), and high parity (9–13 births). The median number of births was four, with 75% of mothers reporting six or fewer births. Maternal age was not included in models due to high collinearity with parity ( $r = 0.87$ ,  $p = 0.001$ ). Maternal education, Spanish fluency, and village region were also correlated, with near town villages accounting for 65% and 90% of participants with conversational and fluent Spanish, respectively, and 83% of those with more than four years of completed education. Relationships between dependent outcomes and Spanish fluency or education are described in text when not

included as covariates in statistical models due to high collinearity. Statistical analyses were conducted using R (ver 3.0.2). Anonymized data and analytical code are available at [https://figshare.com/projects/Tsimane\\_prenatal\\_care\\_shared\\_data/86615](https://figshare.com/projects/Tsimane_prenatal_care_shared_data/86615).

## Results

### Prenatal care:

A slight majority (59%) of Tsimane mothers received at least one prenatal screening (Table 2). However, most *Carnets* recorded only one prenatal screening, and screenings generally consisted only of reproductive history, current weight, and blood pressure. Only one mother in the sample (a native Spanish speaker of mixed-ethnicity) received an ultrasound (at the hospital). Among mothers who received at least one prenatal screening, 39% were seen by a mobile health care promoter in their own village, while the remaining 61% travelled to a clinic or hospital (Table 2). A greater proportion of mothers near town received at least one prenatal screening compared to those in remote villages (Table 2, 65% vs 50%, chi-square = 3.61,  $p = 0.06$ ). The majority of mothers near town who received prenatal screenings received them at the hospital or the Galilea clinic (76%), whereas the majority of mothers from remote villages (77%) received them from visiting medical teams. Overall, only 23% of the women interviewed (33/149) received a prenatal screening from a mobile health care provider.

The proportion of mothers receiving at least one prenatal screening was higher among mothers with greater Spanish fluency: fluent 100% (11/11); conversational 60% (42/70); no fluency 51% (35/68) (chi-squared = 9.27,  $p = 0.01$ ); All fluent mothers received their prenatal screenings at a clinic or hospital, compared to 60% and 50% of mothers with conversational and no fluency, respectively (chi-squared = 8.79,  $p = 0.01$ ). Among remote villages, a smaller but non-significant proportion of mothers conversational or fluent in Spanish obtained screenings than did mothers with no fluency (43% vs. 56%, chi-square = 1.04,  $p = 0.31$ ). However, near town, conversational or fluent mothers were much more likely to receive prenatal screenings than those with no fluency (77% vs. 47%, chi-squared = 8.41,  $p = 0.03$ ).

Fifty percent of mothers reported at least one child death or miscarriage (35% at least one infant death, 23% at least one miscarriage, 8% both). Eleven mothers (9%) had experienced 2–3 child deaths, and four had experienced 2–5 miscarriages (3%). The proportion of mothers reporting at least one child death or miscarriage did not vary significantly by region (56% vs. 46% for remote vs. near town villages; chi-square = 1.56,  $p = 0.21$ ). Three of the eleven mothers (27%) who were fluent reported at least one death or miscarriage, compared to 53% and 51% of mothers with conversational or no fluency. As expected, the percentage of mothers reporting at least one infant death/miscarriage increased with parity: 15% for primiparous mothers, 36% 2–3 births, 60% 4–8 births, 94% 9–13 births. Mothers who had experienced at least one child death or miscarriage were not any more likely to get a prenatal screening than those who had not (60% vs. 58%, chi-square = 0.09,  $p = 0.77$ ).

In a logistic regression model, the likelihood of receiving at least one prenatal screening was significantly lower for mothers in remote villages, but adjusted odds did not



significantly differ by experience of child death/miscarriage or parity (Table 3). Considered independently, neither maternal Spanish fluency nor schooling improved model fit as evaluated by AIC. Interaction terms between village, parity group and offspring death/miscarriage also failed to improve model fit.

Thirteen percent of mothers reported seeking emergency medical care during pregnancy, independent of any prenatal visits (Table 2). Most of these mothers (84%) were multiparous, and 52% reported at least one prior infant death or miscarriage. Most (95%) were from villages near town, and 68% reported at least conversational Spanish fluency. A greater proportion of mothers seeking emergency care also obtained a prenatal screening, as compared to mothers in the general sample (84% vs. 59%). It was not ascertained if emergency visits preceded or followed prenatal screenings, and it is possible that routine prenatal screenings were added to *Carnets* during emergency visits. The majority (58%) of mothers who reported seeking emergency care did so because of severe stomach, back, or other pains at 4–8 months postpartum; the remaining mothers feared miscarriage, often following a fall or heavy physical activity.

### **Birth and postpartum care:**

Ninety-percent of mothers laboured at home and another 9% at another residence (seven in homes of their relatives, five in spousal relatives' homes, and three while working and living in non-Tsimane villages). Only two mothers reported giving birth in a hospital (Table 2). Both mothers were multiparous, from the same large village near town, and anticipated complications due to unusual pain. The first mother (aged 32) began having terrible pains at night. The following morning, she walked 6 km with her mother until she was able to hitch-hike to San Borja. Shortly upon arriving she gave birth without complications, and was released the following day. The other mother (aged 33) went to the hospital after experiencing debilitating pain for one day. Her baby was delivered without complications but was premature. She and her baby were released after three days of observation during which the baby was kept in a separate room.

In interviews, mothers were asked 'Did anyone help you during birth?', along with the age, sex, and relation of named assistants. Mothers were not asked to elaborate on the type of assistance provided, or about any postpartum care assistance. Mothers reported receiving assistance from a wide range of helpers. Ten percent of respondents (15/147) reported giving birth without help, all but one at home. Mothers who were assisted reported one to three helpers (median = 2), most frequently kin, affinal kin, and spouses (Figure 1). Overwhelmingly, helpers were the same age or older than birthing mothers. In only three cases were younger helpers named (a daughter or daughter-in-law). Together, subjects' mothers, spouses, and mothers-in-law accounted for 64% of all helpers. In our sample 28% of mothers lived in the same village as their natal family, 26% in the village of their spouse's family, 36% in the same village as both their and their spouse's family, and 11% in a village with neither their nor their spouses' families present. Number and identity of birth assistants did not differ according to matrilineal vs. patrilineal residence (results not shown). This may reflect the heterogeneity in residence patterns, as well as the possibility of nearby family members travelling to assist in labour, which was not documented in questioning.

Male assistance during birth was not uncommon. While 60% of mothers (79/132) were assisted by women only, 27% were helped by both men and women, and 14% by men only. Spouses accounted for most male help, but other men named included a brother, a grandfather, fathers, and fathers-in-law. While 77% of husbands of women assisted during birth were reportedly at home during the birth, only 40% (42/106) were specifically named as assistants. Interestingly, many mothers reported receiving help from a spouse, spousal kin, or a distant relation even when co-residing with their mothers or older sisters. Unfortunately, it is not clear from the limited line of questioning which close kin were available to assist at the time of birth, nor why, if close female kin were available, mothers were helped by their spouses or affinal kin. Only rarely were strangers named as assistants. For example, a 37-year old mother from a remote village had been walking back from San Borja and went into active labour while passing through a village near town. She progressed quickly and an unrelated Tsimane woman brought her into her home and attended the birth.

Additional insight about the labour and birthing process was gleaned through postpartum interviews conducted opportunistically with 11 mothers who had been visited regularly during their third trimester of pregnancy. Six of these mothers reported having labour pains for 12 h or less. The others reported labour pains lasting anywhere from 18 h to 10 days. Informants reported that during labour, women typically grasp onto long strips of rope-like dried bark (*tapi*) hung from the overhead scaffolding in their huts, which they use to stay in a supported, squatting position very low to the ground. Helpers ‘catch’ the baby from behind the mother. The umbilical cord is cut using sharpened wood that is generally used for arrows (*tacuara*, Sp./*ton*, Tsi.) or housing and other tools (*chuchio*, Sp./*shuri*, Tsi.). According to one informant, custom dictates that an older son should cut the umbilical cord so that the baby will grow as well as its existing siblings. However only one of the postpartum mothers interviewed reported this practice; the rest reported that they themselves, their husbands, or another helper cut the cord.

Maternal use of over-the-counter pharmaceuticals during and after birth was more common than traditional medicine, and largely to alleviate pain (Table 4). Use of pills and intramuscular injections were both reported. Of the 49% (74/150) of mothers who took pharmaceuticals: 27% reported taking a known analgesic (acetaminophen, diclofenac sodium), 22% a known antibiotic, and 23% reported possibly taking an antibiotic but could not be sure. Though we did not systematically document the different types of traditional medicines used, elsewhere it has been reported that Tsimane women commonly use eight different plant species to aid birth or postpartum recovery (Reyes-García, 2001). Notably, 35% (53/150) of mothers reported taking neither pharmaceutical nor traditional medicines, while 15% (22/150) reported taking both.

Separate logistic regressions were run to assess the likelihood of maternal pharmaceutical and traditional medicinal usage during pregnancy or post-natal recovery in association with previous offspring death/miscarriage, parity group, and village region. When considered additively, neither maternal Spanish fluency nor education improved model fit and were not included in final models. Neither pharmaceutical nor traditional medicine usage varied by village region (Table 5). Pharmaceutical usage was more likely with previous offspring death/miscarriage but was not associated with parity group. In contrast, mothers with

high parity were substantially more likely to use traditional medicines than mothers in prime parity (Table 5). In a univariate GLM, each additional birth increased likelihood of traditional medicine usage by 17% (95% CI for OR = 1.04–1.32,  $p = 0.008$ ).

### Neonatal health and care practices:

It was not possible to accurately estimate the proportion of infants in this sample born prematurely or underweight. Prenatal screenings often occurred several months after the last date of menstruation, increasing the likelihood of recall error in estimating gestational age from prenatal *Carnets*. Similarly, infants' first postnatal screenings were recorded on their *Carnets* anywhere from within the first week to the first three months of life. During data collection, nine neonates were opportunistically measured within the first two weeks postpartum. The average weight and length of these infants at (mean  $\pm$  SD) 4.1  $\pm$  4.0 days postpartum was 3.3  $\pm$  0.4 kg and 50.2  $\pm$  1.3 cm, respectively. None of these infants weighed less than 2.5 kg (the low birth weight threshold), even considering that infants normally lose up to 10% of their birth weight over the first two weeks of life (Wright, 2004). Using World Health Organization growth reference standards, the average weight-for-age and length-for-age z-scores for these 10 infants at the time of measurement were  $-0.22 \pm 0.67$  and  $-0.10 \pm 0.69$ , respectively.

Only 3% (5/150) of mothers reported giving their infants traditional medicines after birth. However, mothers were only asked directly about ingested medicines, not topical treatments (including the plant dye *bi*). In contrast, 21% (31/150) reported administering infants some type of pharmaceutical medicine during the first week postpartum: 58% gave an anti-inflammatory (paracetamol or ibuprofen), 7% an antibiotic, and the remaining 35% an unspecified medicine. Mothers administered these medicines primarily for fever and flu-like symptoms. Mothers who took medicines themselves during or after childbirth were no more likely to give their infants medicines than those who did not take any medicines (22% vs. 18%, chi-square = 0.237,  $p = 0.63$ ). The frequency of postnatal pharmaceutical administration was slightly higher among villages near town vs. remote (24% vs. 16%, chi-square = 1.06,  $p = 0.30$ ). However, in a logistic regression, neither village region, parity group, previous offspring death/miscarriage, maternal Spanish fluency, nor maternal education significantly predicted the likelihood of neonatal pharmaceutical administration.

## Discussion

Between 2012–2013, use of biomedical prenatal care and pharmaceuticals by Tsimane women was common but also variable, likely owing to local differences in access and preferences. While 59% of recent mothers reported at least one prenatal screening, most had only one screening with limited services provided. Most of these mothers did not receive prenatal screenings from visiting health care providers, but had to travel to a clinic or hospital. However, mobile health care providers provided the majority of prenatal screenings in remote villages. Mothers nearly universally birthed at home with family assistance. While a substantial number of women reported no medication usage during labour or postpartum recovery, use of over-the-counter pharmaceuticals was more commonly reported than use of traditional medicines. Birth experiences differently influenced medicinal usage, with

mothers who had previously had at least one miscarriage or infant death more likely to use pharmaceuticals than mothers who had not, and higher parity mothers more likely to use traditional medicines than lower parity mothers.

Results demonstrate inequalities in available care throughout the Tsimane territory: in general, mothers who live closer to San Borja are better able to access health care facilities. In villages near town, mothers more fluent in Spanish were even more likely to seek out prenatal screening and/or emergency prenatal care, suggesting they may have been either more motivated to or comfortable seeking out biomedical services. However, the reliance on public-private partnerships to provide mobile medical services may be a major cause of discrepancies in health care access across villages. For example, during the 10-month study period, a mobile team from the Galilea clinic visited remote villages located inside the Estación Biológica de Beni at least four times, but never visited two larger villages that are closer to the clinic but fall outside the EBB boundaries. This is because the EBB provided boat transportation and gas to the Galilea medical team to facilitate visits inside of its boundaries, whereas no government funds were available to organise road transportation services to the villages outside of the reserve.

Previous Tsimane ethnographic research described mothers, grandmothers, and other women in the family as most common birth assistants, with husbands ‘obliged to attend and wait on their pregnant spouses’ (Melgar, 2009). We similarly found that labouring women were most often helped by female kin, followed by spouses. Ten percent of mothers in our study reported no assistance. Ethnographers have previously documented unassisted births as fairly commonplace among Indigenous Amazonian Piro, Cubeo, and Shipibo peoples (Belaunde, 2000). However, a response that ‘no one helped’ may refer to birthing alone and unaided, or relying on one’s own knowledge but still assisted (Jordan, 1997). Ultimately, a range of factors may influence assistance given to Tsimane mothers, including convenience, family composition, kin residence patterns, and individual preference. Future research is needed to ascertain these circumstances and the roles of different assistants, including unassisted birth.

On the surface, the continued prevalence of homebirths and varied patterns of assistance may suggest that Tsimane mothers are fairly experienced in labour, and may not perceive labour and delivery as particularly risky. If so, they may not be highly motivated to seek out professional help during delivery, particularly given the logistical difficulties of accessing hospital services for most Tsimane, and the tendency to associate the hospital with grave illness and death (Gurven et al., 2007). As a cautionary note, however, while the absolute number of Tsimane maternal birth-related deaths is low (30 deaths out of 4275 live births from 1972–2012), in 2012 that rate of maternal mortality was higher than 94% of 183 countries surveyed (Gurven et al., 2016). Furthermore, rates of miscarriage, still birth, and infant deaths are persistently high across the population (Gurven, 2012; Gurven et al., 2007), likely due to endemic infectious disease and related immune and energetic burdens, and traumatic injuries. Greater access to prenatal care, professional care during delivery and postpartum recovery, and improved access to emergency services may therefore still have a positive impact on reducing maternal mortality, premature birth, and neonatal mortality.

However, improved access alone may have only limited impact on maternal and infant health outcomes if implemented without respect for Tsimane autonomy and recognition of cultural as well as regional barriers to access. For example, in a pioneering intercultural health centre in rural Potosi, a dedicated room and traditional midwives were provided to incorporate Aymaran birth practices (Torri & Hollenberg, 2013). However, the initiative met with limited success as women continued to prefer to birth at home surrounded by family, and failed to account for Indigenous beliefs that disfavoured birthing adjacent to a nearby cemetery. Given the continued high rate of Tsimane home births and impediments to travel for dispersed, remote villages, pregnant and postpartum Tsimane women would likely be best served by expansion of existing mobile health care outreach providers. As our results show, these providers have been able to expand prenatal care uptake in remote areas, despite limited and sporadic funding, and could be harnessed to provide additional training and supplies for emergency obstetric care to community members. Such training would ideally avoid failures of culturally-insensitive government-sponsored traditional birth attendant trainings implemented elsewhere in Latin America (Garcia et al., 2018). Specific recommendations appropriate to this population would include providing trainings orally in the Tsimane language, incorporating existing Tsimane knowledge of palliative support and preventative postpartum care, and offering trainings to a variety of experienced birth attendants within communities, given that mothers appear to rely more on kin helpers than specific attendants that serve multiple families.

In addition, any reduction in maternal mortality owing to an increase in hospital births must be weighed against additional costs at the population level (e.g. increased risk of unnecessary caesarean sections and related complications). Any expansion of prenatal and childbirth services should also be coupled with expanded family planning services to reduce unintended consequences associated with improved infant survival, such as higher fertility, shorter inter-birth intervals, and greater strains on household resources available for individual offspring (Gibson & Mace, 2006). Culturally relevant family planning services should further consider that while Tsimane women across all age groups report having more children than they desire, this discrepancy reflects cultural values and limited reproductive autonomy, as much if not more so, than absence of effective contraception (McAllister et al., 2012).

The high degree of spousal participation in the birthing process may reflect the traditional egalitarian social structure of Tsimane society and high esteem for women (Melgar, 2009). However, Tsimane gender roles and spousal relations have also been influenced by colonialism and Christianity, which both promote patriarchal attitudes and subordination of women (Melgar, 2009). Research with families in Mexico suggests that poor maternal and child health outcomes among Indigenous Wixárican families reflect colonialist-imposed gender inequalities, which manifest in spousal abuse, control over maternal health care access, and reduced spousal involvement and support during labour (Gamlin, 2020). Tsimane men are critical to the wellbeing of their families – particularly because of their ability to secure goods and services, including medicine and medical care (Melgar, 2009). Unfortunately this study did not assess the influence of spousal wages, attitudes and beliefs, Spanish fluency, or frequency of town visits on maternal options and preferences for biomedical vs. traditional birth and postpartum care.

There are several other limitations to our study. First, interviews were carried out with mothers from fewer than 10% of Tsimane villages, and study villages spanned a fairly conscripted range within the large Tsimane territory. Future research should also examine prenatal and birth practices among more remote and isolated villages, and in villages with higher rates of ethnic-intermarriage. Village location is also an imprecise proxy of biomedical care access given that individual families across regions vary in their frequency of travel to other villages and markets, due to differences in seasonal access by road or river, participation in wage and agricultural markets, and location of extended kin networks. Second, participant mothers were not directly asked about their beliefs or preferences with regards to traditional and biomedical practices. Future research must also examine if variation in knowledge about available insurance programmes, household wealth, and other resources (e.g. of a motorised boat) additionally influence where, when, and how frequently mothers receive prenatal care.

Additional research is also needed to ascertain factors predicting either traditional or pharmaceutical medicinal administration to neonates. While Tsimane infant morbidity and mortality rates are well documented (Gurven, 2012; Gurven et al., 2007), the paucity of prenatal care and hospital births limits systematic study of gestational lengths, birth weights, and other vital birth statistics. Ongoing observation of prenatal and neonatal health care visits documented by *Carnets* is recommended to help identify regional inequalities, identify high risk areas, and inform appropriate interventions.

However, calls to expand systematic data collection must also consider how maternal and infant care practices affect well-being holistically, as perceived by the Tsimane themselves (Brunson & Suh, 2020). Such research must be conducted collaboratively with Tsimane leaders, health care providers, and communities to promote consensus around research aims and methods and adequately disseminate results (Gurven et al., 2017; Kaplan et al., 2020). To these ends, in 2016, results on regional discrepancies in health care access documented in this study were presented in formal reports to community stakeholders (the Tsimane Gran Consejo, the Beni Biological Reserve, San Borja hospital, and health clinics) as well as to the wider Tsimane community through radio broadcast and meetings in study villages.

### **Conclusion:**

Expanded public health access has been a key component of social reforms in Latin America in recent decades (Vasquez et al., 2019). In Bolivia, expanded maternal and child health care access has been achieved through mixed public-private partnerships and modes of service, including traditional therapies (Silva & Batista, 2010). This approach embraces the Latin American Social Medicine tenet that health care is a human right, while further emphasising interculturalism. However, our survey of Tsimane prenatal and birth practices supports observations elsewhere that individual participation in primary health care may be reduced by privatised health care and selective implementation of pre-designed policies without community-based participation, planning and execution (Friederic & Burke, 2019; Mahmood & Muntaner, 2019). For the Tsimane, additional resources are needed to ensure equitable access to maternal and neonatal health care across all villages. This research must also consider how such services and access to them are perceived as beneficial or not by

Tsimane mothers themselves, and how desired services can be better integrated with, and responsive to, traditional prenatal, birth, and neonatal care practice.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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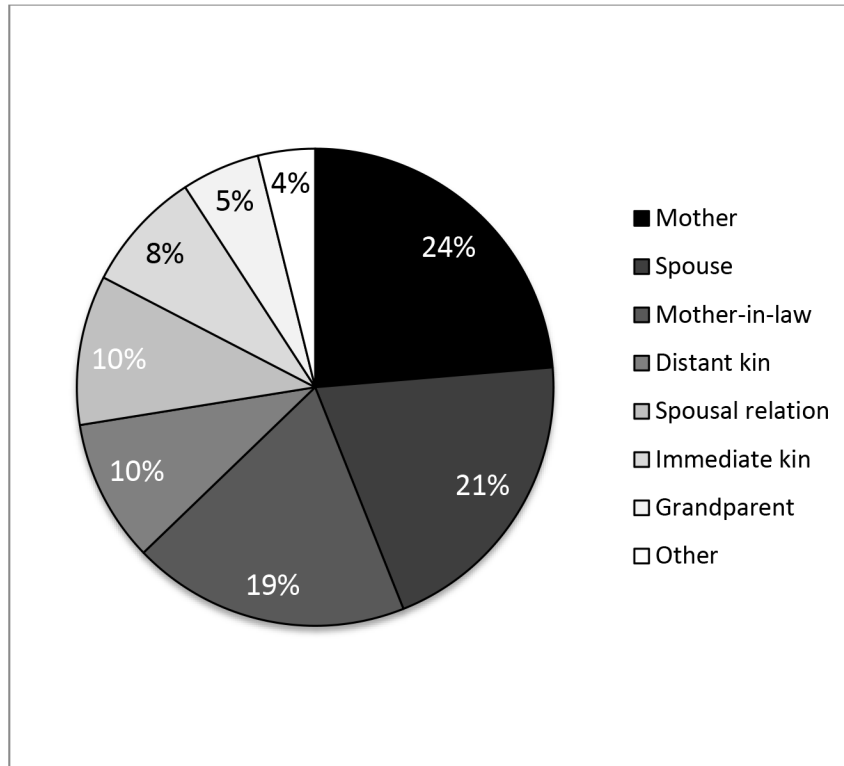
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**Figure 1.** Birth assistants reported by relation to mother (207 total assistants named by 132 maternal subjects).

**Table 1:**

Subject characteristics (n = 151)

(Range, mean, SD, where applicable)	N	%
<i>Maternal age (yrs.)</i> (14 – 49, 27 ± 9)		
< 20	31	20%
20 to 29	69	46%
30 to 39	33	22%
40 and over	18	12%
<i>Village location</i>		
Near town	87	58%
Remote	64	42%
<i>Total births</i> (1 – 13, 5 ± 3)		
No previous birth	26	17%
2–3 (low parity)	39	26%
4–8 (prime parity)	68	45%
9–13 (high parity)	18	12%
<i>Spanish fluency</i>		
None	70	46%
Conversational	70	46%
Fluent	11	7%
<i>Highest grade completed</i> (0 – 12, 2 ± 2)		
None	42	28%
Primary (1 <sup>st</sup> – 5 <sup>th</sup> )	101	67%
Secondary (6 <sup>th</sup> – 12 <sup>th</sup> )	8	5%
<i>Infant sex</i>		
Male	83	55%
Female	68	45%
<i>Infant age (mos.)</i> (0–35, 14.2 ± 9.5)		
0–5	37	25%
6–11	26	17%
12–23	61	40%
24–35	27	18%

**Table 2.**

Percentage of Tsimane mothers who received professional medical attention during pregnancy or childbirth

<b>Maternal interview responses</b>	<b>Near Town % yes (n)</b>	<b>Remote % yes (n)</b>	<b>Total % yes (n)</b>
Received <i>Carnet</i>	65% (57/87)	50% (31/62)	59% (88/149)
Where <i>Carnet</i> received			
Galilea clinical	58% (33/57)	10% (3/30)	41% (36/87)
In village (mobile provider)	19% (11/57)	77% (23/30)	39% (34/87)
San Borja Hospital	18% (10/57)	13% (4/30)	17% (14/87)
HOREB clinic	5% (3/57)	--	3% (3/87)
Sought emergency prenatal care	19% (16/86)	5% (3/61)	13% (19/147)
Place of birth			
At home	91% (79/87)	87% (55/63)	89% (134/150)
In another residence	7% (6/87)	13% (8/63)	9% (14/150)
In hospital	2% (2/87)	--	1% (2/150)

**Table 3.**

Logistic regression of likelihood of at least one prenatal screening (n = 149)

<b>Factor</b>	<b>OR (95% CI)</b>	<b><i>p</i></b>
At least one child death or miscarriage (vs. none)	1.14 (0.53 – 2.494)	0.73
Remote village (vs. near town)	<b>0.55 (0.28 – 1.08)</b>	<b>0.07</b>
<i>Parity group</i>		
Prime (4–8 births)	--	--
Primiparous	1.40 (0.46 – 4.22)	0.55
Low (2–3 births)	0.56 (0.20 – 1.56)	0.27
High (9–13 births)	0.96 (0.24 – 3.91)	0.95

\* Mother reported at least one prior infant death or miscarriage

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**Table 4.**

Mothers' reported use of pharmaceutical and traditional medicines during labor, delivery or postpartum recovery. Reasons for taking specified medicine were given as open-ended responses and are grouped into general categories.

<b>Response:</b>	<b>Pharmaceuticals</b>	<b>Traditional Medicine</b>
<i>Any usage</i>	49% (74/150)	30% (45/150)
<i>Reasons for taking specific medicine</i>	% (n/74)	% (n/45)
Pain	49% (36)	22% (10)
Facilitate birth or placental delivery	20% (15)	16% (7)
Prevent hemorrhaging and infection	8% (6)	16% (7)
Promote healing/cleansing	--	11% (5)
Postpartum contraception	--	13% (6)
No reason given	23% (17)	22% (10)

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**Table 5.**

Logistic regression of factors influencing likelihood of maternal pharmaceutical and traditional medicine usage during labor, birth, or postpartum. recovery (n = 149)

Factor	Pharmaceutical medicine		Traditional medicine	
	OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>
Prior infant death or miscarriage*	<b>2.40</b> (1.14 – 5.03)	0.02	0.58 (0.25 – 1.35)	0.21
<i>Village residence</i>				
Near Town	--	--		
Remote	0.80 (0.41 – 1.58)	0.52	1.34 (0.64 – 2.84)	0.44
<i>Parity group</i>				
Prime (4–8 births)	--	--		
Primiparous	0.89 (0.31 – 2.52)	0.83	1.82 (0.10 – 1.16)	0.38
Low (2–3 births)	0.92 (0.34 – 2.48)	0.94	3.01 (0.24 – 1.55)	0.09
High (9–13 births)	0.83 (0.21 – 3.26)	0.79	<b>12.28</b> (1.31 – 12.71)	0.002

\* At least one prior infant death or miscarriage