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Premature or Just Small? Training Guatemalan Birth Attendants to Weigh and Assess Gestational Age of Newborns: An Analysis of Outcomes

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There is an urgent need to train traditional birth attendants (TBAs) to identify low birth weight infants born at home. It is even more critical that TBAs distinguish between infants that are born prematurely and term infants that are small for gestational age. Many TBAs in low resource countries have limited literacy and training efforts need to be appropriately tailored to meet the needs of women in these settings. Standardized training of TBAs is imperative to identify vulnerable infants born at home and to formulate appropriate responses, such as timely referral to local health facilities. Here we describe the results of our successful efforts to train limited-literacy TBAs in rural Guatemala to identify preterm infants. We engaged TBAs in a 2-day training and standardization sessions in the postpartum ward of a regional hospital, followed by newborn assessments at home births. Similar training efforts should be conducted in other settings where infants are delivered at home by semi-skilled birth attendants, and where preterm infants might not otherwise be identified.

Of the 20 million low birth weight (LBW, defined as birth weight < 2,500 grams) infants born annually, over 95% are born in lower-income countries (UNICEF, 2004). LBW causes significant infant morbidity and mortality in these countries (Kramer, 2003). LBW is a

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We describe Guatemalan birth attendants' identification of vulnerable newborns, their evaluation of gestational age and anthropometry, and the validity of Capurro and New Ballard newborn gestational age assessment methods. We interviewed 49 birth attendants and trained 10 of these women to assess 63 newborns. Capurro and Ballard methods were correlated (Spearman $\rho = .75$, $p < .001$) and showed agreement (Bland-Altman plot, difference and bias, -0.33 ± 1.3 weeks). Prematurity was estimated at 27% (Ballard) and 24% (Capurro); low birth weight was 30%. Capurro provided a simplified, equivalent estimate of gestational age compared to New Ballard that could be used by birth attendants.

simple classification term that does not distinguish between preterm infants (born before 37 weeks of gestational age) and term infants with fetal growth retardation [(FGR), defined as < 10th percentile of birth weight for gestational age]. In Guatemala, the national, officially reported LBW rate was 12% (WHO, 2011). However, approximately 22% of Guatemalan newborns are not weighed at birth (UNICEF, 2004) and over 86% of indigenous, rural Guatemalan women deliver at home, many assisted by traditional birth assistants (TBAs) who work outside of the formal health care system. LBW prevalence is likely to be underestimated since those with little or no access to a formal health care system are not represented in the national estimate. Birth weight measurement and gestational age assessment are critical elements in differentiating between LBW due to prematurity (LBW-preterm) and LBW due to fetal growth retardation (LBW-FGR) because they require different levels of intervention. It is unknown what proportion of LBW is due to prematurity versus FGR.

There are three methods of assessing gestational age: by prenatal ultrasound, by first day of last normal menstrual period (LNMP), and by newborn maturity examination. Gestational age assessment is difficult in rural, developing countries where many women delay seeking early prenatal care, or deliver at home attended by minimally trained TBAs. Prenatal ultrasounds are not accessible or affordable (Neufeld, Haas, Grajeda, & Martorell, 2004) and are rarely used before the 20th week of gestation when dating is most accurate and reliable (Lynch & Zhang, 2007). Menstrual-based dating relies on good maternal recall; studies have found that women with limited education and closely pregnancy spacing are more likely to be uncertain about their LNMP date (Buekens, Delvoye, Wollast, & Robyn, 1984; Verhoeff, Milligan, Brabin, Mlangi, & Nakoma, 1997). Unfortunately, many women in rural Guatemala are illiterate, and regular use of calendars is not common, leading to poor maternal recall. Establishing an accurate gestational age based on ultrasound exam and/or LNMP date under these circumstances is difficult.

There is an urgent need for a simplified, rapid assessment tool to be used by TBAs to identify premature infants during home deliveries. While there are many newborn maturity assessment methods, the methods that assess both physical and neurological criteria, such as the extensive Dubowitz 21-item assessment, considered the “gold standard” (Dubowitz, Dubowitz, & Goldberg, 1970), and two methods derived from the Dubowitz: the New Ballard 12-item assessment (Ballard, et al., 1991), and the Capurro 6-item assessment (Capurro, Konichezky, Fonseca, & Caldeyro-Barcia, 1978) are the most commonly applied. Both the New Ballard and Capurro methods measure physical and neuromuscular maturity and have been found to be more reliable and valid than those that assess only physical criteria (DiPietro & Allen, 1991). Because the Capurro has fewer criteria than the New Ballard, it may be easier for birth attendants to perform, and may be less stressful for the newborn than a more extensive examination.

In Guatemala, TBAs are the primary birth attendants in rural areas and among the poor, but over the years the availability of training for TBAs has been inconsistent and haphazard. In 1997, the Guatemalan Ministry of Health implemented the Extension of Health Coverage (*Extensión de Cobertura*) through the Integrated System for Health Services (*Sistema Integral de Atención en Salud* [SIAS]). One of the many goals of SIAS is to improve maternal and child health by increasing the basic health care service infrastructure, especially in rural, indigenous communities. Through the SIAS program, experienced and newly recruited TBAs are trained (PAHO, 2007). SIAS uses the Partnership for Safe Motherhood and Newborn Health model, which focuses on skilled care during all phases of pregnancy and timely referrals for maternal and newborn complications. There is some evidence that educating TBAs to recognize danger signs and symptoms during the prenatal, intrapartum, and postpartum periods has led to increased referrals to local health centers.

However, it is debatable whether these limited training programs have been successful in improving maternal and infant health outcomes, such as reduced maternal and infant mortality rates (Maupin, 2008).

The purpose of our study was to 1) describe birth attendants' identification of vulnerable newborns for referral to health care facilities, 2) train Guatemalan birth attendants to assess newborn gestational age using both Capurro and New Ballard methods in a sample of newborns delivered in the hospital and at home, 3) compare concurrent and criterion validity of the Capurro and New Ballard methods, and 4) measure weight, length and head circumference, and estimate the effect of maternal and infant characteristics on birth weight in this sample of newborns. The present study provides pilot data for a future longitudinal study that will follow a prospective cohort of mother-infant pairs throughout pregnancy and during the first year of infant life.

METHODS

Design and Sample

Birth attendants: Workshops and standardization sessions—We conducted this cross-sectional study in August, 2009 in the Western highlands of rural Guatemala. Traditional birth attendants were invited to participate in a 2-hour workshop about the identification and care of preterm and low birth weight infants born at home given by two nursing faculty and two midwifery students. During the workshop, we informed the TBAs about the study and asked them to notify us when they attended a home birth. After the workshop, we verbally administered informed consent and a structured questionnaire (due to a high level of limited literacy among these women) to 49 TBAs and auxiliary nurses who attended the workshop to ascertain their current level of identification and referral of vulnerable newborns.

Ten of the 49 workshop attendees (nine traditional birth attendants and one auxiliary nurse) were conveniently selected and attended 2-day training and standardization sessions on newborn anthropometry and gestational age assessment at the regional hospital. Due to space constraints at the regional hospital, only 10 birth attendants were permitted into the postpartum ward for the sessions. These women, referred to hereafter as “intensively-trained”, were trained to assess newborn gestational age using two methods: Capurro [4 physical and 2 neuromuscular maturity criteria (Capurro, et al., 1978)] and New Ballard [6 physical and 6 neuromuscular maturity criteria (Ballard, et al., 1991)]. They were also trained to measure newborn head circumference, birth length, and weight. During the 2-day training session we ascertained reliability between our measurements and their measurements with a minimum of 90% agreement between the two. We reviewed all data entry forms and corrected any reporting errors after each assessment.

Maternal interviews and newborn outcome assessments—Mothers and their infants were consecutively sampled in the hospital post-partum ward or in their home. In the hospital, the charge nurse identified eligible post-partum women with healthy newborns. The intensively-trained birth attendants verbally administered a structured questionnaire to these mothers and assessed the newborn at the bedside. For home births, we used the network of 49 TBAs who attended the 2-hour workshop. These TBAs notified us by cell phones within 24 hours of attended a home birth. We then visited the homes with an intensively-trained birth attendant to conduct the maternal questionnaire and the newborn assessment. The TBA who delivered the infant accompanied us during the home visit. The intensively-trained birth attendant explained the purpose of the study in Spanish or in the Mam language, based on the mother's language preference. After the mother verbally

consented to participate in the study and signed a consent form, a brief, 20-minute structured questionnaire was verbally administered.

The 10 intensively-trained birth attendants assessed and measured between eight and nine newborns ($n = 63$) under the supervision of the authors to assess feasibility of the measures. Attempts were made to evaluate all 63 newborns within 48 hours of birth. The newborn was dressed and swaddled in a hat, shirt, socks, and blanket ensemble that was pre-weighed and recorded on the questionnaire form. During the changing of the newborn's clothes to this standardized outfit, gestational age was assessed. To prevent cold stress, every effort was made to keep the infant at least partially covered during gestational age assessment. Anthropometric measurement was then conducted and newborn weight was measured to the nearest 10 grams using a Seca 334 digital infant scale, and clothing and blanket weight were subtracted from infant weight. The scale has a precision of ± 10 grams and was calibrated with a standard 5 pound weight prior to weighing infants. The hat was removed to measure head circumference to the nearest 0.5 cm using a disposable paper tape. Length was measured to the nearest 0.5 cm with hat and socks removed and using a Seca 210 measuring mat.

Instruments

Structured questionnaires administered to the birth attendants included questions about: education level; training/certification; language preference; delivery equipment owned; prenatal, intrapartum and postpartum payment schedule; history of pregnancy, delivery or postpartum complications; and reasons for referring mothers or newborns to the health center or hospital.

Structured interviews administered to the mothers included questions about: maternal education level, prenatal history (current and previous pregnancies), and prenatal visits with TBAs or health professionals. We asked the mothers who delivered babies at the local hospital to recall their newborn's birth weight, based on what the hospital staff had told them after delivery.

The New Ballard uses 6 physical and 6 neuromuscular maturity criteria and can be used reliably to evaluate infants between 20 and 44 weeks of gestation. The total score ranges from -10 to 50 and is used to estimate gestational age in weeks (Ballard, et al., 1991). Among 252 infants born in the United States who were assessed during the development of the Ballard scale, the Ballard correlated highly with the Dubowitz newborn maturity exam ($r=0.969$) and was found to be as reliable as the Dubowitz when both were measured against gestational age by menstrual dates ($r=0.852$ vs. $r=0.848$ respectively)(Ballard, Novak, & Driver, 1979). Using an expanded version of the Ballard, referred to as the New Ballard, 530 infants were assessed within 96 hours of birth. The New Ballard was compared to gestational age based on ultrasound (Spearman rank correlation, $r_s = 0.97$), with a standard error of estimation of ± 2 weeks. For individual items and the total score, interrater agreement ranged from $r_s=0.61$ to 0.91 , and agreement within one point between the two scorers ranged from 0.79 to 1.00 (Kappa scores) (Ballard, et al., 1991).

The Capurro newborn maturity assessment method is a simplified algorithm using 4 physical criteria and 2 neurological criteria derived from the Dubowitz instrument. This method may sacrifice accuracy and precision by reducing the number of measurement criteria from 21 items to 6 items. However, the authors who developed the instrument, based on the examination of 115 Uruguayan infants, reported a correlation coefficient (r) = 0.90 compared to the Dubowitz method and a standard error of estimation (SE) of 8.4 days (Capurro, et al., 1978). A comparison of methods in 358 Cameroonian newborns found the New Ballard and Dubowitz scores to correlate highly with the last normal menstrual period

(LNMP) dating method ($r=0.94$ and $r=0.93$, respectively) (Sunjoh, Njamnshi, Tietche, & Kago, 2004).

We received ethical approval from the Committee for Human Research at the University of California, San Francisco, and from the San Marcos National Hospital, Guatemala. Written informed consent for participation in the study was obtained from all participants or, where participants were infants, consent was obtained by the mother of the infant.

Statistical Analysis

Descriptive statistics were calculated using frequencies, percentages, means and standard deviations. The distributions of the variables were evaluated to assess whether assumptions of normality were met; parametric or non-parametric tests were used based on these findings. The correlation between the total Capurro and New Ballard gestational scores was measured, and the correlation between individual items and sub-scale items (neurologic and physical) were assessed against the total score for each scale. For these tests of association Spearman's correlation was used as the assumption of normality was not fulfilled. A Bland-Altman plot was used to compare agreement between the two gestational age assessment methods (Bland & Altman, 1986, 1999).

The effects of maternal and infant characteristics on birth weight were assessed using multivariate linear regression models. These independent variables were included in the models if there was a statistical association ($p<.10$) with birth weight using appropriate parametric or non-parametric hypothesis tests. Variables in the model were assessed for multicollinearity using a variance inflation factor (VIF), and were removed if VIF was > 10 . Outliers were classified using Studentised residuals ± 3.0 , and a sub-group analysis was compared with and without outliers. Leverage plots and partial regression plots were used to evaluate any influence individual observations might have on model coefficients. Predicted residuals were plotted against a normal distribution, and against the fitted values, to assess for functional form and constant variance. Restricted vs. full (saturated) models were compared using a likelihood-ratio test to determine which model best described the data. Stata version 11 (StataCorp, College Station, Texas) was used for all data analyses.

RESULTS

The 10 birth attendants who participated in the standardization training had a mean age of 47 years (standard deviation (SD), 13) and had completed an average of 4 years of school (SD, 3). Six of the TBAs self-identified as Mam speaking indigenous women, and all but one spoke Spanish fluently. There were no statistically significant differences in baseline characteristics between the 10 birth attendants who were intensively trained and the other 39 TBAs who attended the 2 hour workshop (Table 1).

Identification of vulnerable newborns for referral

We asked 49 birth attendants who attended the 2-hour workshop to state reasons for referring mothers or newborns to a health center or hospital (see Table 2). Eighteen, or 37% of the 49 birth attendants, stated that they would refer preterm or low birth weight newborns to a health center or a local hospital. Seven (14%) birth attendants said that they had treated a low birth weight infant without referring them for care. Twenty-six (53%) stated that they had never delivered a low birth weight or preterm infant. Birth attendants were asked if they thought infants were taken to health centers or hospitals when they referred them, and if not, why they thought mothers did not heed their advice. Eighteen (37%) of the birth attendants said sick infants were always taken to health centers when referred. Reasons for not going to health facilities were: lack of money ($n = 11$); fear or distrust of treatment received at health

centers or hospitals ($n = 9$); adherence to the 2–3 week postpartum confinement period, referred to as the *dieta*, use of folk or home remedies ($n = 8$); and lack of knowledge ($n = 7$).

Comparison of Capurro and New Ballard newborn gestational age methods

Sixty-three mothers were interviewed and their healthy infants were assessed by the 10 trained birth attendants. Of these, 41 infants were assessed at the regional hospital and 22 infants born at home were assessed during home visits in 13 different rural communities. All infants were evaluated at the hospital within 48 hours of birth. Fifty-nine percent of home births were evaluated within 48 hours of birth.

Sixty New Ballard and 63 Capurro newborn gestational age evaluations had complete data. Using the New Ballard score, the birth attendants estimated that 17/60 (28%) infants were preterm, with the lowest gestational age calculated at 32 weeks. Using the Capurro score, the birth attendants estimated that 16/63 (25%) infants were preterm, with the lowest gestational age calculated at 35 weeks. Table 3 demonstrates the scale items and their correlations.

The Spearman correlation coefficient of association between the New Ballard and the Capurro methods was .75 ($p < .001$). Comparison of the Capurro and New Ballard methods revealed no statistically significant difference (paired t -test ($df = 1.87$ (59), $p < .07$). Thus both methods were comparable when used by the birth attendants to evaluate newborn gestational age and were compared in linear regression models.

The Bland-Altman plot of agreement between the 60 paired New Ballard and Capurro gestational age measurements showed good agreement (see Figure 1). Eight of the 60 paired measures fell outside of the limits of agreement (mean ± 2 standard deviations). The mean difference (a measure of bias) and standard deviation of the differences (a measure of precision) between the measures were -0.33 ± 1.3 weeks.

Newborn anthropometric assessment

Among all 63 infants assessed at birth in the hospital and at the home visits, 19 (30%) infants were LBW. The LBW rate was 17.1% for infants born in the hospital ($n = 7$) and 54% for infants evaluated in their homes ($n = 12$); this difference was statistically significant ($\chi^2 = 9.54$ (62), $p = .002$). Mothers who delivered at home had less formal education ($p < .05$), were more likely to speak the Mam-Mayan language ($p < .001$), and were more likely to receive prenatal care from a TBA ($p < .001$). Infants born at home had lower birth weight, lower birth length, and were born a week earlier compared with those assessed in the hospital (all $p < .05$). There was no statistically significant difference in infant head circumference measurements based on place of delivery (Table 4).

Among the 41 mothers surveyed in the hospital, 32 women reported birth weights for their newborns based on what they hospital personnel told them at the time of delivery. There was a significant difference between newborn weights reported by hospital personnel (mean $\pm$ SD, $3,120 \pm 360$ grams), and newborn weights that were measured by the study team at the bedside within 24 hours of birth (mean $\pm$ SD, $2,868 \pm 386$ grams) (paired t -test ($df = 5.14$ (31), $p < .001$). The mean difference between the two weights was 252 grams [95% CI, 152 to 352].

Although 57 of the mothers who participated in the study were able to state their LNMP (13 of whom could only provide a month and year), only 14 (22%) of the women reported having an ultrasound during any stage of the pregnancy. Fifty of 63 mothers (83%) had been told their expected due date. Mothers who delivered at the hospital were three times more likely to have been told their due date as women who delivered at home (74.3% versus 25.6%, $\chi^2 = 5.51$ (62), $p = .02$).

Estimates of maternal and infant characteristics on infant birth weight

In a multivariate regression model of birth weight, four independent variables (language spoken by mother, number of deliveries, prenatal care received during current pregnancy, and the Capurro score in weeks) accounted for approximately 30% of the variance in birth weight (Table 5). Neither age of newborn at assessment nor sex of infant was significant in any of the models. Indigenous women who spoke Mam as their primary language had infants that weighed 291 grams less than women who spoke Spanish as their primary language ($p = .005$), after controlling for parity, prenatal care, and newborn gestational age estimated using the Capurro method. Women who received prenatal care from any type of provider (TBAs, health center, or hospital) weighed 165 grams more than women who did not receive prenatal care, although this difference was not statistically significant ($p = .33$) after controlling for other variables in the model. In the model, each previous reported delivery contributed 31 grams to infant birth weight; this was not statistically significant ($p = .08$). Weekly increments in Capurro gestational age score accounted for an increase in infant weight of 66 grams ($p < .01$), holding other variables in the model constant. Substituting the New Ballard method for the Capurro method in the multiple regression model did not appreciably change the point estimates, but did change the precision of these estimates due to reduced sample size ($n = 60$) (Table 5).

DISCUSSION

In Guatemala, LBW prevalence is underreported; our finding of LBW rate of 30% is nearly treble the national rate (WHO, 2011). Infants born to indigenous women at home are even more vulnerable (SEGEPLAN, 2010), with over 50% of the study infants weighing less than 2,500 grams. Over 40% of the newborns born to Mam-speaking indigenous women in this sample were estimated to be preterm (less than 37 weeks gestation) using the Capurro (42%) and New Ballard methods (56%). The New Ballard and Capurro methods showed good agreement. The birth attendants reported that the Capurro method, with only 6 criteria, was a more feasible method of assessing newborn gestational age than the New Ballard method with 12 criteria. LBW-preterm and LBW-FGR have different etiologies. While LBW-preterm may be attributed to causes such as perinatal infections, maternal physiological abnormalities, genetic anomalies or disease, more than 50% of LBW-FGR has been attributed to poor maternal nutrition. (Kramer, 1987) Environmental factors, such as maternal infections (Scrimshaw, 2003), tobacco smoke (Leonardi-Bee, Smyth, Britton, & Coleman, 2008), and household indoor air pollution (HAP) from solid cooking fuels play an important role in LBW, although the relative contribution of environmental exposures to LBW-PT versus LBW-FGR is not well described.

While preterm and FGR are contributing factors in the newborns measured in this study, FGR contributed significantly to LBW. Two-thirds of the infants who were LBW were not preterm, as defined by the Capurro method. Despite the limited prior training on recognition of specific characteristics of a premature newborn, 14 (28%) of the 49 TBAs and auxiliary nurses stated that they had referred premature newborns to local health centers in the past. The 22 infants born at home, 12 of whom were low birth weight, would likely not have been taken to the clinic to be measured or weighed until after the 2–3 week *dieta* confinement period. This critical period for weighing and assessing the newborn is a lost opportunity since many FGR and preterm infants are not referred to a local health facility.

Among the women who delivered in the hospital, infant weight was reported by the mothers as approximately 250 grams heavier than the weight obtained by the birth attendants using a calibrated scale and standardized clothing. While maternal recall bias in favor of reporting heavier newborn birth weights may factor into this difference, we visited the delivery room and found that the balance scale was not properly calibrated. Among women who delivered

at home, only 6 (27%) of the infants had been weighed at birth by the TBA prior to evaluation by our study team. Thus, during this study period, birth weights that would be used in the nationally reported data would systematically have under-detected low birth weight and vulnerable infants were likely not identified. TBA training has increasingly been scrutinized as resource-poor countries attempt to devise interventions to decrease maternal and neonatal mortality (Bailey, Szaszdi, & Glover, 2002; Carlo, et al., 2010; Darmstadt, et al., 2009). Trainings are largely designed to support risk management practices, safe birth practices, and prevention of neonatal sepsis (Maupin, 2008; L. Sibley & Ann Sipe, 2004; L. M. Sibley, Sipe, & Koblinsky, 2004). We show that intensively-trained birth attendants can incorporate well-validated New Ballard and Capurro scales to assess newborn gestational age and birth weight measures. Furthermore, our intensively trained birth attendants were similar to the general sample of birth attendants on all socio-demographic characteristics, from which we can infer that this training could be extended in the future to a larger TBA sample with the same level of success.

Limitations

A limitation of our study was convenience sampling of both birth attendants and participating mothers and infants. Accordingly, we can only describe findings but cannot draw inferences about the general population. While this feasibility study was not powered to detect a statistically significant outcome, we were able to detect statistically significant differences in birth weight based on access to prenatal care and ethnicity, both of which signal drastic inequities in health among this rural poor sample in Guatemala. Since we measured infants at birth, a further limitation was our inability to evaluate any prenatal factors contributing to low birth weight, most importantly, prenatal maternal weight, postpartum maternal height and weight, or maternal nutrition and weight gain during pregnancy.

A further limitation is that we were not able to compare newborn gestational age with accurate pregnancy dating verified by first trimester ultrasound measurements. Approximately 70% of the women in our study were able to recall their LNMP, but LNMP was poorly recalled, especially when asked after delivery. In a previous prenatal care study of 171 Guatemalan women, gestational age, as determined by LNMP and newborn maturity exam (modified Capurro method—5 physical maturity criteria, no neuromuscular evaluation), was validated against gestational age established by early second trimester prenatal ultrasound. The newborn maturity exam predicted a gestational age that was 3.3 days less than the ultrasound, and this difference was statistically significant ($p < .001$) (Tofail, et al., 2009). Only 20% of the variance in gestational age assessed by ultrasound was explained by the newborn maturity examination (Neufeld, Haas, Grajeda, & Martorell, 2006), and might have increased had the authors included neuromuscular maturity criteria in their evaluation. Similarly, a hospital-based study in Zimbabwe determined a Pearson correlation coefficient of .80 between mothers' last menstrual period (LMP) and the Ballard method among 364 newborns (Feresu, et al., 2002). In resource-limited countries where women do not have access to regular prenatal care and deliver infants at home, gestational age assessment conducted by trained birth attendants, and based on a simplified neonatal maturity exam using both physical and neuromuscular maturity criteria, may be the only feasible method of establishing LBW and/or prematurity (Verhoeff, et al., 1997).

CONCLUSIONS

We assessed the feasibility of newborn gestational age assessment and newborn length, weight, and head circumference measurement within 48 hours of delivery by 10 intensively-trained birth attendants. To our knowledge, our study is the first to test the use of the New

Ballard and Capurro newborn maturity assessments in a rural, Guatemalan setting. A study in Malawi trained nurses to assess gestational age using the New Ballard method (Verhoeff, et al., 1997). Ours is the first study to evaluate the feasibility of training limited-literacy birth attendants to do the same.

With intensive training and close supervision, Guatemalan birth attendants were able to assess gestational age using the simplified 6-criteria Capurro technique, which provided an equivalent estimate of newborn gestational age compared with the 12-criteria New Ballard method. Our future efforts will focus on extending newborn gestational age training to other birth attendants in this resource-limited region of Guatemala to help them identify and refer infants at risk to higher levels of care. Identifying factors associated with birth weight and preterm birth, such as delays in seeking care, or differences in infant vulnerability based on maternal or infant risk factors, could be used in future intervention studies aimed at improving neonatal survival.

References

- Bailey PE, Szaszdi JA, Glover L. Obstetric complications: does training traditional birth attendants make a difference? *Rev Panam Salud Publica*. 2002; 11(1):15–23. [PubMed: 11858126]
- Ballard JL, Khoury JC, Wedig K, Wang L, Eilers-Walsman BL, Lipp R. New Ballard Score, expanded to include extremely premature infants. *J Pediatr*. 1991; 119(3):417–423. [PubMed: 1880657]
- Ballard JL, Novak KK, Driver M. A simplified score for assessment of fetal maturation of newly born infants. *J Pediatr*. 1979; 95(5 Pt 1):769–774. [PubMed: 490248]
- Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet*. 1986; 1(8476):307–310. [PubMed: 2868172]
- Bland JM, Altman DG. Measuring agreement in method comparison studies. *Stat Methods Med Res*. 1999; 8(2):135–160. [PubMed: 10501650]
- Buekens P, Delvoe P, Wollast E, Robyn C. Epidemiology of pregnancies with unknown last menstrual period. *J Epidemiol Community Health*. 1984; 38(1):79–80. [PubMed: 6707567]
- Capurro H, Konichezky S, Fonseca D, Caldeyro-Barcia R. A simplified method for diagnosis of gestational age in the newborn infant. *J Pediatr*. 1978; 93(1):120–122. [PubMed: 650322]
- Carlo WA, McClure EM, Chomba E, Chakraborty H, Hartwell T, Harris H, et al. Newborn care training of midwives and neonatal and perinatal mortality rates in a developing country. *Pediatrics*. 2010; 126(5):e1064–e1071. [PubMed: 20937659]
- Darmstadt GL, Lee AC, Cousens S, Sibley L, Bhutta ZA, Donnay F, et al. 60 Million non-facility births: who can deliver in community settings to reduce intrapartum-related deaths? *Int J Gynaecol Obstet*. 2009; 107(Suppl 1):S89–S112. [PubMed: 19815200]
- DiPietro JA, Allen MC. Estimation of gestational age: implications for developmental research. *Child Dev*. 1991; 62(5):1184–1199. [PubMed: 1756662]
- Dubowitz LM, Dubowitz V, Goldberg C. Clinical assessment of gestational age in the newborn infant. *J Pediatr*. 1970; 77(1):1–10. [PubMed: 5430794]
- Feresu SA, Gillespie BW, Sowers MF, Johnson TR, Welch K, Harlow SD. Improving the assessment of gestational age in a Zimbabwean population. *Int J Gynaecol Obstet*. 2002; 78(1):7–18. [PubMed: 12113965]
- Kramer MS. Intrauterine growth and gestational duration determinants. *Pediatrics*. 1987; 80(4):502–511. [PubMed: 3658568]
- Kramer MS. The epidemiology of adverse pregnancy outcomes: an overview. *J Nutr*. 2003; 133 Suppl 2(5):1592S–1596S. [PubMed: 12730473]
- Leonardi-Bee J, Smyth A, Britton J, Coleman T. Environmental tobacco smoke and fetal health: systematic review and meta-analysis. *Arch Dis Child Fetal Neonatal Ed*. 2008; 93(5):F351–F361. [PubMed: 18218658]
- Lynch C, Zhang J. The research implications of the selection of a gestational age estimation method. *Paediatr Perinat Epidemiol*. 2007; 21(Suppl 2):86–96. [PubMed: 17803622]

- Maupin JN. Remaking the Guatemalan midwife: health care reform and midwifery training programs in Highland Guatemala. *Med Anthropol*. 2008; 27(4):353–382. [PubMed: 18958785]
- Neufeld LM, Haas JD, Grajeda R, Martorell R. Ultrasound measurement of fetal size in rural Guatemala. *Int J Gynaecol Obstet*. 2004; 84(3):220–228. [PubMed: 15001369]
- Neufeld LM, Haas JD, Grajeda R, Martorell R. Last menstrual period provides the best estimate of gestation length for women in rural Guatemala. *Paediatr Perinat Epidemiol*. 2006; 20(4):290–298. [PubMed: 16879501]
- PAHO. Perfil del sistema de salud en Guatemala. Washington, DC: Pan American Health Organization; 2007.
- Scrimshaw NS. Historical concepts of interactions, synergism and antagonism between nutrition and infection. *J Nutr*. 2003; 133(1):316S–321S. [PubMed: 12514318]
- SEGEPLAN. Guatemala City, Guatemala: Serviprensa; 2010. Tercer informe de avances en el cumplimiento de los Objetivos de desarrollo del milenio. Objetivo 5: Mejorar la salud materna [Third report on the advances of meeting the Millenium Development Goals. Objective 5: Improve Maternal Health].
- Sibley L, Ann Sipe T. What can a meta-analysis tell us about traditional birth attendant training and pregnancy outcomes? *Midwifery*. 2004; 20(1):51–60. [PubMed: 15020027]
- Sibley LM, Sipe TA, Koblinsky M. Does traditional birth attendant training increase use of antenatal care? A review of the evidence. *J Midwifery Womens Health*. 2004; 49(4):298–305. [PubMed: 15236709]
- Sunjoh F, Njamnshi AK, Tietche F, Kago I. Assessment of gestational age in the Cameroonian newborn infant: a comparison of four scoring methods. *J Trop Pediatr*. 2004; 50(5):285–291. [PubMed: 15510760]
- Tofail F, Vahter M, Hamadani JD, Nermell B, Huda SN, Yunus M, et al. Effect of arsenic exposure during pregnancy on infant development at 7 months in rural Matlab, Bangladesh. *Environ Health Perspect*. 2009; 117(2):288–293. [PubMed: 19270801]
- UNICEF. Low birthweight: Country, regional and global estimates. New York: United Nation's Childrens Fund and World Health Organization; 2004.
- Verhoeff FH, Milligan P, Brabin BJ, Mlangi S, Nakoma V. Gestational age assessment by nurses in a developing country using the Ballard method, external criteria only. *Ann Trop Paediatr*. 1997; 17(4):333–342. [PubMed: 9578793]
- WHO. World Health Statistics 2011. Geneva: World Health Organization; 2011.

FIGURE 1.
Bland-Altman plot of agreement between New Ballard and Capurro Gestational Age Assessment Methods

Table 1

Participant characteristics of intensively trained birth attendants and workshop participants

Characteristic	Intensive Training (n=10)	General Training (n=39)
Age, years (SD)	47.6 (12.6)	47.9 (15.2)
Education, years (SD)	4.6 (3.1)	2.8 (4.9)
Indigenous (Mam-speaking), n (%)	6 (60)	27 (60)
Auxiliary Nurse, n (%)	1 (10)	7 (18)
Traditional Birth Attendant, n (%)	9 (90)	32 (82)
Cost per delivery, US\$ equivalent (SD)	8.03 (6.23)	6.11 (5.75)
Supplies owned		
Scissors, n (%)	10 (100)	36 (92)
Scale (spring balance), n (%)	8 (80)	24 (62)
Thermometer, n (%)	5 (50)	15 (38)
Delivery kit, n (%)	1 (10)	2 (5)
Bulb syringe, n (%)	1 (10)	3 (8)
Gloves, n (%)	0 (0)	4 (10)

Table 2

Reasons for referring mothers or newborns to health center or hospital among 49 workshop participants

Reason stated:	Referred
Eclampsia during pregnancy	18 (37%)
Eclampsia during delivery	10 (20%)
Vaginal Bleeding during pregnancy	15 (31%)
Vaginal Bleeding during delivery	14 (28%)
Vaginal bleeding post-partum	13 (27%)
Delivery; long labor	21 (43%)
Sepsis post-partum	10 (21%)
Sick newborn	16 (33%)
Preterm or low birth weight newborn	18 (37%)

Table 3

New Ballard and Capurro scales: Spearman rank correlation of individual items, neurologic and physical subscales with total scale scores

Criteria	Score Range	Mean Score (S.D.)	Correlation ^a
NEW BALLARD^b			
<i>Neurological Criteria</i>			
Neurological subscale	−4 to 25	18.1 (2.2)	0.77*
Posture	0 to 4	3.1 (0.6)	0.52*
Square window	−1 to 4	2.9 (1.3)	0.26
Arm recoil	0 to 4	3.0 (0.8)	0.51*
Popliteal angle	−1 to 5	3.8 (0.8)	0.44*
Heel to ear	−1 to 4	2.7 (0.6)	0.46*
Scarf sign	−1 to 4	2.5 (0.5)	0.09
<i>Physical Criteria</i>			
Physical subscale	−8 to 25	14.2 (3.3)	0.93*
Skin	−1 to 5	1.8 (0.9)	0.66*
Lanugo	−1 to 4	1.4 (1.1)	0.54*
Plantar creases	−2 to 4	3.3 (0.8)	0.48*
Breast	−1 to 4	2.8 (0.9)	0.48*
Ear	−2 to 4	2.2 (0.8)	0.59*
Genitalia	−1 to 4	2.7 (0.9)	0.54*
Ballard, total score	−12 to 50	38.1 (4.7)	
CAPURRO^c			
<i>Neurological Criteria</i>			
Neurological subscale	0 to 30	20.5 (3.9)	0.58*
Scarf sign	0 to 18	16.8 (2.4)	0.29
Head lag	0 to 12	3.7 (2.7)	0.58*
<i>Physical Criteria</i>			
Physical subscale	6 to 79	48.8 (12.2)	0.96*
Skin	0 to 20	8.9 (4.7)	0.68*
Plantar creases	0 to 20	17.6 (3.7)	0.54*
Breast	6 to 15	7.2 (3.2)	0.62*
Ear	0 to 24	15.1 (6.3)	0.76*
Capurro, total Score	6 to 109	69.3 (14.0)	

* $p < .05$

^b To calculate age in weeks, use regression equation Ballard = $0.42 * (\text{raw total score}) + 24.49$

^c To calculate age in days, add 200 to total score

Table 4

Participant characteristics of 63 mothers and infants evaluated at hospital and at home

	Hospital birth n=41	Home birth n=22	p value
Maternal age, years (SD)	25.2 (6.4)	26.5 (6.7)	
Maternal education, years (SD)	6 (4.9)	3.2 (2.3)	<.05
Indigenous (Mam language), n (%)	1 (2)	18 (81)	<.01
Prenatal care with TBA, n (%)	19 (45)	18 (82)	<.01
Primiparous, n (%)	12 (29)	6 (27)	
Parity, n (SD)	3 (2)	4 (3)	
Older sibling died at < 1 year of age, n (%)	5 (12)	5 (23)	
Hours since birth, (SD)	17.5 (12.9)	45.5 (21.0)	<.001
Birth weight, grams (SD)	2867 (383)	2571 (301)	<.05
Birth length, cm (SD)	48.6 (2.2)	47.1 (2.0)	<.05
Head circumference, cm (SD)	33.5 (1.7)	33.1 (1.3)	
New Ballard score, weeks (SD) (n=60)	38.5 (2.1)	37.2 (1.4) ^a	<.05
Capurro score, weeks (SD)	38.9 (2.1)	37.7 (1.7)	<.05
Male sex, n (%)	24 (58)	7 (32)	<.05

^a 19 home births measured using New Ballard method

Table 5

Summary of multivariate linear regression models for variables predicting birth weight outcome, Capurro method of newborn gestational age assessment^a (Model 1) and New Ballard method of newborn gestational age assessment^b (Model 2)

Variables	β , gram change	95% CI
Model 1		
Indigenous ethnicity, speaks Mam language	−291	[−492, −92]
Received prenatal care during current pregnancy	+165	[−177, 508]
Number of pregnancies prior to this pregnancy	+31	[−4, 66]
1 week increase in Capurro score	+66	[23, 109]
Model 2		
Indigenous ethnicity, speaks Mam language	−313	[−540, −87]
Received prenatal care during current pregnancy	+147	[−247, 542]
Number of pregnancies prior to this pregnancy	+27	[−10, 64]
1 week increase in New Ballard score	+60	[12, 107]

^a F (4, 58) = 6.91; R-squared = .32; Adjusted R-squared = .28

^b F (4, 55) = 6.12; R-squared = .31; Adjusted R-squared = .26