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## Evaluation of Adjustment Methods Used to Determine Prevalence of Low Birth-weight Babies at a Rural Hospital in Andhra Pradesh, India

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### Summary

Accurate reporting of prevalence of low birth weight (LBW) is important for monitoring health of a population. LBW is often underestimated in developing countries due to heaping of the data at 2.5 kg. UNICEF uses an average adjustment factor of 25% to re-classify babies listed as exactly 2.5 kg into the LBW category. From October 2009 to February 2010, we weighed 859 consecutive live births at a rural hospital in Andhra Pradesh, India, using analog and digital scales to evaluate the relative validity of the adjustment factor. Significantly more babies weighed exactly 2.5 kg on analog (13.4%) versus digital (2.2%) scales, showing heaping. Percentage of LBW by digital method (29.5%) was significantly higher compared to the analog method (23%) and with adjustment factors (26.4%). Conventional methods of adjusting birth-weight data underestimate the prevalence of LBW. Sensitive digital weighing machines or better adjustment methods are needed to monitor LBW in developing countries.

**Keywords:** Adjustment factor, Birth-weight, Low birth-weight, Rural India

The proportion of infants with low birth weight (LBW) is a key indicator of general population health. While birth weight (BW) is easily measured and reliably recorded in most developed countries through vital statistics,<sup>1</sup> accurate BW data are not available for developing countries.<sup>2-5</sup> Biases in available BW data from developing countries systematically underestimate the prevalence of LBW.<sup>4,6</sup>

To correct for this bias, statistical adjustment factors were derived from a study of BW data from 62 surveys

conducted by the Demographic and Health Surveys (DHS) Program in 42 developing countries. The major source of bias was “heaping” at multiples of 500 g. Heaping is also called digit preference and refers to very large frequencies at round numbers due to a pattern of misreporting.<sup>5</sup> Heaping is particularly of concern when analyzing BW data because the cut-off for LBW is 2.5 kg,<sup>3</sup> where there is typically an implausibly large “heap”.

The above-referenced DHS study resulted in two proposed methods for correcting the heaping at 2.5 kg. First, they proposed the following formula for the calculation of an adjustment factor (Method (i)) (T. Croft, personal communication, February 10, 2009).

$$\text{Adjustment factor} = A/(A + C) \quad (1)$$

$$\text{Adjusted number of LBW infants} = (\text{Original\#LBW}) + \left(\frac{A}{A + C}\right) * B \quad (2)$$

Where,

A = infants weighing 2.001-2.499 kg

B = infants weighing exactly 2.5 kg

C = infants weighing 2.501-2.999 kg

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When this method was applied to the 62 DHS, the average adjustment factor was 26% (range: 12-42%). Therefore, a general adjustment factor of 25% is used (Method (ii)). This methodology has been applied to international estimates of LBW by UNICEF and the WHO and can be considered an accepted method for adjusting LBW data to correct for heaping at 2.5 kg.<sup>7,8</sup>

We have evaluated this method using BW data from a rural population in the state of Andhra Pradesh, India.

From October 14, 2009 through February 14, 2010 BW was recorded for consecutive births occurring at MediCiti Hospital, a rural private hospital in Ghanpur Village in the Ranga Reddy District, in the state of Andhra Pradesh, India. The hospital provides services to surrounding villages and towns. Ninety-six percent of women in this population deliver in medical institutions.<sup>9</sup> Each newborn was weighed by the conventional method on a 50-g graduated analog scale (10 kg-50 g-Doebel-Braun baby weighing scale with an analog spring base) and the BW was recorded by the labor room nurse, who was not given any particular training pertaining to the study. Then, each baby was weighed and the weight recorded by a research nurse specially trained for this study to measure babies on a SECA 354 10-g sensitive digital scales. These “digital BWs” are considered the true BWs or gold standard.

Approval from the MediCiti Institute of Medical Sciences Institutional Ethics Committee was obtained for the study. Informed consent was obtained from all mothers whose newborns were included in the study.

Using the digital BWs as the gold standard, a true prevalence of LBW for this birth cohort was calculated and compared to the prevalence of LBW from the analog scale data. The adjustment factor was calculated using Equation 1. Prevalence of LBW, sensitivity, and specificity were calculated from the raw analog data, Method (i) adjusted analog data using the 25% adjustment factor, and Method (ii) adjusted analog data using the calculated adjustment factor (Equation 1). The digital and analog BW data were compared to determine what percentage of babies listed as weighing 2.5 kg in the analog data were actually LBW according to the digital data.

Sample size was calculated using a method designed for a one-sample study of screening tests based on hypothesis testing for the sensitivity and specificity of the tests. Using the most stringent parameters, a sample size of 413 is required.<sup>10</sup>

All analyses were completed using SAS 9.2. Descriptive statistics were calculated and digital and analog mean BWs were compared using a paired Student's t-test. The prevalence of LBW from all three methods were then compared to the true prevalence using the One Sample Binomial Proportions Test. Sensitivity and specificity were calculated for raw and adjusted analog data using the digital BWs as the gold standard.

Nine hundred and thirteen consecutive births during the study period were taken into consideration. The BWs of 52 newborns on digital scale and two BWs on analog scale were missing. [Table 1] The mean and standard deviation of the 52 analog BW data points that were excluded did not differ significantly from the 859 analog BW data points that were included in the analysis. (2.71 kg  $\pm$  0.46 vs. 2.73 kg  $\pm$  0.48).

Birth weights of 859 babies weighed both on analog and digital weighing scales were analyzed. In the BW distributions, heaping can be seen at 500-g intervals in the analog but not digital data [Figure 1]. A significantly higher number of newborns were weighed as exactly 2.5 kg by the analog scale (11.5%) compared to the digital scale (2.2%,  $P < 0.0001$ ) [Table 1].

The true prevalence of LBW, based on the digital scale data, is 29.5%. The raw data from the analog scale has a significantly lower prevalence of LBW (23.0%,  $P=0.00002$ ). The calculated adjustment factor for Method (i) is 33.7%; this proportion of the babies weighing exactly 2.5 kg will be reclassified as LBW. After applying this adjustment factor, the prevalence of LBW was underestimated (26.9%,  $P > 0.05$ ), though not statistically significant. After correction using Method (ii), the LBW prevalence was significantly lower than the true prevalence (26.0%,  $P=0.0231$ ) (Table 1).

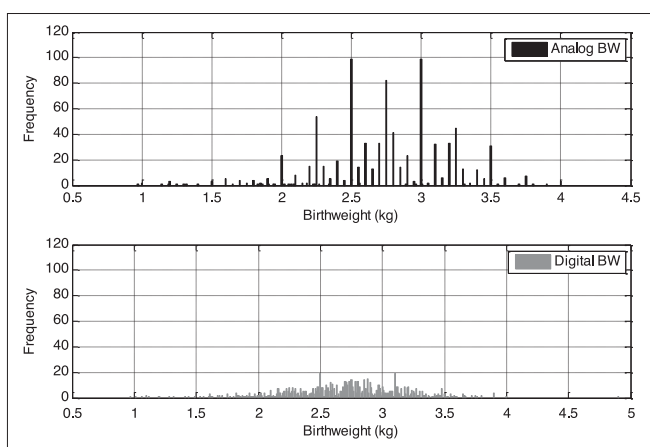
Among the 99 babies weighing exactly 2.5 kg according to the analog scale, 49 babies (49.5%) weighed less than 2.5 kg on the digital scale. This percentage is compared to the method (i) adjustment factor of 33.7%. When 49.5% of babies weighing exactly 2.5 kg were added to LBW category, the computed LBW prevalence was 28.7% which is much closer to the true prevalence of 29.5% from the digital BW data.

Sensitivity and specificity were calculated using the digital BW data as the gold standard. The analog scale method had a sensitivity of 0.75 and a specificity of 0.98. Method (i)

**Table 1: Population statistics, adjustment methods and prevalence of LBW**

A. Population statistics					
	Analog scale	Digital scale	p-value		
Total number of births = 913					
Births with Missing weights	2	52			
Births with available weights	911	861			
Births with analog and digital weights = 859					
Birth weight kg (Mean±SD)	2.73±0.48	2.70±0.48	0.237*		
Number (%) of babies weighing 2.5 kg (B)	99 (11.53)	19 (2.2)	<0.0001†		
B. Adjustment Method (ii)–Parameters for calculation of adjustment factor					
Number (%) of babies weighing between 2.0 and 2.5kg (A)	132 (15.37)				
Number (%) of babies weighing between 2.5 and 3.0kg (C)	260 (30.27)				
Adjustment factor (A/(A+C))	.3367				
C. Prevalence of LBW from Digital Scale, Analog Scale and Adjustment Methods					
	n	%	N	%	
1. LBW: < 2.5 kg	198	23.05	253	29.45	.00002††
2. LBW: < 2.5 kg + adjustment factor (i)	223	25.96			.0231††
3. LBW: < 2.5 kg + adjustment factor (ii)	231	26.93			.1054
D. Sensitivity and Specificity of Analog Scale Data and Adjustment Factors					
	Sensitivity		Specificity		
1. LBW: < 2.5 kg	0.75		0.98		
2. LBW: < 2.5 kg + adjustment factor (i)	0.80		0.96		
3. LBW: < 2.5 kg + adjustment factor (ii)	0.81		0.96		

\*Mean BW compared using a student's t-test; †Prevalence of 2.5kg compared using the one-sample binomial proportions test; ††Analog LBW prevalence is significantly different from digital scale LBW prevalence according to the one sample binomial proportions test



**Figure 1: Birth-weight frequency and distribution from analog and digital scales**

had a sensitivity of 0.80 and a specificity of 0.96. Method (ii) had a sensitivity of 0.81 and specificity of 0.96.

Our study confirms the previous findings that there is significant heaping at multiples of 500 g when conventional analog scales are used to measure babies' weight at birth. As in the earlier studies, this leads to a significant underestimation of the prevalence of LBW in a population.

Our study assessed the available statistical methods of adjusting BW data, by comparing with BWs taken

on a sensitive digital scale. These data acted as a gold standard and represented the true prevalence of LBW in this population. We then determined if the two UNICEF statistical adjustment methods were able to produce accurate prevalence of LBW in the biased analog BW data. UNICEF, the WHO and the government of India have estimated prevalence of LBW in India to be around 30%.<sup>7,8,11</sup> The prevalence of LBW by each of the methods under review here were comparable to these published figures. However, the true proportion of LBW babies was underestimated by the raw analog BW data and by both of the adjustment methods tested here. Both the analog method of measuring BW and the adjustment method using 25% significantly underestimated the percentage of LBW babies in the population. Method (i) produces an estimate of LBW that is lower, though not significantly lower than the true value.

While the current adjustment method indicates that 33.7% of babies weighing exactly 2.5 kg should be reclassified as LBW, an analysis of the analog and digital weight from this population shows that 49.5% of babies weighed as exactly 2.5 kg on the analog scale should be re-classified as LBW. This difference in proportion to be reclassified is the basis of the underestimation of the prevalence of LBW.

Our study was completed at one rural hospital, limiting its generalizability. Also, the published methods of adjusting BW data were derived from household DHS, while ours is institutional data. Institutional deliveries have often been described as biased because those who deliver in hospitals in the developing world are typically of a higher socioeconomic status than those who deliver at home. However, we believe the use of institutional data is appropriate in this specific population where more than 90% of the general population delivers in institutions.<sup>9</sup>

BW is an important variable both for policy and research, but accurate BW data from the developing world are lacking. Ideally, all BWs should be measured using a sensitive digital scale and recorded accurately in readily available, national systems of vital statistics. This would allow researchers and health administrators to determine the true prevalence of LBW in a population. When this is not available, adequate and appropriate statistical adjustment methods are needed that can help in eliminating the specific biases in the available data. We have shown that the available statistical adjustment methods underestimate the prevalence of LBW. For the future, it is imperative that new statistical adjustment methods are developed so that this important health measure, LBW, is accurately and properly captured.

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