RESEARCH PAPER

# Validity of Maternal Report of Birthweight in a Cohort Study and Its Implication on Low Birthweight Rate Using Simulations

AKSHAY SWAMINATHAN[1], TINKU THOMAS[2], DANIEL J CORSI[3], PRATIBHA DWARKANATH[4], SV SUBRAMANIAN[5] AND ANURA V KURPAD[6]

*From Department of [1]Statistics, Harvard College, Cambridge, Massachusetts, USA; Department of [2]Biostatistics, St. John's Medical College, Bangalore, Karnataka; [3]OMNI Research Group, Clinical Epidemiology Program, Ottawa Hospital Research Institute, Ottawa, Canada; Division of [4]Nutrition, St. John's Research Institute, Bangalore, Karnataka; Department of [5]Social and Behavioral Sciences, Harvard School of Public Health, Boston, Massachusetts, USA and [6]Department of Physiology, St. John's Medical College, Bangalore, Karnataka, India.*

*Correspondence to: Dr Tinku Thomas, Department of Biostatistics, St John's Medical College, St. John's National Academy of Health Sciences, Bangalore - 560 034, Karnataka, India. tinku.sarah@sjri.res.in*
*Received:* March *15, 2019; Initial review:* April *22, 2019; Accepted:* September *19, 2019.*

**Objective**: Maternal recall of birthweight is a convenient and cost-effective way to obtain birthweight measurements when official records are unavailable. It is important to assess the validity of maternal recall of birthweight before using these measurements to draw conclusions about a population. **Methods**: This is secondary analysis of data from a previous cohort study. We analyzed actual and reported birthweights of 200 mother-and-child pairs from Southern India. We validated maternal report of birthweight by generating correlation coefficients, summary statistics, and Bland-Altman plots. We ran simulations to evaluate how misclassification as low or normal birthweight changed with the mean birthweight of the cohort. **Results**: Reported birthweight was strongly correlated with actual birthweight (r=0.80, $P$<0.001); 55%, 78.5%, and 93% of subjects reported values within 50 g, 250 g, and 500 g, respectively of actual birthweight. None of sociodemographic covariates was significantly associated with the accuracy of maternal recall of birthweight. 7.5% of children were misclassified as either low or normal birthweight by reported birthweight. Simulations revealed that increasing the reported and actual birthweights by 500g reduces the misclassification rate from 7.5% to 1.5%. **Conclusion**: Maternal recall is a sufficiently accurate measure of actual birthweight. However, the distribution of actual birthweight in the population must be taken into consideration when classifying babies as low or normal birthweight, especially in populations where mean birthweight is close to 2500g.

**Keywords**: *Child health, Estimation, Self-reported data*.

Many of the most pressing current global health issues, including diabetes, cancer, obesity and cardiovascular disease, have been linked to birthweight and body weight in early life [1-5]. Maternal report of birthweight is a convenient and cost-effective method of obtaining birthweight measurements if accurate birth records are not available, such as in certain developing countries. Assessing the accuracy of this type of measurement is necessary to validate the results of analyses that rely on maternal report of birthweight. Rate of low birth weight in India is 18% [6]. The error in reporting of birthweight by mothers may result in misclassification into low birthweight category. There is currently no evaluation of the potential misclassification of low birthweight due to measurement error arising as a consequence of maternal report.

While previous studies have analyzed the accuracy and correlates of maternal report of birthweight [7-13], most have focused on cohorts from developed countries. We evaluated the accuracy of maternal reports at varying time points ranging from 6 months to 7 years after birth, and studied the association with various sociodemographic characteristics.

## METHODS

Subjects were part of a prospective observational cohort study in Southern India on 2001 pregnant women, and this report is a secondary analysis of data from that study [14]. For this analysis, we reviewed 200 mother-child pairs, for which we had 199 maternal reports of birthweight and 200 measured birthweight. Pregnant women in the age range of 17-40 years on their first visit for a registered antenatal checkup were recruited in the pregnancy cohort from the Department of Obstetrics of St. John's Medical College Hospital, Bangalore, India. Infants were weighed to the nearest 10g on an electronic weighing scale (Salter Housewares 914 Electronic Baby and Toddler Scale, NY, USA) immediately after birth. Data on maternal education, possession, household income, sex and birth order of the sampled child and parity of the mother were collected in the pregnancy cohort.

As part of a study on inter-generational transmission of nutrition, the last 1000 women in chronological order of pregnancy cohort recruitment (women who delivered live babies from 2008 to 2013) of the original 2,001 were identified as initial subjects for follow-up analysis. Of these 1000 women, 560 were deemed valid for data collection (others either did not have a valid phone number or address or were not residents of Bangalore). Of these, using a questionnaire, one follow-up data was finally collected from 200 consenting, contactable mothers between December 2013 and December 2014, within 7 years after delivery. The telephone numbers of the mother, spouse or other relatives which were available in the pregnancy cohort were tried, to establish contact and obtain residential address of the mother and the child. A maximum of three home visits were made by a trained field worker to collect data, once the telephonic contact was made with the mother. Birthweight reported in kilograms by some mothers were converted to grams for comparison with the birth records. Maternal and child age at the time of revisit was collected. The institutional ethical review board of St. John's Medical College Hospital approved the study protocols of both the pregnancy cohort and the child follow-up study on inter-generational transmission of nutrition.

*Statistical analysis*: All statistical analysis was conducted on R version 3.3.2. Pearson correlation coefficients and interclass correlation coefficients (ICC) for absolute agreement were calculated to quantify correlation between actual and reported birthweight. Paired t-tests were used to compare actual and reported birthweight overall and in different subgroups (<3 years old, 3-5 years old, >5 years old, low birthweight (LBW), and normal birthweight. LBW was defined as <2500 g and normal birthweight was defined as ≥2500 g in measured weight. Independent sample t-test was used to compare the difference between reported and actual birthweight in LBW and normal birthweight infants. Bland-Altman plots with limits of agreement [Mean difference (2 SD)] were used to assess the difference between actual and reported birthweight. Sensitivity, specificity, positive predictive values (PPV), and negative predictive values (NPV) were calculated for reported classification of infants as LBW or normal birthweight, as well as proportion of misclassified children. Cumulative percent accuracy calculations were used to determine accuracy of reported birthweight within increasing margins of error. Linear regression and subsequent multiple linear regression was used to determine the association between 23 sociodemographic variables and the accuracy of reported birthweight. Linear regression was also used to compare the effect of using reported *vs* actual birthweight as both independent (for child growth) and dependent variables (on maternal characteristics) in regression analysis. The regression coefficients between the reported and actual birthweight were compared using 95% confidence intervals (CI). In addition, we generated a simulated dataset of 2000 actual and reported birthweights to illustrate how the distribution of actual birthweight affects misclassi-fication. The simulated actual birthweights were drawn from a normal distribution with mean 2878 g and standard deviation 400 g and then scaled to the mean. The simulated reported birthweights were set as the simulated actual birthweights plus a normally distributed error term with mean 10 g and standard deviation 300 g. Parameters for the simulated dataset were estimated based on the summary statistics of our study cohort.

## RESULTS

The median age of children at revisit was 41 months (***Table* I**). The average measured birthweight of the original cohort was 2870 g (450 g) and that of the revisit sub-sample of 200 children was 2878 g (406 g) (***Table* II)**. The average reported birthweight was 2889 g, which strongly correlated with actual birthweight (r=0.80 and ICC=0.79). Correlation remained high (r>0.8) across all age groups. ICC was high for normal birthweight babies (0.71) than for LBW babies (0.29).

Bland-Altman plots revealed the difference between each pair of reported and actual birthweight versus the mean of each pair (***Fig.* 1a**). The mean difference between reported and measured birthweight was 13 g (95% CI: -29 to 54). The difference was randomly distributed about zero (Mean=152 g, paired t-test *P*=0.83), suggesting that mothers of LBW children are not more likely to over or under-report their birthweight compared to mothers of normal birthweight children. The upper and lower limits of agreement of the Bland-Altman plot were 23 and 83 g, respectively.

We calculated the accuracy of reported birthweight within increasing margins of error for more insight into the bias. Overall, 110 (55%) subjects reported birthweight within 50 g of actual, 157 (78.5%) subjects reported birthweight within 250 g of actual, and 185

**TABLE I** SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE REVISIT COHORT (*N*=200)

| *Characteristics* | *Value* |
|---|---|
| Child's age at follow-up (mo)# | 41 (22, 57.25) |
| Age of mother at follow-up (y)# | 27 (24, 30) |
| Years of education of mother# | 12 (10, 15) |
| Total number of possessions# | 17 (16, 19) |
| Yearly household income (INR)# | 15000 (10000, 27250) |
| Yearly household income during pregnancy (INR)# | 14000 (10000, 23500) |
| Male sex | 104 (52) |
| *Mother's education level*$ | |
| Up to secondary | 63 (32) |
| Diploma or higher secondary | 57 (29) |
| Degree | 42 (21) |
| Professional degree | 22 (11) |
| Post graduate or above | 15 (8) |
| First in birth order$ | 140 (70) |
| Parity of mother$ | |
| 1 | 97 (49) |
| 2 | 98 (49) |
| 3 | 4 (2) |
| *Possessions*$ | |
| Flush Toilet | 56 (28) |
| Running cold water | 149 (75) |
| Running hot water | 83 (42) |
| Car | 51 (26) |
| Two-wheeler | 161 (81) |
| Television | 197 (99) |
| Refrigerator | 131 (66) |
| Washing machine | 83 (42) |
| Fixed telephone | 19 (10) |
| Radio | 28 (14) |

*#Median (IQR); $n (%); INR: Indian Rupee (65 INR = 1 US dollar).*

(93%) subjects reported BW within 500 g of actual (***Fig. 1b***). Treating reported BW as a test that can either be positive (reported Low Birthweight) or negative (reported Normal Birthweight), sensitivity, specificity, PPV, and NPV were calculated to be 77%, 96%, 83%, and 94%, respectively against the actual. 7.5% (15/199) of children were misclassified according to reported birthweight.

In simple linear regression, only one out of 23 sociodemographic variables, whether or not the family possessed a television, was a significant determinant of the accuracy of reported birthweight. Multiple linear regression showed no significant associations between any of the sociodemographic variables and the accuracy.

We conducted linear regressions using reported birthweight and actual birthweight as either the independent or dependent variable to assess how using reported birthweight instead of actual birthweight affects the estimate for the regression coefficient (***Web Fig. 1***). In each pair of regressions, the 95% CI for the regression estimate using reported birthweight largely overlapped with the 95% CI of the coefficient estimate for the regression using actual birthweight, indicating that there is no sufficient evidence of a difference in estimates by either using reported or actual birthweights.

To illustrate how the distribution of actual birthweight in a population affects the misclassification rate, we analyzed the distribution of our cohort and a simulated dataset of 2000 actual and reported birthweight. ***Fig. 2a*** shows the distribution of BW in our study cohort, and ***Fig. 2b*** shows the distribution of birthweight in our study cohort after a positive shift of 500 g. The 7.5% misclassification rate drops to 1.5% after the 500 g shift. ***Fig. 2c*** and **2d** show how misclassification rate changes with varying mean actual birthweight. In both the study cohort (***Fig. 2c***) and simulated population (***Fig. 2d***), the highest misclassification rate occurs when the mean actual birthweight is between approximately 2250 g and

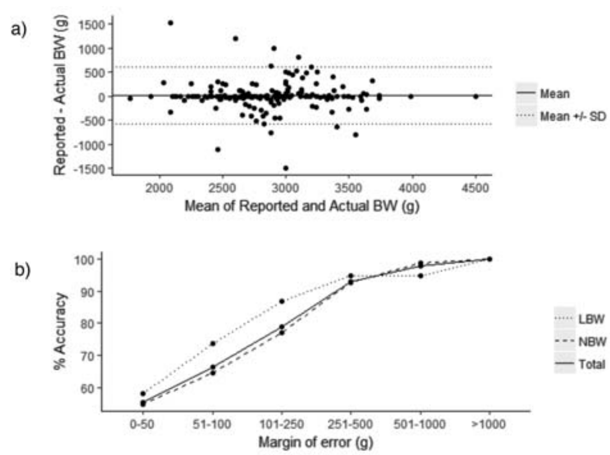


***Fig.* 1** *(a) Bland-Altman plot of actual and reported birthweights (BW). Points on graph represent difference in BW (Y-axis) against mean of reported and measured BW. Solid line: Mean difference. Dotted line: Mean difference ±2 SD. (b) Cumulative percent accuracy plot of maternal reports. Points on the graph represent the cumulative percent accuracy of reported BW within various margins of error. The dotted line represents actual LBW babies, the dashed line actual NBW babies, and the solid line all babies.*

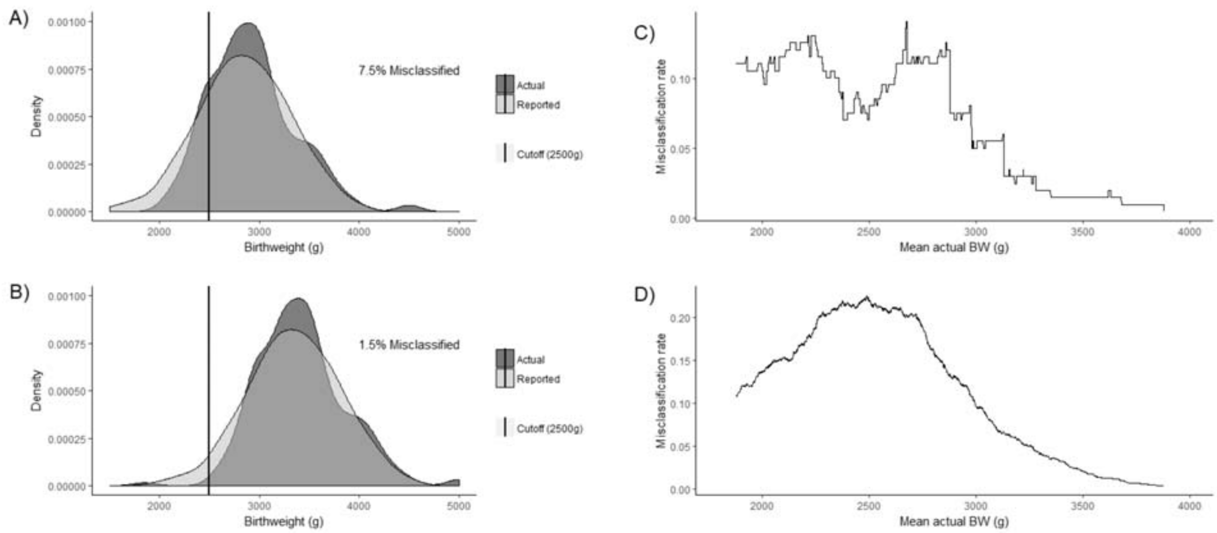


***Fig.* 2** *(a) Distribution of study cohort with mean actual birthweight (BW) 2878 g resulting in 7.5% misclassification; (b) Distribution of shifted study cohort with mean actual BW 3378 g resulting in 1.5% misclassification; (c) Misclassification rate vs. mean actual BW in study cohort; (d) Misclassification rate vs. mean actual BW in simulated cohort.*

2750 g. Misclassification rate drops quickly as the mean actual birthweight passes 2750 g.

## DISCUSSION

Our results indicate that maternal report of birthweight is a sufficiently accurate measure of the actual birthweight. However, it must be emphasized that relying on maternal report is not appropriate in all contexts, regardless of the accuracy of this metric. Although it may be sufficiently accurate in surveys where actual birthweight data is unavailable, population assessments, prevalence estimates and trials with birthweight as an outcome should use recorded birthweight data in order to maintain the highest standards of accuracy.

Studies from other countries have reported slightly higher overall correlations, [7,9,10,12,13]. Similarly, strong correlations across the three age groups indicate that age of child does not influence the difference between reported and actual birthweight. The correlation and ICC were lower for the LBW group; however, there was no association between sociodemographic variables and accuracy of reported birthweight. This suggests that maternal report of birthweight is a stable measurement that is not influenced by attributes of the child, by attributes of the mother, or by attributes of the household. That is, recall bias was found to be random. Comparison of percent accuracy measurements of reported birthweight between our cohort and other studies show lower, yet still comparable rates of accuracy [7,10].

In order to explore the differential effects of using reported and actual birthweight as outcome and predictor variables, we conducted two linear regressions where

**TABLE II** REPORTED, ACTUAL AND DIFFERENCE (REPORTED–ACTUAL) IN BIRTHWEIGHT

| | *Reported/Actual, n* | *Reported BW* | *Actual BW* | *Difference BW* |
|---|---|---|---|---|
| Overall | 199/200 | 2889 (2820, 2959) | 2878 (2822, 2935) | 13 (-29, 54) |
| Low BW | 38/38 | 2337 (2222, 2451) | 2314 (2254, 2373) | 23 (-86, 132) |
| Normal BW | 161/162 | 3020 (2952, 3087) | 3010 (2961, 3060) | 10 (-35, 55) |
| *Current age* | | | | |
| <3 years | 87 | 2883 (2774, 2991) | 2889 (2799, 2978) | -6 (-62, 49) |
| 3-5 years | 72 | 2891 (2768, 3013) | 2886 (2789, 2982) | 10 (-78, 98) |
| >5 years | 41 | 2900 (2759, 3042) | 2842 (2729, 2956) | 59 (-9, 126) |

*Values are Mean (95% CI); BW: Birthweight.*

**WHAT THIS STUDY ADDS?**

- Maternal report was found to be an adequate proxy for actual birthweight
- Rate of misclassification as either low birthweight or normal birthweight was 7.5%, higher than in reports from high-income countries.

birthweight was considered as a dependent variable with maternal education and maternal height as predictors and 2 additional regressions where birthweight was a predictor for child height and height to age *Z* score (HAZ) at follow up. We found no significant differences in the regression coefficient estimates when reported birthweight was used instead of actual birthweight in linear regression, indicating that reported birthweight is a sufficiently accurate proxy for actual birthweight in linear regression analyses. There were similar associations of birthweight with maternal education and child growth in subsets of actual and reported birthweights in NFHS-3 data.

Sensitivity analysis revealed that 7.5% of children would be misclassified as LBW or normal birthweight. This is notably higher than the 1.1% [7] and 1.6% [8] misclassification rates in previous cohorts studies. It is important to note that the proportion of misclassified children is not necessarily an indicator of the accuracy of maternal report; rather, it depends greatly on the distribution of birthweight in the population as well as the cutoff of 2500 g used for LBW and normal birthweight.

Maternal report in our cohort from Southern India is more likely to result in misclassification than previous cohorts [7,8], since our cohort had more birthweights near the cutoff weight for LBW.

Since association studies between birthweight and disease may require dividing subjects into groups based on birthweight cutoffs, populations where the distribution centers around the cutoff value may experience higher rates of misclassification. This suggests that in countries such as India, where average birthweight is closer to the cutoff for LBW, studies that use maternal report may be misclassifying a larger proportion of children. Moreover, small changes in birthweight distribution may lead to significant fluctuations in misclassification rate.

The limitations of our study are our relatively small sample cohort size, as well as low variability in certain sociodemographic variables. Moreover, this was a follow-up study on women who had earlier participated in a cohort and there is a possibility of more accurate reported birthweight, in this sample than in a general population.

In conclusion, while actual accurate measurements of birthweight are required in many studies, we corroborate findings from previous studies that maternal report of birthweight is a sufficiently accurate proxy for actual birthweight. We have also elucidated that the maternal report is not influenced by sociodemographic characteristics of the child, mother, or household. An important area of investigation for future studies would be on the effect of distribution of birthweight in a population, on misclassification of children as low birthweight. This is an especially relevant question in developing countries like India, where research studies and national maternal and child health indicators may depend on maternal report of birthweight due to unavailability of accurate birth records.

*Acknowledgments*: AS acknowledges the helpful comments provided by his colleagues at St. John's Research Institute.
*Contributors*: AS: led statistical analysis and drafted the manuscript; TT: conceived the original study idea, edited the manuscript, and contributed to study design; DJC: revised manuscript and contributed to follow up study design; PD: revised the manuscript and contributed to follow up study design; SVS: contributed to follow up study design and revised manuscript; AVK: contributed to study design and reviewed the manuscript. All authors read and approved the final manuscript.
*Funding*: No direct financial support or funding was obtained to conduct this study. Funding for the follow-up cohort was study was provided by the Harvard Centre for Population and Developmental Studies, Boston, USA. AS was supported by the Harvard Global Health Institute. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.
*Competing interests*: None stated.

## REFERENCES

1. Barker DJ, Winter PD, Osmond C, Margetts B, Simmonds SJ. Weight in infancy and death from ischaemic heart disease. Lancet. 1989;2:577-80.
2. Curhan GC, Chertow GM, Willett WC, Spiegelman D, Colditz GA, Manson JE, *et al*. Birth weight and adult hypertension and obesity in women. Circulation. 1996;94:1310-5.
3. Forsen T, Eriksson J, Tuomilehto J, Reunanen A, Osmond

C, Barker D. The fetal and childhood growth of persons who develop type 2 diabetes. Ann Intern Med. 2000;133:176-82.
4. McCormack VA, dos Santos Silva I, Koupil I, Leon DA, Lithell HO. Birth characteristics and adult cancer incidence: Swedish cohort of over 11,000 men and women. Int J Cancer. 2005;115:611-7.
5. Rich-Edwards JW, Colditz GA, Stampfer MJ, Willett WC, Gillman MW, Hennekens CH, *et al*. Birthweight and the risk for type 2 diabetes mellitus in adult women. Ann Intern Med. 1999;130:278-84.
6. International Institute for Population Sciences (IIPS) and ICF. National Family Health Survey (NFHS-4), 2015-16: India. Mumbai: IIPS; 2017.
7. Adegboye AR, Heitmann B. Accuracy and correlates of maternal recall of birthweight and gestational age. British J Obs Gynec. 2008;115:886-93.
8. Gayle HD, Yip R, Frank MJ, Nieburg P, Binkin NJ. Validation of maternally reported birth weights among 46,637 Tennessee WIC program participants. Public Health Rep. 1988;103:143-7.
9. Olson JE, Shu XO, Ross JA, Pendergrass T, Robison LL. Medical record validation of maternally reported birth characteristics and pregnancy-related events: a report from the Children's Cancer Group. Am J Epidemiol. 1997;145:58-67.
10. O'Sullivan JJ, Pearce MS, Parker L. Parental recall of birth weight: how accurate is it? Arch Dis Child. 2000;82:202-3.
11. Sanderson M, Williams MA, White E, Daling JR, Holt VL, Malone KE, *et al*. Validity and reliability of subject and mother reporting of perinatal factors. Am J Epidemiol. 1998;147:136-40.
12. Tomeo CA, Rich-Edwards JW, Michels KB, Berkey CS, Hunter DJ, Frazier AL, *et al*. Reproducibility and validity of maternal recall of pregnancy-related events. Epidemiology. 1999;10:774-7.
13. Walton KA, Murray LJ, Gallagher AM, Cran GW, Savage MJ, Boreham C. Parental recall of birthweight: a good proxy for recorded birthweight? Eur J Epidemiol. 2000;16:793-6.
14. Dwarkanath P, Barzilay JR, Thomas T, Thomas A, Bhat S, Kurpad AV. High folate and low vitamin B-12 intakes during pregnancy are associated with small-for-gestational age infants in South Indian women: A prospective observational cohort study. Am J Clin Nutr. 2013;98: 1450-8.