BMJ Open

Predictive Accuracy of Perceived Baby Birth Size for Birthweight: A Cross-sectional Study from the 2016 Ethiopian Demographic and Health Survey

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-031986
Article Type:	Research
Date Submitted by the Author:	29-May-2019
Complete List of Authors:	Nigatu, Dabere; Bahir Dar University College of Medical and Health Sciences, Department of Reproductive Health and Population Studies Haile, Demewoz; Addis Ababa University College of Health Sciences, School of Public Health; University of California, Program in International and Community Nutrition, Department of Nutrition Gebremichael, Bereket; Department of Nursing and midwifery, Allied school of health science, Addis Ababa University, Addis Ababa, Ethiopia Tiruneh, Yordanos; University of Texas Health Science Center at Tyler, Department of Community Health; University of Texas Southwestern Medical Center at Dallas, Department of Clinical Sciences
Keywords:	Predictive accuracy, Perceived baby size, Birthweight, Ethiopia

Predictive Accuracy of Perceived Baby Birth Size for Birthweight: A Cross-sectional Study from the 2016 Ethiopian Demographic and Health Survey

Dabere Nigatu[1], Demewoz Haile[2,3], Bereket Gebremichael[4], Yordanos Tiruneh[5,6]

Affiliations:

[1] Department of Reproductive Health and Population Studies, School of Public Health, College of Medicine and Health Sciences, Bahir Dar University, Bahir Dar, Ethiopia

[2] School of Public Health, College of Health Sciences, Addis Ababa University, Addis Ababa, Ethiopia

[3] Department of Nutrition, Program in International and Community Nutrition, University of California, Davis, USA

[4] Allied School of Health Science, College of Medicine and Health Science, Addis Ababa University, Addis Ababa, Ethiopia

[5] Department of Community Health, The University of Texas Health Science Center at Tyler, Tyler, Texas, USA

[6] Department of Clinical Sciences, University of Texas Southwestern Medical Center, Dallas, Texas, USA

Corresponding author:

Dabere Nigatu;

Department of Reproductive Health and Population Studies, School of Public Health, College of Medicine and Health Sciences, Bahir Dar University, Bahir Dar, Ethiopia

Email Address: daberen@yahoo.com

ABSTRACT

Objectives: The study was designed to evaluate the accuracy of maternally perceived baby birth size assessments as a predictor of birthweight and examine factors influencing the accuracy of maternal size assessments.

Study design: Cross-sectional study.

Setting: The study is based on a nationally representative data drawn from the 2016 Ethiopian Demographic and Health Survey.

Participants: We included 1,455 children who had both birth size and birthweight data.

Main outcome measures: Predictive accuracy of baby birth size for low birthweight. Level of discordance between birth size and birthweight including factors influencing discordance size estimation.

Results: The analysis of mother-reported baby birth size as a proxy indicator of low birthweight revealed lower sensitivity (57%) and positive predictive value (41%) than specificity (89%) and negative predictive value (94%). The two measurements agreed in 86.2% of the cases (kappa=0.41). However, when the comparison was made between baby size and birthweight on a five-point scale, agreement between the measures dropped to 46% (kappa=0.15). Maternal age, wealth index quintile, marital status, and maternal education were significant predictors of discordance.

Conclusions: Maternal assessment of baby size at birth is inaccurate proxy indicator of low birthweight in Ethiopia. There is a modest agreement between baby birth size and birthweight. Therefore, a mother's birth size assessment should be used as proxy indicator with caution and should take maternal characteristics into consideration.

Key words: Predictive accuracy; Perceived baby size; Birth size; Birthweight; Ethiopia

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study is based on nationally representative survey data drawn from the 2016 Ethiopian Demographic and Health Survey.
- The study evaluated both aggregate and individual level concordance between birth size and birthweight.
- We compared estimated newborn birth size against birthweight without considering other size dimensions that likely affect a mother's judgment of birth size.
- We also assumed that reported birthweight is correctly measured or recalled to make comparison with maternally perceived baby birth size.
- The birthweight data shows heaping to certain digits, which might be introduced because of the tendency of enumerators or respondents to report certain digits at the expense of others.

INTRODUCTION

Birthweight is a good summary measure of multifaceted public health problems that include long-term maternal malnutrition, poor maternal health, and poor maternal healthcare utilization during pregnancy.[1 2] It is also an important indicator of a child's vulnerability to the risk of childhood illnesses and the child's chances of survival.[3-5] In most instances low birthweight (LBW) is linked with high morbidity and mortality during the neonatal period and later life.[5-7] LBW babies are at higher risk of early growth retardation, infectious diseases, and neurologic, neurosensory, and developmental delays.[7-10]

Although every country has a public interest in generating birthweight data, in many developing countries the majority of newborns are not weighed at birth.[11] For this reason, in retrospective surveys, including the Demographic and Health Survey (DHS), birthweight data are collected either from written records or maternal recall, which is informed by maternal assessments of baby size at birth.[1 11] According to the 2011 Ethiopian DHS (EDHS) report, only 5% of children in Ethiopia are weighed at birth [5], a figure which has grown to 14% in the most recent EDHS report. Thus, information on mothers' subjective estimates of their babies' birth sizes is the only means of addressing the birth characteristics of 86% of newborns of unknown birthweight in Ethiopia.[1] While a mother's subjective assessment of the size of her baby at birth is still a useful proxy indicator in the absence of measured birthweight [5], it can be influenced by societal and contextual factors. The average size of infants in the community around a newborn and the characteristics of the infant and its parents influence the accuracy of the assessment.[12 13] Wide variability is also observed in the distribution of maternal perceptions of baby size at birth between countries.[12] Studies evaluating the relationship between maternal perceptions of baby size and actual birthweight concluded that maternal recall of baby size is an imprecise proxy indicator of birthweight.[14 15]

Although maternal perceptions of baby size at birth is widely used proxy indicator for birthweight, the extent of agreement between these perceptions and recorded or recalled actual birthweight has not been examined in Ethiopia. This study fills this gap in the literature by evaluating the accuracy of maternal baby size assessments to predict LBWs obtained from record or maternal recall. The study also examined the factors influencing the agreement between maternal baby size assessments and recorded or recalled birthweights in Ethiopia.

METHODS

Study setting and design

The current study used the 2016 EDHS data. It is the fourth nationally representative survey conducted in Ethiopia. The sampling frame used for the 2016 EDHS is based on the 2007 Ethiopia Population and Housing Census (PHC) conducted by the Ethiopia Central Statistical Agency. Multi-stage stratified cluster sampling was used to recruit the sample population. The detailed sampling procedure can be accessed in the DHS country report.[1]

This study is based on a total of 11,023 live births during the five years preceding administration of the survey. Only singleton births (10,731) were included in this study. From singleton births, 1,455 children who had both birthweight and birth size data were considered for the study (Figure 1).

Variables measure

We included measures of maternal characteristics and child characteristics as explanatory variables. These include educational status, age, marital status, pregnancy (wanted/unwanted), antenatal care, place of delivery, child's sex, birth order, child survival status, and media exposure.

Household characteristics also assessed by residence and wealth index quintile. Wealth index scores were created based on the number and kinds of consumer goods in a household, ranging from a television to a bicycle or car; housing characteristics such as the source of drinking water and toilet facilities; and flooring materials. Detail on the DHS wealth index construction can be found in Rutstein 2004 and EDHS 2016 report.[1 16]

Outcome variables measures: a) Baby size, the EDHS has a question designed to assess maternal perceptions of baby size at birth for all live births that occurred during the five years preceding the survey. The mothers were asked to retrospectively classify their babies' sizes at birth as "very large," "larger than average," "average," "smaller than average," or "very small". Then we recoded into two categories; very large, larger than average and average responses were categorised as "average or above average" category whereas smaller than average and very small responses were categorised as "small". b) Birthweight, following the question on mother's perceived baby size, the survey has a question to collect information on birthweight from written records or mother's recall. Then, the birthweight obtained from record or mother's recall was classified using the WHO cutoff point as "LBW" if birthweight <2500g or normal birthweight "NBW" if birthweight ≥2500g. Furthermore, the birthweight data was normalized and categorised into five categories based on standard deviation (SD). Thus, the categories were: birthweight greater than +2SD from the mean taken as "very large", between +2SD and +1SD from the mean as "larger than average", between +1SD and -1SD from the mean as "average", between -1SD and -2SD from the mean as "smaller than average", and less than -2SD from the mean as "very smaller" categories. This statistical categorization of the measured birthweight into five categories using the standard deviation was done in order to test the agreement of the measured birthweight with mother's perceived baby size category at birth. Then, we matched to generate new variable with three response categories; if the mother's response on perceived baby size agree with the response categories obtained from the birthweight considered as "*concordant*", and if the responses not agree further classified as "*underestimate*" if the mother's response is smaller than birthweight category, and *"overestimate*" if it is larger than birthweight category.

Data analysis

Data were analysed using STATA version 14.0 statistical software package. We analysed considering for complex survey and we reported weighted figures.

The Boerma et al. (1996) sensitivity-specificity analysis was applied to measure indicator accuracy.[17] Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were analysed to evaluate maternal perceptions of baby size at birth as an indicator of LBW. In this study, sensitivity is the proportion of actual LBW newborns who are accurately identified as small in size by mothers and specificity is the proportion of actual NBW newborns who are accurately identified as "average or above average" by their mothers. PPV is the proportion of actual LBW babies among those identified as small by their mothers and NPV is the proportion of actual NBW babies whom mothers reported as "average or above average" in size.

Kappa statistics was used to evaluate the extent of agreement between birthweights and birth sizes as a measure of LBW.[18] The Landis and Koch (1977) benchmark was applied to judge the relative strength of agreement associated with kappa statistics.[19] One-way analysis of variance (ANOVA) was also performed to evaluate the presence of significant mean birthweight differences between birth size categories.

Multinomial logistic regression model was used to identify predictor variables as the outcome variable follows a multinomial probability distribution.[20] Our outcome variable was categorised as concordant, underestimate, or overestimate. Concordant was the base outcome category of the outcome variable. A Wald test was executed to test the significance of the independent variables in the model. Variables with p-value lower than 0.25 were selected as candidate variables in the multivariable multinomial logistic regression model.[21] An odds ratio with a 95% confidence interval was used to identify the factors associated with underestimate or overestimate responses as compared with concordant responses as indicators. Statistical significance for the explanatory variables was declared at P-values lower than 0.05.

Ethical considerations

This study is based on secondary data. The 2016 EDHS data set were accessed after obtaining permission from The DHS Program. The primary data were collected in line with national and international ethical guidelines. Reader can refer the 2016 EDHS report for further reading on the survey protocol.[1]

Patient and Public Involvement

We did not involve patients or the public in this work

RESULTS

Sociodemographic characteristics of study population

From 1455 mothers, 57.8% were in the age group of 20-29 years. About 51.5% mothers were rural residents. More than half (53%) of mothers were from richest wealth quintile. Ninety two percent of the mothers were married at the time of the survey and 29% of mothers had no formal education. The mean birthweight was 3332.3g; the smallest and largest birthweights were 500g and 6000g, respectively. About 12% of the babies weigh <2500g and 40.7% were perceived as average size baby at birth (Table 1).

Table 1: Sociodemographic characteristics of mothers and children, EDHS 2016 (n=1455)

Variables	Number	Percentage
Mother's age		
≤ 19	58	4.0
20-29	841	57.8
30-39	483	33.2
40-49	73	5.0
Residence		
Urban	705	48.5
Rural	750	51.5
Wealth index quintile		
Poorest	103	7.1
Poorer	147	10.1
Middle	201	13.8
Richer	233	16.0
Richest	771	53.0
Marital status		
Never married	34	2.3
Currently married	1,345	92.4
Formerly married	77	5.3
Mother's education		
No education	425	29.2
Primary	551	37.9
Secondary	262	18.0

Higher	217	14.9
Sex of child		
Male	745	51.2
Female	710	48.8
Birthweight		
<2500g	180	12.3
≥2500g	1,275	87.7
Perceived baby birth size		
Very large	411	28.3
Larger than average	204	14.0
Average	592	40.7
Smaller than average	98	6.7
Very small	150	10.3

Birthweight data description

The birthweight data shows 81% heaping to multiple of 500g and 9% heaping at exactly 2500g (Figure 2). All the birthweight data were heaped to terminal digits "0" or "5". We also examined the relationship between reporting method and presence of heaping to multiples of 500g, with the result indicating that the proportion of heaping to multiples of 500g did not show significant differences based on reporting method, i.e., whether obtained from a written card or maternal recall.

Accuracy of mothers' perceived baby size to predict LBW

This study evaluated the distribution of mean birthweight by perceived baby size at birth. Maternal perceptions of baby size followed a trend that was similar to that for mean birthweights. As maternally perceived size at birth decreased from very large to very small, mean birthweight also consistently decreased, from 4057.6g to 2423.5g. However, a higher standard error is obtained for two extreme categories, i.e., very small and very large, which indicates lower accuracy of the estimate. The results obtained from a one-way ANOVA also indicated the presence of significant mean birthweight differences between perceived birth-size groups ($F=254.4$, $P< 0.001$).

Sensitivity, PPV, specificity, and NPV were determined through comparison of mother-reported baby size at birth with birthweights. Maternally perceived birth-size responses of "very small" or "smaller than average" were used to measure LBW and the remaining response categories were used to measure NBW. As indicated in table 2, mothers correctly identified only 57% of actual LBWs and only 41% of babies perceived as small by their mothers were actually in the LBW category. Specificity and NPV were nearly 89% and 94%, respectively, which are higher than sensitivity and PPV.

Table 2: Accuracy of mothers' perceived baby birth size to predict low birthweight, EDHS 2016.

Variables	**Birthweight**		**Total (%)**
	<2500g (%)	>=2500g (%)	
Perceived baby size at birth			
Small size	103(57.1)	145(11.4)	248(17.0)
Normal (average or above)	77(42.9)	1130(88.6)	1207(83.0)
Total (%)	180(100.0)	1275(100.0)	1455(100.0)
Indicator accuracy with 95% CI			
Sensitivity	57.05(47.78,65.85)		
PPV	41.32(32.80,50.41)		
Specificity	88.59(85.63,91.01)		

NPV	93.61(91.45,95.25)

CI confidence interval; PPV positive predictive value; NPV negative predictive value

The extent of agreement between maternal subjective assessments of baby birth size and birthweight shown by kappa statistics revealed a moderate level of agreement (kappa=0.41) between the two measures. The birthweights and maternally perceived birth-size assessments agreed in 86.2% of the cases.

Factors influencing concordance of mothers' perceived baby birth size with birthweight

In EDHS data, maternally perceived newborn size was assessed with five ordered categories ("very large," "larger than average," "average," "smaller than average" and "very small") while birthweights based on mothers self-report or medical record were captured in grams. To compare perceived size and birthweight, the birthweight obtained from card or mother's recall was normalized and classified into five categories based on standard deviation. Then, matching across the categories was done. Thus, the proportion of concordant responses were 45%. Further classification of the discordant shows that 15.8% of the maternally perceived sizes were underestimates while 39.2% of the maternally perceived sizes were overestimates (Figure 3).

We also evaluated the level of agreement between maternal assessments of birth size and birthweight across five ordered categories using kappa statistics. We found concordance between the two measurements of 46%, with the kappa coefficient indicating slight agreement (kappa=0.15).

A multinomial logistic regression model was fitted to identify factors that influence the incorrect assessment of baby size at birth. Taking "concordant" as the base outcome category, comparisons were made with the remaining response categories. The results indicate that maternal age, household wealth index quintile, marital status, and maternal education were significant predictors of discordance (underestimated or overestimated) between birth size and birthweights as compared with concordant responses. Mothers in the 20–29 age group (AOR 0.28, 95% CI 0.10, 0.79) and the 30–39 age group (AOR 0.24, 95% CI 0.08, 0.72) were less likely to underestimate size than to report concordant size as compared with mothers younger than 20 years of age. Mothers from higher wealth quintile were three times more likely to underestimate baby size at birth compared with mothers from the lowest wealth quintile (AOR 3.11, 95% CI 1.34, 7.25). Similarly, mothers from higher wealth quintiles were more likely to overestimate baby size at birth compared with mothers from the poorest wealth quintile (AOR 2.34, 95% CI 1.22, 4.51; Table 3).

Mothers who were married at the time of the survey were 68% less likely to underestimate their babies' sizes at birth than to offer concordant estimates (AOR 0.32, 95% CI 0.17, 0.61) compared with mothers who had never been married. Mothers who had completed secondary education were less likely than uneducated mothers to overestimate infant size at birth than to offer a concordant estimate (AOR 0.47, 95% CI 0.26, 0.83; Table 3).

Table 3: Factors associated with discordance between mother's reported baby size and birthweight, EDHS 2016.

Explanatory variables	**Mother's estimation(Concordant as base outcome)**	
	Underestimate	**Overestimate**
	Adjusted OR(95% CI)	Adjusted OR (95% CI)
Mother's age		
< =19	1.00 (Reference)	1.00 (Reference)
20-29	0.28(0.10,0.79)[a]	1.33(0.48,3.72)
30-39	0.24(0.08,0.72)[a]	1.26(0.45,3.57)
40-49	0.33(0.08,1.31)	1.47(0.44,4.92)

Residence		
Urban	1.00 (Reference)	1.00 (Reference)
Rural	1.12(0.62,2.03)	0.75(0.42,1.34)
Wealth index quintile		
Poorest	1.00 (Reference)	1.00 (Reference)
Poorer	1.74(0.65,4.71)	1.57(0.80,3.06)
Middle	2.40(0.96,6.00)	1.24(0.61,2.55)
Richer	3.11(1.34,7.25)[a]	2.34(1.22,4.51)[a]
Richest	2.05(0.87,4.83)	1.44(0.68,3.08)
Sex of child		
Male	1.00 (Reference)	1.00 (Reference)
Female	1.20(0.78,1.85)	0.74(0.53,1.03)
Place of delivery		
Home	1.00 (Reference)	1.00 (Reference)
Health facility	0.79(0.32,1.99)	1.70(0.75,3.87)
Marital status		
Never married	1.00 (Reference)	1.00 (Reference)
Currently married	0.32(0.17,0.61)[a]	0.83(0.40,1.71)
Formerly married	0.45(0.18,1.07)	0.56(0.21,1.50)
Mother's education		
No education	1.00 (Reference)	1.00 (Reference)
Primary	0.64(0.36,1.15)	0.64(0.40,1.03)
Secondary	0.55(0.26,1.17)	0.47(0.26,0.83)[a]

Higher	0.69(0.30,1.58)	0.59(0.33,1.07)

[a] variables significantly associated at p-value less than 0.05; OR odds ratio; CI confidence interval

DISCUSSION

Our study revealed three pertinent findings. First, we found that only 57% of the mothers identified actual low birthweight implying that a considerable number of LBW infants could be misclassified. Second, our finding shows that less than half percent (46%) concordance between mothers' reported baby size and birthweight when they are compared across five categories indicating a high individual level misclassification. Third, maternal characteristics were the main factors associated with incorrect estimation of birth size, suggesting that anyone using maternally perceived birth size assessment as a proxy indicator should consider the characteristics of the mothers involved in the study.

As strength, this study is based on nationally representative survey data. We analysed both aggregate and individual level concordance between birth size and birthweight.

This study is subject to limitations. First, we compared estimated newborn birth size against birthweight without considering other size dimensions that likely affect a mother's judgment of birth size. As Channon 2011 noted, a mother's judgment of her newborn's birth size depends not only on birthweight but also on other size dimensions such as length and subcutaneous fat [13], which were not captured in the DHS data. We also assumed that reported birthweight is correctly measured or recalled. Our analysis suggest birthweight data heaping, which is a common measurement error that can be introduced into data such as age, birthweight, and height because of the tendency of enumerators or respondents to report certain digits at the expense of others.[22] The level of missing birthweights (85%) might also limit this study because weighed and non-weighed children might have different characteristics. Black et al. revealed that those who were weighed were more likely to have mothers who live in urban areas and who are educated and born in a healthcare facility.[11]

The sensitivity-specificity analysis undertaken for our study revealed that mothers correctly identified only 57% of actual LBW newborns (sensitivity=0.57) and only 41% of newborns perceived as small by their mothers were actually LBW babies (PPV =0.41). However, the specificity (89%) and NPV (94%) scores are much higher than the sensitivity and PPV scores. This finding implies that Ethiopian mothers can correctly identify larger newborns as large but they are less likely to identify smaller newborns as small. Smaller/LBW babies were subject to misclassification, i.e., smaller newborns were more likely to be classified as larger babies. Therefore, using maternally perceived birth size to estimate the prevalence of LBW newborns underestimates the actual prevalence of LBW newborns. Incorrect quantification of the prevalence of LBW newborns leads to poor public health planning. Our findings are consistent with study done in Cameroon with comparable sensitivity (60%), specificity (93%), NPV (96%), and PPV (44%) scores.[23] Our results are also consistent with others[11 14] that have noted that maternally perceived small birth size as reported in surveys is not a sensitive indicator of LBW. Studies done in Nepal, Uganda and Colombia revealed higher sensitivity (66-76%) than our study findings.[15 24 25]

Our study revealed 86% aggregate-level agreement between birth size and birthweight with kappa coefficient showing a moderate level of agreement between the two measurements (Kappa=0.41), while 46% concordance was obtained when they were compared across five categories with kappa coefficients indicating slight agreement between the measurements (Kappa=0.15). This implies that there was better aggregate-level agreement than individual-level agreement between birth size and birthweight. Therefore, the low magnitude of the incorrect group-level assessment of children might mask the high magnitude of incorrect assessments occurring at the individual level. This will underestimate the magnitude of individual-level birthweight-related problems, consequently reducing programmatic attention that benefits individuals.

The use of maternal birth-size assessment as a proxy indicator of birthweight might be affected by various factors. Our study found that maternal age was significantly associated with accurate estimation of birth size. Older mothers were less likely than younger mothers to underestimate birth size. Previous studies examining the association between maternal age and correct estimation of birth size have reported mixed results. Channon 2007 reported that, in Malawi, mothers who were younger than 20 years of age were more likely to classify their infants as smaller than their actual correct sizes compared with mothers aged 20–29 years. The same study revealed that older mothers were more likely to overestimate their baby's sizes in Malawi while in Cambodia mothers were less likely to overestimate their newborns' birth sizes.[12] The association of maternal age and perceived baby size warrants further investigation.

Wealth index quintile was significantly associated with misclassification of newborn birth size in our study. Mothers from higher wealth quintiles were more likely to estimate birth size incorrectly. This implied that it is difficult to know the direction of the bias in estimation of birthweight among wealthier mothers and we are unsure why it is linked with both overestimation and underestimation. But, this may reflect the fact that well-to-do mothers are more likely to perceive their newborns as normal, presumably because of good prenatal care, perhaps in their minds reducing the chance of bearing a LBW newborn. Alternatively, the tendency to misclassify birth size among wealthier mothers in our study could also be due to social desirability bias, as evidenced in Tate et al., who found that mothers with smaller newborns tended to overestimate their weights while those with larger newborns tended to underestimate their weights.[26] Still this

297 needs further investigation to characterize which of the mothers from rich wealth quintile
298 underestimate or overestimate the baby birth size.

299 We found that currently married mothers were less likely to underestimate their newborn's sizes
300 as compared with never married mothers. similarly, in Kazakhstan, never married mothers were
301 less likely to correctly assess their babies' sizes than currently married counterparts.[12] We also
302 found that maternal education was significantly associated correct maternal assessment of birth
303 size. Educated mothers were less likely than mothers with no education to provide overestimated
304 reports rather than concordant reports of newborn size at birth. Studies conducted in Uganda and
305 Cameroon have also revealed that mothers who were educated were more likely to give accurate
306 estimate than non-educated mothers.[12 23 24] Another study conducted in Nepal also reported
307 that illiterate women were less likely to be accurate in identifying LBW newborns than literate
308 women.[15] This might reflect the fact that educated women are well informed about the
309 relationship between newborn size and birthweight, a benchmark which likely influences their
310 ability to estimate correctly. In addition, numerical recall might be better among educated women.
311 For example, a study relating birthweight recall and educational level revealed that fewer years of
312 education were significantly associated with greater birthweight recall bias.[25]

313 **CONCLUSIONS**

314 Maternal assessment of birth size is a less sensitive proxy indicator of LBW in Ethiopia. Hence,
315 estimation of the prevalence of LBW based on maternal assessment of birth size underestimates
316 the magnitude of the actual problem. Our study also reveals slight agreement between perceived
317 birth size and birthweight. Maternal characteristics such as age, wealth status, marital status, and
318 education were significant predictors of discordant birth-size assessments. It is recommended that
319 maternal birth-size assessment be used as a proxy indicator with caution and researchers and

healthcare workers should consider differences in maternal characteristics such as age, wealth status, marital status, and education.

ACKNOWLEDGEMENTS

The authors thank ICF Macro-international for allowing us to use the 2016 Ethiopian Demographic and Health Survey data set for free. We would also like to thank Patricia Malloy (Assistant professor) at the University of Saskatchewan for English language editing.

FUNDING

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

COMPETING INTEREST

The authors declare that we have no competing interests.

AUTHORS' CONTRIBUTIONS

DN conceived the study, performed the data analysis, contributed in the interpretation of data and drafting the manuscript, and critically reviewed the manuscript. DH conceived the study, contributed in the interpretation of data, and critically reviewed the manuscript. BG contributed in the interpretation of data, drafted the manuscript, and critically reviewed the manuscript. YT contributed in the interpretation of data, and critically reviewed the manuscript. All authors read and approved the final manuscript.

CHECKLIST AND FLOW DIAGRAM FOR THE APPROPRIATE REPORTING

The authors followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for writing this manuscript (see S1 table in supplementary file)

PATIENT CONSENT

Not applicable

DATA AVAILABILITY

The data were obtained from The Demographic and Health Survey Program repository. The authors have no mandate to share the data set or make it publicly available. In fact, the data can be accessed by requesting from the DHS Program website (Available at: https://www.dhsprogram.com/data/available-datasets.cfm).

REFERENCES

1. Central Statistical Agency (CSA) [Ethiopia] and ICF-International. Ethiopia Demographic and Health Survey 2016. Addis Ababa, Ethiopia and Rockville, Maryland, USA, 2016.

2. Mukuria A, Aboulafia C, Themme A. The Context of Women's Health: Results from the Demographic and Health Surveys, 1994-2001. Calverton, Maryland, USA: ORC Macro 2005.

3. Wilcox AJ. On the importance and unimportance of birthweight. International Journal of Epidemiology 2001;**30**:1233-41

4. Milde SH. Birth weight predicts brain development. ScienceNordic 2012

5. Central Statistical Agency (CSA) [Ethiopia]andICF-International. Ethiopia Demographic and Health Survey 2011. Addis Ababa, Ethiopia and Rockville, Maryland, USA, 2012.

6. O'Leary M, Edmond K, Floyd S, Newton S, Thomas G, Thomas SL. A cohort study of low birth weight and health outcomes in the first year of life, Ghana. Bull World Health Organ 2017;**95**:574-83 doi: http://dx.doi.org/10.2471/BLT.16.180[published Online First: Epub Date]|.

7. Lemons JA, Bauer CR, Oh W, et al. Very Low Birth Weight Outcomes of the National Institute of Child Health and Human Development Neonatal Research Network, January 1995 Through December 1996. Pediatrics 2001;**107**(1)

8. World Health Organization (WHO). Guidelines on optimal feeding of low birthweight infants in low-and middle-income countries. Geneva, Switzerland, 2011.

9. Ballot DE, Ramdin T, Rakotsoane D, et al. Assessment of developmental outcome in very low birth weight infants in Southern Africa using the Bayley Scales of Infant Development (III). BMJ Paediatrics Open 2017;**1** doi: doi:10.1136/bmjpo-2017-000091[published Online First: Epub Date]|.

10. Vohr BR, Wright LL, Dusick AM, et al. Neurodevelopmental and Functional Outcomes of Extremely Low Birth Weight Infants in the National Institute of Child Health and Human Development Neonatal Research Network, 1993-1994. Pediatrics 2000;**105**(6):1216-26 doi: DOI: 10.1542/peds.105.6.1216[published Online First: Epub Date]|.

11. Blanc AK, Wardlaw T. Monitoring low birth weight: an evaluation of international estimates and an update estimation procedures. Bull World Health Organ 2005;**83**(3):178-85

12. Channon AR. Birth Weight Data in 15 Demographic and Health Surveys. University of Southampton, 2007.

13. Channon AR. Can mothers judge the size of their newborn? Assessing the determinants of a mother's perception of a baby's size at birth. Journal of Biosocial Science 2011;**00**:1–19

14. Islam MM. Can Maternal Recalled Birth Size be Used as a Proxy Measure of Birth Weight? An Evaluation Based on a Population Health Survey in Oman. Matern Child Health J 2014;**18**:1462-70 doi: 10.1007/s10995-013-1386-7[published Online First: Epub Date]|.

15. Shakya K, Shrestha N, Bhatt M, Hepworth S, Onta S. Accuracy of low birth weight as perceived by mothers and factors influencing it: A facility based study in NepaL. International Journal of Medical Research & Health Sciences 2015;**4**(2):274-80 doi: 10.5958/2319-5886.2015.00051.X[published Online First: Epub Date]|.

16. Rutstein SO, Johnson K. The DHS Wealth Index. DHS Comparative No. 6. Calverton, Maryland: ORC Macro, 2004.

17. Boerma JT, Weinstein KI, Rutstein SO, Sommerfelt AE. Data on birth weight in developing countries: can surveys help? Bulletin of the World Health Organization 1996;**74**(2):209-16

18. Cohen J. A Coefficient of Agreement for Nominal Scales. Educational and Psychological Measurement 1960;**20**(1):37-49

19. Landis JR, Koch GG. The Measurement of Observer Agreement for Categorical Data. International Biometric Society 1977;**33**(1):159-74

20. Ben-Akiva M, Lerman S. *Discrete choice models*: London: MIT Press, 1985.

21. Hosmer DW, Lemeshow S. *Applied Logistic Regression*. Second Edition ed. New York, United State of America: John Wiley & Sons, Inc., 2000.

22. Siegel JS, Swanson DA. *The methods and materials of demography*. Second Edition ed. USA: Elsevier Academic Press, 2004.

23. Mbuagbaw L, Gofin R. Can recall of birth size be used as a measure of birthweight in Cameroon? Paediatric & Perinatal Epidemiology 2010;**24**(4):383-9 doi: 10.1111/j.1365-3016.2010.01128.x.[published Online First: Epub Date]|.

24. Lule SA, Webb EL, Ndibazza J, et al. Maternal recall of birthweight and birth size in Entebbe, Uganda. Tropical Medicine and International Health 2012;**17**(12):1465-69 doi: 10.1111/j.1365-3156.2012.03091.x[published Online First: Epub Date]|.

25. Boeke CE, Marín C, Oliveros H, Mora-Plazas M, Agudelo-Cañas S, Villamor E. Validity of Maternal Birthweight Recall Among Colombian Children. Maternal and Child Health Journal 2012;**16** (4):753-59

411 26. Tate AR, Dezateux C, Cole TJ, Davidson L, the-Millennium-Cohort-Study-Child-Health-Group. Factors affecting a mother's recall of her baby's birth weight. International Journal of Epidemiology 2005;**34**:688-95

414

415

Figures legends

Figure 1: Flow chart showing the study population, EDHS 2016

Figure 2: Percentage distribution of birthweight data showing heaping to multiple of 500g, EDHS 2016

Figure 3: Percentage distribution of agreement between birthweight and maternal assessment of baby birth size, EDHS, 2016

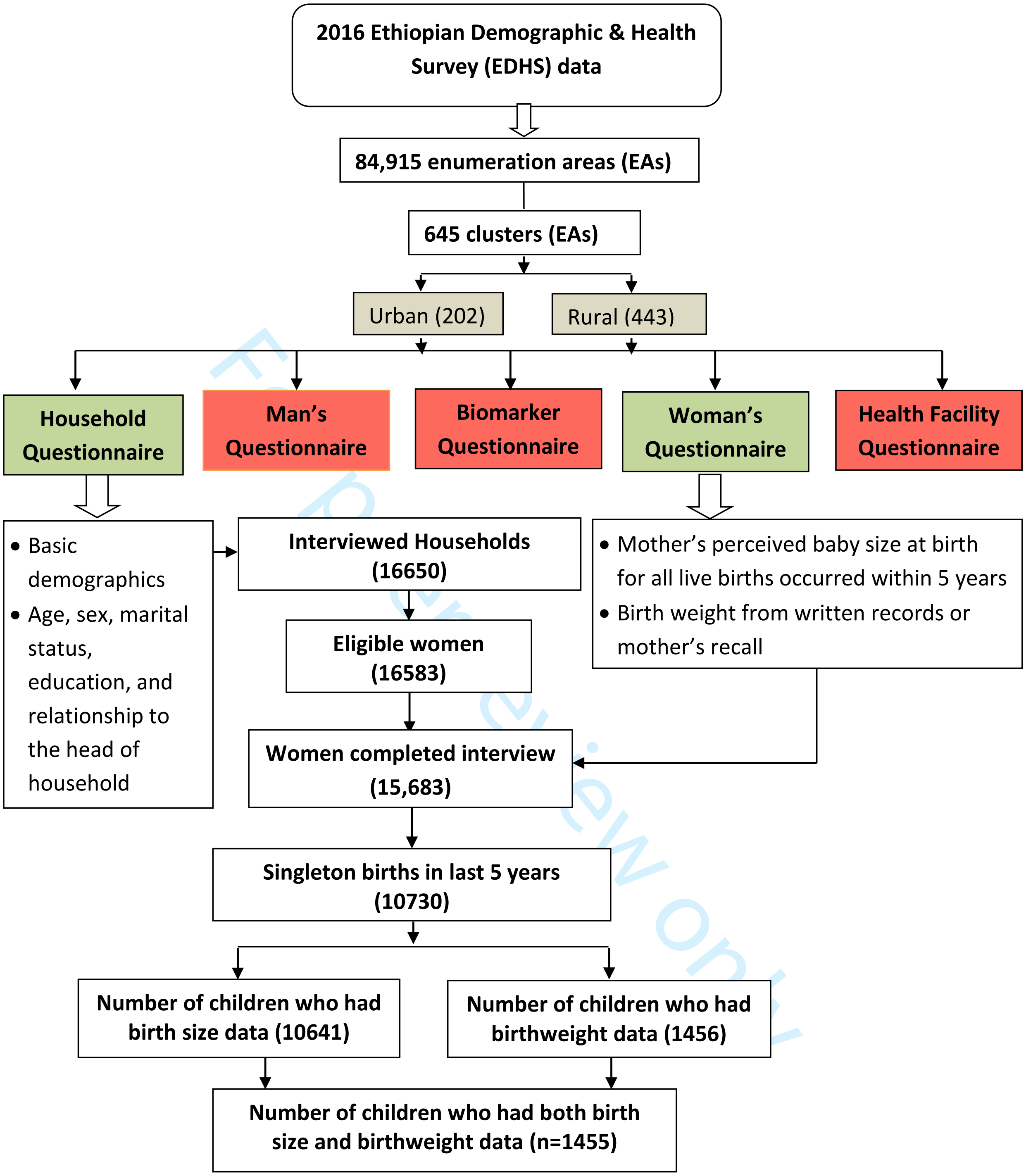

Figure 1: Flow chart showing the study population, EDHS 2016

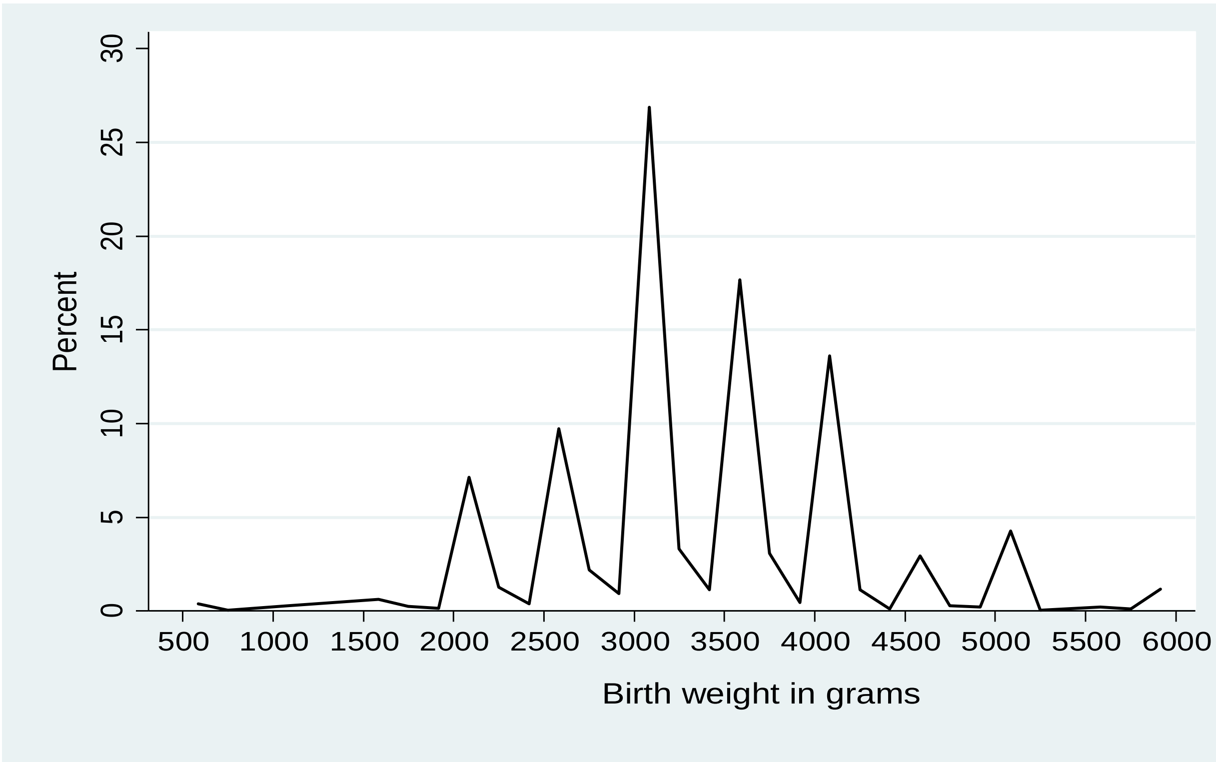

Figure 2: Percentage distribution of birthweight data showing heaping to multiple of 500g, EDHS 2016

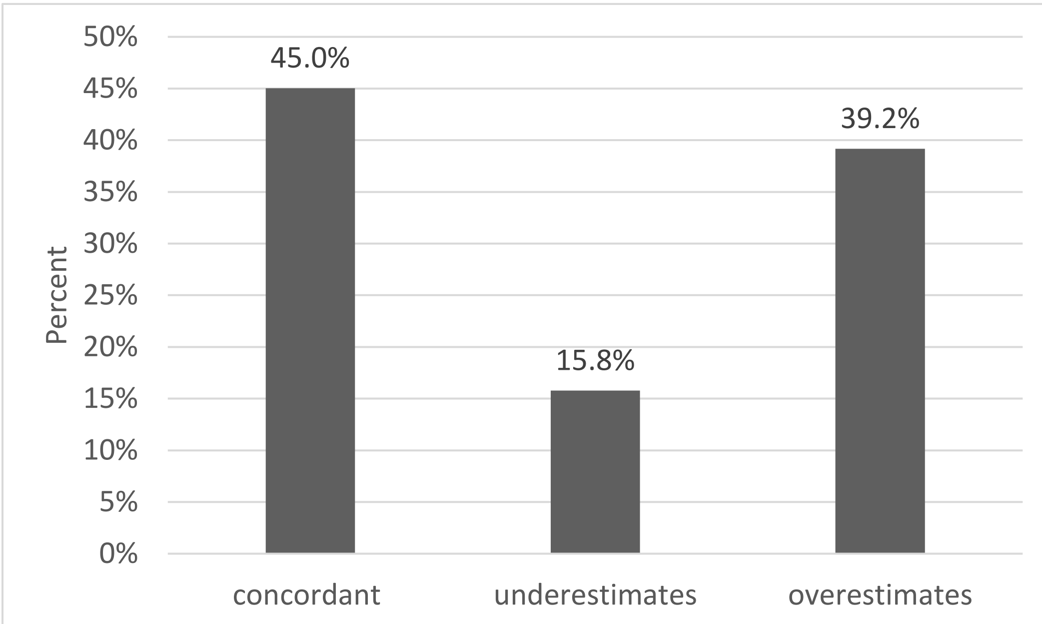

Figure 3: Percentage distribution of agreement between birthweight and maternal assessment of baby birth size, EDHS, 2016

S1 table: STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Title of the study: Predictive Accuracy of Perceived Baby Birth Size for Birthweight: A Cross-sectional Study from the 2016 Ethiopian Demographic and Health Survey

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5

Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	5-6
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible,	8

		examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-10
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	10-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14
		(*b*) Report category boundaries when continuous variables were categorized	9-10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	15

Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	N/A

N/A, not applicable

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Predictive Accuracy of Perceived Baby Birth Size for Birth weight: A Cross-sectional Study from the 2016 Ethiopian Demographic and Health Survey

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-031986.R1
Article Type:	Original research
Date Submitted by the Author:	12-Aug-2019

Complete List of Authors:	Nigatu, Dabere; Bahir Dar University College of Medical and Health Sciences, Department of Reproductive Health and Population Studies Haile, Demewoz; Addis Ababa University College of Health Sciences, School of Public Health; University of California, Program in International and Community Nutrition, Department of Nutrition Gebremichael, Bereket; Department of Nursing and midwifery, Allied school of health science, Addis Ababa University, Addis Ababa, Ethiopia Tiruneh, Yordanos; University of Texas Health Science Center at Tyler, Department of Community Health; University of Texas Southwestern Medical Center at Dallas, Department of Clinical Sciences

Primary Subject Heading:	Public health
Secondary Subject Heading:	Public health, Epidemiology
Keywords:	Predictive accuracy, Perceived baby size, Birth weight, Ethiopia

Predictive Accuracy of Perceived Baby Birth Size for Birth weight: A Cross-sectional Study from the 2016 Ethiopian Demographic and Health Survey

Dabere Nigatu[1], Demewoz Haile[2,3], Bereket Gebremichael[4], Yordanos Tiruneh[5,6]

Affiliations:

[1] Department of Reproductive Health and Population Studies, School of Public Health, College of Medicine and Health Sciences, Bahir Dar University, Bahir Dar, Ethiopia

[2] School of Public Health, College of Health Sciences, Addis Ababa University, Addis Ababa, Ethiopia

[3] Department of Nutrition, Program in International and Community Nutrition, University of California, Davis, USA

[4] Allied School of Health Science, College of Medicine and Health Science, Addis Ababa University, Addis Ababa, Ethiopia

[5] Department of Community Health, The University of Texas Health Science Center at Tyler, Tyler, Texas, USA

[6] Department of Clinical Sciences, University of Texas Southwestern Medical Center, Dallas, Texas, USA

Corresponding author:

Dabere Nigatu;

Department of Reproductive Health and Population Studies, School of Public Health, College of Medicine and Health Sciences, Bahir Dar University, Bahir Dar, Ethiopia

Email Address: daberen@yahoo.com

ABSTRACT

Objectives: The study was designed to evaluate the accuracy of maternally perceived baby birth size assessments as a predictor of birth weight and examine factors influencing the accuracy of maternal size assessments.

Study design: Cross-sectional study.

Setting: The study is based on a nationally representative data drawn from the 2016 Ethiopian Demographic and Health Survey.

Participants: We included 1,455 children who had both birth size and birth weight data.

Main outcome measures: Predictive accuracy of baby birth size for low birth weight. Level of discordance between birth size and birth weight including factors influencing discordance.

Results: The analysis of mother-reported baby birth size as a proxy indicator of low birth weight revealed lower sensitivity (57%) and positive predictive value (41%) than specificity (89%) and negative predictive value (94%). The two measurements agreed in 86.2% of the cases (kappa=0.41, $P < 0.001$). However, when the comparison was made between baby size and birth weight on a five-point scale, the agreement between the measures dropped to 46% (kappa=0.15, $P < 0.001$). Maternal age, wealth index quintile, marital status, and maternal education were significant predictors of the discordance between birth size and birth weight.

Conclusions: Maternal assessment of baby size at birth is an inaccurate proxy indicator of low birth weight in Ethiopia. There is a modest agreement between baby birth size and birth weight. Therefore, a mother's recall of birth size should be used as a proxy indicator for low birth weight with caution and should take maternal characteristics into consideration.

Key words: Predictive accuracy; Perceived baby size; Birth size; Birth weight; Ethiopia

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study is based on nationally representative survey data drawn from the 2016 Ethiopian Demographic and Health Survey.
- The study evaluated both aggregate and individual level concordance between birth size and birth weight.
- We compared estimated newborn birth size against birth weight without considering other size dimensions that likely affect a mother's judgment of birth size.
- We also assumed that reported birth weight is correctly measured or recalled to make comparison with maternally perceived baby birth size.
- The birth weight data shows heaping to certain digits, which might be introduced because of the tendency of enumerators or respondents to report certain digits at the expense of others.

INTRODUCTION

Birth weight is a good summary measure of multifaceted public health problems that include long-term maternal malnutrition, poor maternal health, and poor maternal healthcare utilization during pregnancy.[1 2] It is also an important indicator of a child's vulnerability to the risk of childhood illnesses and the child's chances of survival.[3-5] In most instances low birth weight (LBW), <2500g, is linked with high morbidity and mortality during the neonatal period and later life.[5-7] LBW babies are at higher risk of early growth retardation, infectious diseases, and neurologic, neurosensory, and developmental delays.[7-10]

Although every country has a public interest in generating birth weight data, in many developing countries the majority of newborns are not weighed at birth because of the fact that most childbirths are occurring at home.[11] According to the 2011 Ethiopian Demographic and Health Survey (EDHS) report, only 5% of children in Ethiopia are weighed at birth [5], a figure which has grown to 14% in the most recent EDHS report. Thus, information on mothers' subjective estimates of their babies' birth sizes is the only means of addressing the birth characteristics of 86% of newborns of unknown birth weight in Ethiopia.[1] For this reason, in many large community based surveys including the Demographic and Health Surveys (DHS), mother reported birth size data are collected to use it as a proxy indicator of birth weight in low and middle income countries.[1 11]

While a mother's subjective assessment of the size of her baby at birth is still a useful proxy indicator in the absence of measured birth weight [5], it can be influenced by societal and contextual factors. The average size of infants in the community around a newborn and the characteristics of the infant and its parents influence the accuracy of the assessment.[12 13] Wide variability is also observed in the distribution of maternal perceptions of baby size at birth between countries.[12] Studies evaluating the relationship between maternal perceptions of baby size and actual birth weight concluded that maternal recall of baby size is an imprecise proxy indicator of birth weight.[14 15]

Although maternal perceptions of baby size at birth is widely used proxy indicator for birth weight, the extent of agreement between these perceptions and recorded or recalled actual birth weight has not been examined in Ethiopia. This study fills this gap in the literature by evaluating the accuracy of maternal baby size assessments to predict LBWs obtained from record or maternal recall. On top of this, investigating the level of accuracy of maternally perceived birth size as proxy indicator of low birth weight is very important to inform the health policy makers, health care programmers and managers, and responsible others for informed decision. The study also examined the factors influencing the agreement between maternal baby size assessments and recorded or recalled birth weights in Ethiopia.

METHODS

Study setting and design

This analysis is done based on the 2016 EDHS data. The sampling frame used for the 2016 EDHS is based on the 2007 Ethiopia Population and Housing Census (PHC) conducted by the Ethiopia Central Statistical Agency. Multi-stage stratified cluster sampling was used to recruit the sample population. The detailed sampling procedure can be accessed in the DHS country report.[1]

This study is based on a total of 11,023 live births during the five years preceding administration of the survey. Only singleton births (10,731) were included in this study. From singleton births, 1,455 children who had both birth weight and birth size data were considered for this analysis (Figure 1).

Description of variables measure

A multinomial logistic regression model was used to identify factors influencing discordance between birth size and birth weight.

i. Explanatory variables

Maternal and child characteristics were included in the study as explanatory variables. These include educational status, age, marital status, pregnancy (wanted/unwanted), antenatal care, place of delivery, child's sex, birth order, child's survival status, and media exposure. Household characteristics also assessed by residence and wealth index quintile. Wealth index scores were created based on the number and kinds of consumer goods in a household, ranging from a television to a bicycle or car; housing characteristics such as the source of drinking water and toilet facilities; and flooring materials. Detail on the DHS wealth index construction can be found in Rutstein 2004 and EDHS 2016 report.[1 16]

ii. Outcome variables

a) Baby size: The 2016 EDHS has a question designed to assess maternal perceptions of baby size at birth for all live births occurred during the last five years preceding the survey. The mothers were asked to retrospectively classify their babies' sizes at birth as "very large," "larger than average," "average," "smaller than average," or "very small". Then we recoded into two categories; very large, larger than average and average responses were categorised as "average or above average" category whereas smaller than average and very small responses were categorised as "small".

b) Birth weight: The 2016 EDHS collect birth weight data in grams from written records or mother's recall. Then, the birth weight obtained from record or mother's recall was classified using the WHO cutoff point as "LBW" if birth weight <2500g or normal birth weight "NBW" if birth weight ≥2500g.[17] Furthermore, the birth weight data was normalized and categorised into five categories based on standard deviation (SD). Thus, the categories were: birth weight greater than +2SD from the mean taken as “very large”, between +2SD and +1SD from the mean as “larger than average”, between +1SD and -1SD from the mean as “average”, between -1SD and -2SD from the mean as “smaller than average”, and less than -2SD from the mean as “very smaller” categories.[12] This statistical categorization of the measured birth weight into five categories using the standard deviation was done in order to test the agreement of the measured birth weight with mother’s perceived baby size category at birth. Then, we matched to generate new variable with three response categories; if the mother’s response on perceived baby size agree with the response categories obtained from the birth weight considered as “*concordant*”, and if the responses not agree further classified as “*underestimate*” if the mother’s response is smaller than birth weight category, and *“overestimate*” if it is larger than birth weight category.

In the DHS questionnaire, the questions on birth size and birth weight were ordered in a way that minimizes bias. The question which assess mother’s perceived baby size precede the question on birth weight to minimize the influence of maternal knowledge about birth weight on assessment of size at birth.

Data analysis

Data were analysed using STATA version 14.0 statistical software package. We used the “svy” command in STATA to weight the survey data as per recommendation of the EDHS.

The Boerma et al. (1996) sensitivity-specificity analysis approach was applied to measure indicator accuracy.[18] Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were analysed to evaluate maternal perceptions of baby size at birth as an indicator of LBW. In this study, sensitivity is the proportion of actual LBW newborns who are accurately identified as small in size by mothers and specificity is the proportion of actual normal birth weight

(NBW) newborns who are accurately identified as "average or above average" by their mothers. PPV is the proportion of actual LBW babies among those identified as small by their mothers and NPV is the proportion of actual NBW babies whom mothers reported as "average or above average" in size.

Kappa statistics was used to evaluate the extent of agreement between birth weights and birth sizes as a measure of LBW.[19] The Landis and Koch (1977) benchmark was applied to judge the relative strength of agreement associated with kappa statistics.[20] One-way analysis of variance (ANOVA) was also performed to evaluate the presence of significant mean birth weight differences between birth size categories.

Multinomial logistic regression model was used to identify predictor variables as the outcome variable follows a multinomial probability distribution.[21] Our outcome variable was categorised as concordant, underestimate, or overestimate. Concordant was the base outcome category of the outcome variable. A Wald test was executed to test the significance of the independent variables in the model. Variables with p-value lower than 0.25 were selected as candidate variables in the multivariable multinomial logistic regression model.[22] An odds ratio with a 95% confidence interval was used to identify the factors associated with underestimate or overestimate responses as compared with concordant responses as indicators. Statistical significance for the explanatory variables was declared at P-values lower than 0.05.

Ethical considerations

This study is based on secondary data. The 2016 EDHS data set were accessed after obtaining permission from The DHS Program. The primary data were collected in line with national and international ethical guidelines. Reader can refer the 2016 EDHS report for further reading on the survey protocol.[1]

170 **Patient and Public Involvement**

171 We did not involve patients or the public in this work

172 **RESULTS**

173 **Socio-demographic characteristics**

174 From 1455 mothers, 57.8% were in the age group of 20-29 years. About 51.5% mothers were rural
175 residents. More than half (53%) of mothers were from richest wealth quintile. Ninety two percent
176 of the mothers were married at the time of the survey and 29% of mothers had no formal education.
177 The mean birth weight with standard deviation (SD) was 3332.4g (±940.3g); the smallest and
178 largest birth weights were 500g and 6000g, respectively. About 12% of the babies weigh <2500g
179 and 40.7% were perceived as average size baby at birth (Table 1).

180 Table 1: Socio-demographic characteristics of women and index child, EDHS 2016 (n=1455)

Variables	**Frequency**	**Percentage**
Mother's age		
≤ 19	58	4.0
20-29	841	57.8
30-39	483	33.2
40-49	73	5.0
Residence		
Urban	705	48.5
Rural	750	51.5
Wealth index quintile		
Poorest	103	7.1

Poorer	147	10.1
Middle	201	13.8
Richer	233	16.0
Richest	771	53.0
Marital status		
Never married	34	2.3
Currently married	1,345	92.4
Formerly married	77	5.3
Mother's education		
No education	425	29.2
Primary	551	37.9
Secondary	262	18.0
Higher	217	14.9
Sex of child		
Male	745	51.2
Female	710	48.8
Birth weight		
<2500g	180	12.3
≥2500g	1,275	87.7
Mean (SD)=3332.4g (±940.3g)		
Source of birth weight data		
Written card	107	7.4
Mother's recall	1,348	92.6

Perceived baby birth size		
Very large	411	28.3
Larger than average	204	14.0
Average	592	40.7
Smaller than average	98	6.7
Very small	150	10.3

Birth weight data description

We evaluated the presence of digit preference in the recording of birth weight. Digit preference or also called heaping is a common measurement error that can be introduced into birth weight data because of the tendency of enumerators or respondents to report certain digits at the expense of others.[23 24] The birth weight data showed 81% heaping to multiple of 500g and 9% heaping at exactly 2500g (Figure 2). All the birth weight data were heaped to terminal digits "0" or "5". We also examined the relationship between reporting method and presence of heaping to multiples of 500g, with the result indicating that the proportion of heaping to multiples of 500g did not show significant differences based on reporting method, i.e., whether obtained from a written card or maternal recall.

Accuracy of mothers' perceived baby size to predict LBW

Maternal perceptions of baby size followed a trend that was similar to that for mean birth weights. As maternally perceived size at birth decreased from very large to very small, mean birth weight also consistently decreased, from 4057.6g to 2423.5g. However, a higher standard error is obtained for two extreme categories, i.e., very small (102.4g) and very large (84.3g), which indicates lower accuracy of the estimate (see supplementary table 1). The results obtained from a one-way

197 ANOVA also indicated the presence of significant mean birth weight differences between perceived birth-size groups (F=254.4, P< 0.001).

199 Sensitivity, PPV, specificity, and NPV were determined through comparison of mother-reported baby size at birth with birth weights categories. Maternally perceived birth-size responses of "very small" or "smaller than average" were used to measure LBW and the remaining response categories were used to measure NBW. As indicated in table2, maternal birth size recall correctly identified only 57% (103/180) of actual LBWs and only 41% (103/248) of babies perceived as small by their mothers were actually in the LBW category. Specificity and NPV were nearly 89% (1130/1275) and 94% (1230/1207), respectively, which are higher than sensitivity and PPV.

206 Table 2: Accuracy of mothers' perceived baby birth size to predict low birth weight, EDHS 2016.

Variables	**Birth weight**		**Total (%)**
	<2500g (%)	>=2500g (%)	
Perceived baby size at birth			
Small size	103(57.1)	145(11.4)	248(17.0)
Normal (average or above)	77(42.9)	1130(88.6)	1207(83.0)
Total (%)	180(100.0)	1275(100.0)	1455(100.0)
Indicator accuracy with 95% CI			
Sensitivity	57.05(47.78,65.85)		
PPV	41.32(32.80,50.41)		
Specificity	88.59(85.63,91.01)		
NPV	93.61(91.45,95.25)		

207 CI confidence interval; PPV positive predictive value; NPV negative predictive value

The extent of agreement between maternal subjective assessments of baby birth size and birth weight shown by kappa statistics found a moderate level of agreement (kappa=0.41, $P < 0.001$) between the two measures. The birth weights and maternally perceived birth-size assessments agreed in 86.2% of the cases (see supplementary table 2).

Factors influencing concordance of mothers' perceived baby birth size with birth weight

In EDHS data, maternally perceived newborn size was assessed with five ordered categories ("very large," "larger than average," "average," "smaller than average" and "very small") while birth weights based on mothers self-report or medical record were captured in grams. To compare perceived size and birth weight, the birth weight obtained from card or mother's recall was normalized and classified into five categories based on standard deviation. Then, matching was done across the categories. Thus, the proportion of concordant responses were 45%. Further classification of the discordant showed that 15.8% of the maternally perceived sizes were underestimates while 39.2% of the maternally perceived sizes were overestimates (Figure 3).

We also evaluated the level of agreement between maternal assessments of birth size and birth weight across five ordered categories using kappa statistics. We found concordance between the two measurements of 46%, with the kappa coefficient indicating slight agreement (kappa=0.15, $P < 0.001$) (see supplementary table 2).

A multinomial logistic regression model was fitted to identify factors that influence the incorrect assessment of baby size at birth. Taking "concordant" as the base outcome category, comparisons were made with the remaining response categories. The results indicate that maternal age, household wealth index quintile, marital status, and maternal education were significant predictors of discordance (underestimates or overestimates) between birth size and birth weights as compared with concordant responses. Mothers in the 20–29 age group (AOR 0.28, 95% CI 0.10, 0.79) and the 30–39 age group (AOR 0.24, 95% CI 0.08, 0.72) were less likely to underestimate size than to report concordant size as compared with mothers younger than 20 years of age. Mothers from higher wealth quintile were three times more likely to underestimate baby size at birth compared with mothers from the lowest wealth quintile (AOR 3.11, 95% CI 1.34, 7.25). Similarly, mothers from higher wealth quintiles were more likely to overestimate baby size at birth compared with mothers from the poorest wealth quintile (AOR 2.34, 95% CI 1.22, 4.51; Table 3).

Mothers who were married at the time of the survey were 68% less likely to underestimate their babies' sizes at birth than to offer concordant estimates (AOR 0.32, 95% CI 0.17, 0.61) compared with mothers who had never been married. Mothers who had completed secondary education were less likely than uneducated mothers to overestimate infant size at birth than to offer a concordant estimate (AOR 0.47, 95% CI 0.26, 0.83; Table 3).

Table 3: Factors associated with discordance between mother's reported baby size and birth weight, EDHS 2016.

Explanatory variables	**Mother's estimation(Concordant as base outcome)**	
	Underestimate	**Overestimate**
	Adjusted OR(95% CI)	Adjusted OR (95% CI)
Mother's age		
< =19	1.00 (Reference)	1.00 (Reference)
20-29	0.28(0.10,0.79)[a]	1.33(0.48,3.72)
30-39	0.24(0.08,0.72)[a]	1.26(0.45,3.57)
40-49	0.33(0.08,1.31)	1.47(0.44,4.92)
Residence		
Urban	1.00 (Reference)	1.00 (Reference)

Rural	1.12(0.62,2.03)	0.75(0.42,1.34)
Wealth index quintile		
Poorest	1.00 (Reference)	1.00 (Reference)
Poorer	1.74(0.65,4.71)	1.57(0.80,3.06)
Middle	2.40(0.96,6.00)	1.24(0.61,2.55)
Richer	3.11(1.34,7.25)[a]	2.34(1.22,4.51)[a]
Richest	2.05(0.87,4.83)	1.44(0.68,3.08)
Sex of child		
Male	1.00 (Reference)	1.00 (Reference)
Female	1.20(0.78,1.85)	0.74(0.53,1.03)
Place of delivery		
Home	1.00 (Reference)	1.00 (Reference)
Health facility	0.79(0.32,1.99)	1.70(0.75,3.87)
Marital status		
Never married	1.00 (Reference)	1.00 (Reference)
Currently married	0.32(0.17,0.61)[a]	0.83(0.40,1.71)
Formerly married	0.45(0.18,1.07)	0.56(0.21,1.50)
Mother's education		
No education	1.00 (Reference)	1.00 (Reference)
Primary	0.64(0.36,1.15)	0.64(0.40,1.03)
Secondary	0.55(0.26,1.17)	0.47(0.26,0.83)[a]
Higher	0.69(0.30,1.58)	0.59(0.33,1.07)

244 [a] variables significantly associated at p-value less than 0.05; OR odds ratio; CI confidence interval

DISCUSSION

This study revealed three pertinent findings. First, we found that only 57% of the mothers identified actual low birth weight implying that a considerable number of LBW infants could be misclassified. Second, our finding shows that less than half (46%) concordance between mothers' reported baby size and birth weight when they are compared across five categories indicating a high individual level misclassification. Third, maternal characteristics were the main factors associated with incorrect estimation of birth size, suggesting that anyone using maternally perceived birth size assessment as a proxy indicator should consider the characteristics of the mothers involved in the study.

As strength, this study is based on nationally representative survey data. We analysed both aggregate and individual level concordance between birth size and birth weight.

This study has also its own limitations that should be considered in the interpretation of the findings. First, we compared estimated newborn birth size against birth weight without considering other size dimensions that likely affect a mother's judgment of birth size. As Channon 2011 noted, a mother's judgment of her newborn's birth size depends not only on birth weight but also on other size dimensions such as length and subcutaneous fat [13], which were not captured in the DHS data. We also assumed that reported birth weight is correctly measured or recalled. But our analysis suggest birth weight data heaping, which is a common measurement error that can be introduced into data such as age, birth weight, and height because of the tendency of enumerators or respondents to report certain digits at the expense of others.[24] The level of missing birth weights (85%) might also limit this study because weighed and non-weighed children might have different characteristics. Black et al. revealed that those who were weighed were more likely to have mothers who live in urban areas and who are educated and born in a healthcare facility.[11]

Moreover, the current analysis included higher proportion of children from the top wealth quintile because of the fact that children with birth weight data were from households with good socio-economic status.

The sensitivity-specificity analysis undertaken for our study revealed that mothers correctly identified only 57% of actual LBW newborns (sensitivity=0.57) and only 41% of newborns perceived as small by their mothers were actually LBW babies (PPV =0.41). However, the specificity (89%) and NPV (94%) scores are much higher than the sensitivity and PPV scores. This finding implies that Ethiopian mothers can correctly identify larger newborns as large but they are less likely to identify smaller newborns as small. Smaller/LBW babies were subject to misclassification, i.e., smaller newborns were more likely to be classified as larger babies. Therefore, using maternally perceived birth size to estimate the prevalence of LBW newborns underestimates the actual prevalence of LBW newborns. Incorrect quantification of the prevalence of LBW newborns leads to poor public health planning and focus. Our findings are consistent with study done in Cameroon with comparable sensitivity (60%), specificity (93%), NPV (96%), and PPV (44%) scores.[25] Our results are also consistent with others[11 14] that have noted that maternally perceived small birth size as reported in surveys is not a sensitive indicator of LBW. Studies done in Nepal, Uganda and Colombia revealed higher sensitivity (66-76%) than our study findings.[15 26 27]

Our study revealed 86% aggregate-level agreement between birth size and birth weight with kappa coefficient showing a moderate level of agreement between the two measurements (Kappa=0.41), while 46% concordance was obtained when they were compared across five categories with kappa coefficients indicating slight agreement between the measurements (Kappa=0.15). This implies that there was better aggregate-level agreement than individual-level agreement between birth size and birth weight. Therefore, the low magnitude of the incorrect group-level assessment of children might mask the high magnitude of incorrect assessments occurring at the individual level. This will underestimate the magnitude of individual-level birth weight-related problems, consequently reducing programmatic attention that benefits individuals.

The use of maternal birth-size assessment as a proxy indicator of birth weight might be affected by various factors. Our study found that maternal age was significantly associated with accurate estimation of birth size. Older mothers were less likely than younger mothers to underestimate birth size. Previous studies examining the association between maternal age and correct estimation of birth size have reported mixed results. Channon 2007 reported that, in Malawi, mothers who were younger than 20 years of age were more likely to classify their infants as smaller than their actual correct sizes compared with mothers aged 20–29 years. The same study revealed that older mothers were more likely to overestimate their baby's sizes in Malawi while in Cambodia mothers were less likely to overestimate their newborns' birth sizes.[12] The association of maternal age and perceived baby size warrants further investigation.

Wealth index quintile was significantly associated with misclassification of newborn birth size in our study. Mothers from higher wealth quintiles were more likely to estimate birth size incorrectly. This implied that it is difficult to know the direction of the bias in estimation of birth weight among wealthier mothers and we are unsure why it is linked with both overestimation and underestimation. But, this may reflect the fact that well-to-do mothers are more likely to perceive their newborns as normal, presumably because of good prenatal care, perhaps in their minds reducing the chance of bearing a LBW newborn. Alternatively, the tendency to misclassify birth size among wealthier mothers in our study could also be due to social desirability bias, as evidenced in Tate et al., who found that mothers with smaller newborns tended to overestimate their weights while those with larger newborns tended to underestimate their weights.[28] Still this needs further investigation to characterize which of the mothers from rich wealth quintile underestimate or overestimate the baby birth size.

We found that currently married mothers were less likely to underestimate their newborn's sizes as compared with never married mothers. similarly, in Kazakhstan, never married mothers were less likely to correctly assess their babies' sizes than currently married counterparts.[12] We also found that maternal education was significantly associated correct maternal assessment of birth size. Educated mothers were less likely than mothers with no education to provide overestimated reports rather than concordant reports of newborn size at birth. Studies conducted in Uganda and Cameroon have also revealed that mothers who were educated were more likely to give accurate estimate than non-educated mothers.[12 25 26] Another study conducted in Nepal also reported that illiterate women were less likely to be accurate in identifying LBW newborns than literate women.[15] This might reflect the fact that educated women are well informed about the relationship between newborn size and birth weight, a benchmark which likely influences their ability to estimate correctly. In addition, numerical recall might be better among educated women. For example, a study relating birth weight recall and educational level revealed that fewer years of education were significantly associated with greater birth weight recall bias.[27]

CONCLUSIONS

Maternal assessment of birth size is a less sensitive proxy indicator of LBW in Ethiopia. Hence, estimation of the prevalence of LBW based on maternal assessment of birth size underestimates the magnitude of the actual problem. Our study also reveals slight agreement between perceived birth size and birth weight. Maternal characteristics such as age, wealth status, marital status, and education were significant predictors of discordant birth-size assessments. It is recommended that maternal recall on birth-size should be used as a proxy indicator with caution and researchers and healthcare workers should consider differences in maternal characteristics such as age, wealth status, marital status, and education.

ACKNOWLEDGEMENTS

The authors thank ICF Macro-international for allowing us to use the 2016 Ethiopian Demographic and Health Survey data set for free. We would also like to thank Patricia Malloy (Assistant professor) at the University of Saskatchewan for English language editing.

FUNDING

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

COMPETING INTEREST

The authors declare that we have no competing interests.

AUTHORS' CONTRIBUTIONS

DN conceived the study, performed the data analysis, contributed in the interpretation of data and drafting the manuscript, and critically reviewed the manuscript. DH conceived the study, contributed in the interpretation of data, and critically reviewed the manuscript. BG contributed in the interpretation of data, drafted the manuscript, and critically reviewed the manuscript. YT contributed in the interpretation of data, and critically reviewed the manuscript. All authors read and approved the final manuscript.

CHECKLIST AND FLOW DIAGRAM FOR THE APPROPRIATE REPORTING

The authors followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for writing this manuscript (see table 4)

PATIENT CONSENT

Not applicable

DATA AVAILABILITY

The data were obtained from The Demographic and Health Survey Program repository. The authors have no mandate to share the data set or make it publicly available. The data can be accessed by requesting from the DHS Program website (Available at: https://www.dhsprogram.com/data/available-datasets.cfm).

REFERENCES

1. Central Statistical Agency (CSA) [Ethiopia] and ICF-International. Ethiopia Demographic and Health Survey 2016. Addis Ababa, Ethiopia and Rockville, Maryland, USA, 2016.

2. Mukuria A, Aboulafia C, Themme A. The Context of Women's Health: Results from the Demographic and Health Surveys, 1994-2001. Calverton, Maryland, USA: ORC Macro 2005.

3. Wilcox AJ. On the importance and unimportance of birthweight. International Journal of Epidemiology 2001;**30**:1233-41

4. Milde SH. Birth weight predicts brain development. ScienceNordic 2012

5. Central Statistical Agency (CSA) [Ethiopia] and ICF-International. Ethiopia Demographic and Health Survey 2011. Addis Ababa, Ethiopia and Rockville, Maryland, USA, 2012.

6. O'Leary M, Edmond K, Floyd S, Newton S, Thomas G, Thomas SL. A cohort study of low birth weight and health outcomes in the first year of life, Ghana. Bull World Health Organ 2017;**95**:574-83 doi: http://dx.doi.org/10.2471/BLT.16.180[published Online First: Epub Date]|.

7. Lemons JA, Bauer CR, Oh W, et al. Very Low Birth Weight Outcomes of the National Institute of Child Health and Human Development Neonatal Research Network, January 1995 Through December 1996. Pediatrics 2001;**107**(1)

8. World Health Organization (WHO). Guidelines on optimal feeding of low birthweight infants in low-and middle-income countries. Geneva, Switzerland, 2011.

9. Ballot DE, Ramdin T, Rakotsoane D, et al. Assessment of developmental outcome in very low birth weight infants in Southern Africa using the Bayley Scales of Infant Development (III). BMJ Paediatrics Open 2017;**1** doi: doi:10.1136/bmjpo-2017-000091[published Online First: Epub Date]|.

10. Vohr BR, Wright LL, Dusick AM, et al. Neurodevelopmental and Functional Outcomes of Extremely Low Birth Weight Infants in the National Institute of Child Health and Human Development Neonatal Research Network, 1993-1994. Pediatrics 2000;**105**(6):1216-26 doi: DOI: 10.1542/peds.105.6.1216[published Online First: Epub Date]|.

11. Blanc AK, Wardlaw T. Monitoring low birth weight: an evaluation of international estimates and an update estimation procedures. Bull World Health Organ 2005;**83**(3):178-85

12. Channon AR. Birth Weight Data in 15 Demographic and Health Surveys. University of Southampton, 2007.

13. Channon AR. Can mothers judge the size of their newborn? Assessing the determinants of a mother's perception of a baby's size at birth. Journal of Biosocial Science 2011;**00**:1–19

14. Islam MM. Can Maternal Recalled Birth Size be Used as a Proxy Measure of Birth Weight? An Evaluation Based on a Population Health Survey in Oman. Matern Child Health J 2014;**18**:1462-70 doi: 10.1007/s10995-013-1386-7[published Online First: Epub Date]|.

15. Shakya K, Shrestha N, Bhatt M, Hepworth S, Onta S. Accuracy of low birth weight as perceived by mothers and factors influencing it: A facility based study in NepaL. International Journal of Medical Research & Health Sciences 2015;**4**(2):274-80 doi: 10.5958/2319-5886.2015.00051.X[published Online First: Epub Date]|.

16. Rutstein SO, Johnson K. The DHS Wealth Index. DHS Comparative No. 6. Calverton, Maryland: ORC Macro, 2004.

17. World Health Organization. ICD-10 : international statistical classification of diseases and related health problems. Thenth revision, 2nd ed. Geneva: World Health Organization, 2004.

18. Boerma JT, Weinstein KI, Rutstein SO, Sommerfelt AE. Data on birth weight in developing countries: can surveys help? Bulletin of the World Health Organization 1996;**74**(2):209-16

19. Cohen J. A Coefficient of Agreement for Nominal Scales. Educational and Psychological Measurement 1960;**20**(1):37-49

20. Landis JR, Koch GG. The Measurement of Observer Agreement for Categorical Data. International Biometric Society 1977;**33**(1):159-74

21. Ben-Akiva M, Lerman S. *Discrete choice models*: London: MIT Press, 1985.

22. Hosmer DW, Lemeshow S. *Applied Logistic Regression*. 2nd ed. New York, United State of America: John Wiley & Sons, Inc., 2000.

23. Emmerson AJ, Roberts SA. Rounding of birth weights in a neonatal intensive care unit over 20 years: an analysis of a large cohort study. BMJ open 2013;**3**(12):e003650 doi: 10.1136/bmjopen-2013-003650[published Online First: Epub Date]|.

24. Siegel JS, Swanson DA. *The methods and materials of demography*. 2nd ed. USA: Elsevier Academic Press, 2004.

25. Mbuagbaw L, Gofin R. Can recall of birth size be used as a measure of birthweight in Cameroon? Paediatric & Perinatal Epidemiology 2010;**24**(4):383-9 doi: 10.1111/j.1365-3016.2010.01128.x.[published Online First: Epub Date]|.

26. Lule SA, Webb EL, Ndibazza J, et al. Maternal recall of birthweight and birth size in Entebbe, Uganda. Tropical Medicine and International Health 2012;**17**(12):1465-69 doi: 10.1111/j.1365-3156.2012.03091.x[published Online First: Epub Date]|.

27. Boeke CE, Marín C, Oliveros H, Mora-Plazas M, Agudelo-Cañas S, Villamor E. Validity of Maternal Birthweight Recall Among Colombian Children. Maternal and Child Health Journal 2012;**16** (4):753-59

28. Tate AR, Dezateux C, Cole TJ, Davidson L, the-Millennium-Cohort-Study-Child-Health-Group. Factors affecting a mother's recall of her baby's birth weight. International Journal of Epidemiology 2005;**34**:688-95

Figures legends

Figure 1: Flow chart showing the study population, EDHS 2016

Figure 2: Percentage distribution of birth weight data showing heaping to multiple of 500g, EDHS 2016

Figure 3: Percentage distribution of agreement between birth weight and maternal assessment of baby birth size, EDHS, 2016

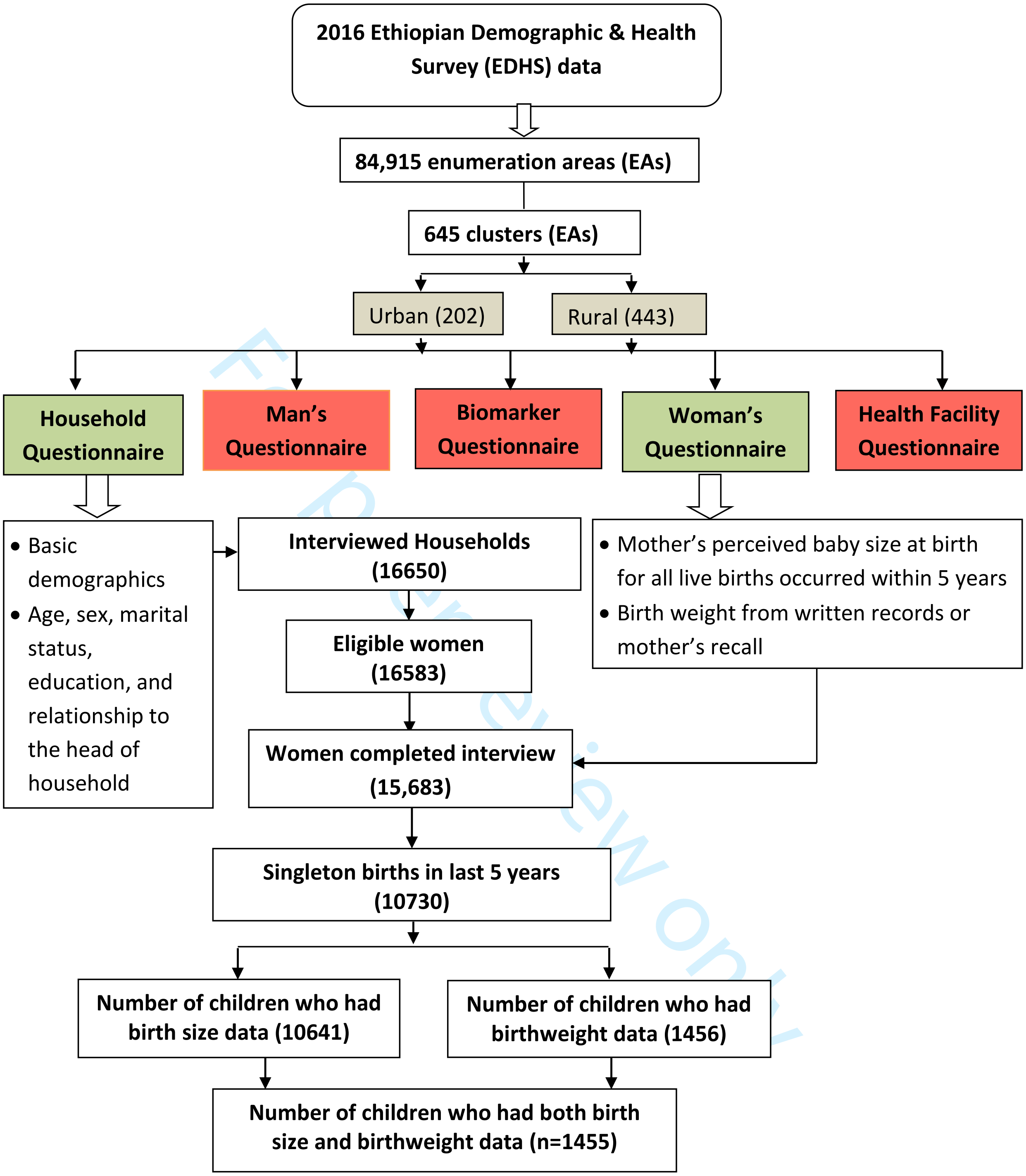

Figure 1: Flow chart showing the study population, EDHS 2016

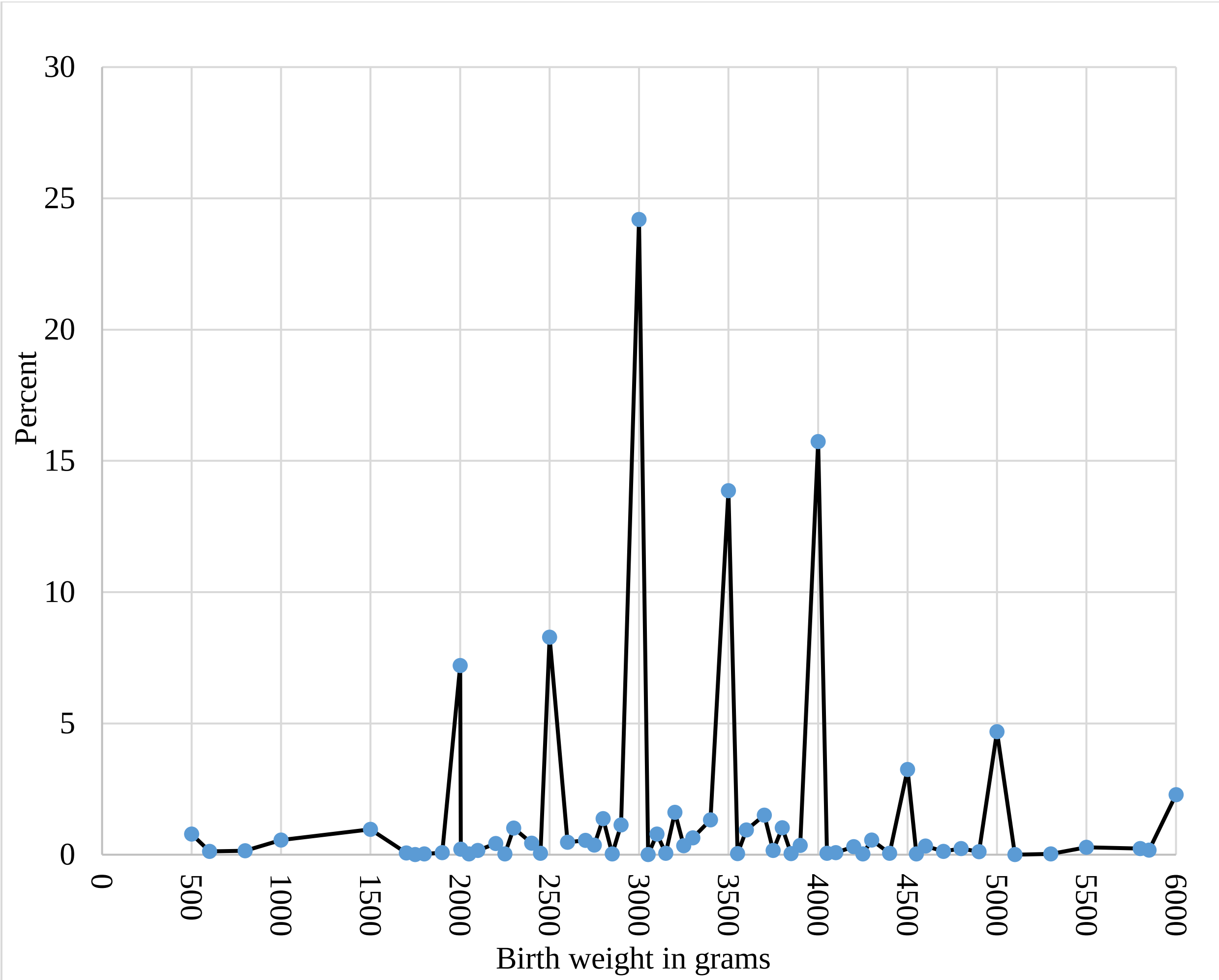

Figure 2: Percentage distribution of birthweight data showing heaping to multiple of 500g, EDHS 2016

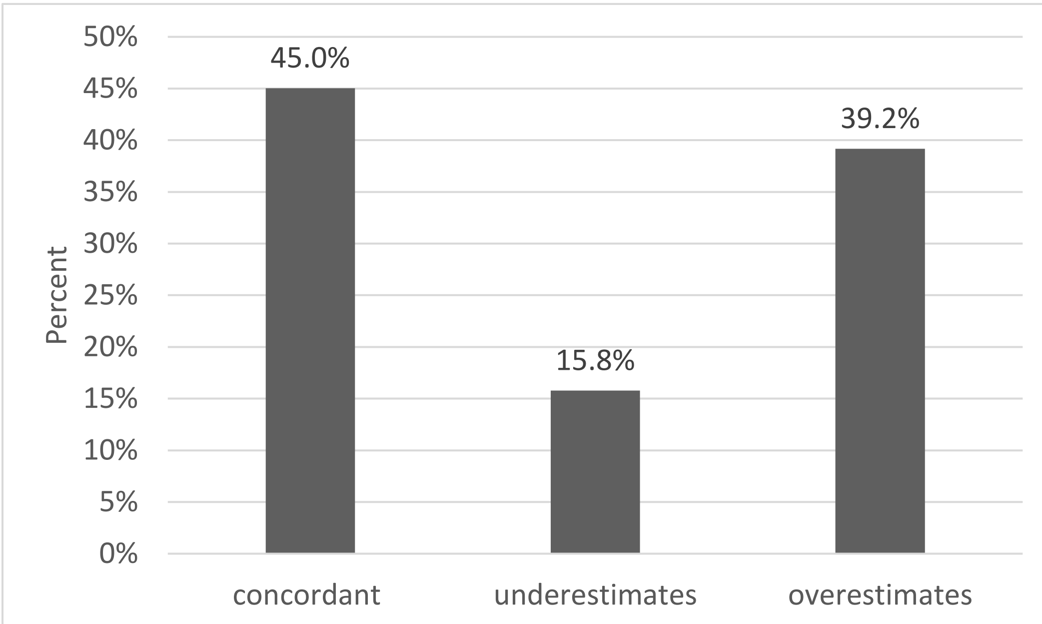

Figure 3: Percentage distribution of agreement between birthweight and maternal assessment of baby birth size, EDHS, 2016

Supplementary table 1: Mean birth weight by mother's perceived baby size at birth, EDHS 2016.

Mother's perceived baby size at birth	Mean	SE	95%CI
Very large	4057.75	84.34	3891.98, 4223.52
Larger than average	3552.69	64.86	3425.20, 3680.19
Average	3111.33	35.07	3042.40, 3180.26
Smaller than average	2560.58	80.97	2401.42, 2719.73
Very small	2423.47	102.40	2222.20, 2624.74

SE standard error, CI confidence interval

Supplementary table 2: The agreement between birth size and birth weight both at aggregate level and across five categories level using Kappa statistics.

Variables considered	**Agreement**	**Expected agreement**	**Kappa coefficient**	**z**	**P-value**
Birth weight versus Birth size*	86.24%	76.64%	0.41	19.13	<0.001
Birth weight versus Birth size**	46.03%	36.40%	0.15	15.13	<0.001

* Birth weight is aggregated as low birth weight (<2500g) or normal birth weight (≥2500g) and the birth size also reduced from five categories to binary categories (small size or normal size)

** Both birth weight and birth size were compared across five categories (very large, larger than average, average, smaller than average or very smaller)

Table 4: **STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of cross-sectional studies**

Title of the study: Predictive Accuracy of Perceived Baby Birth Size for Birthweight: A Cross-sectional Study from the 2016 Ethiopian Demographic and Health Survey

Section/Topic	**Item #**	**Recommendation**	**Reported on page #**
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5

Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	5-6
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible,	8

		examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-10
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	10-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14
		(*b*) Report category boundaries when continuous variables were categorized	9-10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	15

Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	N/A

N/A, not applicable

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Predictive Accuracy of Perceived Baby Birth Size for Birth Weight: A Cross-sectional Study from the 2016 Ethiopian Demographic and Health Survey

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-031986.R2
Article Type:	Original research
Date Submitted by the Author:	15-Oct-2019

Complete List of Authors:	Nigatu, Dabere; Bahir Dar University College of Medical and Health Sciences, Department of Reproductive Health and Population Studies Haile, Demewoz; Addis Ababa University College of Health Sciences, School of Public Health; University of California Davis, Institute of Global Nutrition Gebremichael, Bereket; Department of Nursing and midwifery, Allied school of health science, Addis Ababa University, Addis Ababa, Ethiopia Tiruneh, Yordanos; University of Texas Health Science Center at Tyler, Department of Community Health; University of Texas Southwestern Medical Center at Dallas, Department of Clinical Sciences

Primary Subject Heading:	Public health
Secondary Subject Heading:	Public health, Epidemiology
Keywords:	Predictive accuracy, Perceived baby size, Birth weight, Ethiopia

Predictive Accuracy of Perceived Baby Birth Size for Birth Weight: A Cross-sectional Study from the 2016 Ethiopian Demographic and Health Survey

Dabere Nigatu[1], Demewoz Haile[2], Bereket Gebremichael[3], Yordanos M. Tiruneh[4,5]

Affiliations:

[1] Department of Reproductive Health and Population Studies, School of Public Health, College of Medicine and Health Sciences, Bahir Dar University, Bahir Dar, Ethiopia

[2] School of Public Health, College of Health Sciences, Addis Ababa University, Addis Ababa, Ethiopia

[3] Allied School of Health Science, College of Medicine and Health Science, Addis Ababa University, Addis Ababa, Ethiopia

[4] Department of Community Health, The University of Texas Health Science Center at Tyler, Tyler, Texas, USA

[5] Department of Population and Data Sciences, University of Texas Southwestern Medical Center, Dallas, Texas, USA

Corresponding author:

Dabere Nigatu;

Department of Reproductive Health and Population Studies, School of Public Health, College of Medicine and Health Sciences, Bahir Dar University, Bahir Dar, Ethiopia

Email Address: daberen@yahoo.com

ABSTRACT

Objectives: The study was designed to evaluate the accuracy of maternally perceived baby birth size assessments as a measure of birth weight and examine factors influencing the accuracy of maternal size assessments.

Study design: Cross-sectional study.

Setting: The study is based on national data from the 2016 Ethiopian Demographic and Health Survey.

Participants: We included 1,455 children who had both birth size and birth weight data.

Main outcome measures: Predictive accuracy of baby birth size for low birth weight. Level of discordance between maternally perceived birth size and birth weight including factors influencing discordance.

Results: Mother-reported baby birth size had low sensitivity (57%) and positive predictive value (41%) to indicate low birth weight but had high specificity (89%) and negative predictive values (94%). The percent of agreement between birth weight (<2500gram vs >=2500gram) and maternally perceived birth size (small size vs average or above) was 86% and kappa statistics indicated a moderate level of agreement (kappa=0.41, $P < 0.001$). Maternal age, wealth index quintile, marital status, and maternal education were significant predictors of the discordance between birth size and birth weight.

Conclusions: Maternal assessment of baby size at birth is an inaccurate proxy indicator of low birth weight in Ethiopia. Therefore, a mother's recall of birth size should be used as a proxy indicator for low birth weight with caution and should take maternal characteristics into consideration.

Key words: Predictive accuracy; Perceived baby size; Birth size; Birth weight; Ethiopia

STRENGTHS AND LIMITATIONS OF THIS STUDY

- The study evaluated both aggregate and individual level concordance between birth size and birth weight.
- We compared estimated newborn birth size against birth weight without considering other size dimensions that likely affect a mother's judgment of birth size.
- We also assumed that reported birth weight is correctly measured or recalled to make comparison with maternally perceived baby birth size.
- The birth weight data shows heaping to certain digits, which might be introduced because of the tendency of enumerators or respondents to report certain digits at the expense of others.

INTRODUCTION

Birth weight is a good summary measure of multifaceted public health problems that include long-term maternal malnutrition, poor maternal health, and poor maternal healthcare utilization during pregnancy.[1 2] It is also an important indicator of a child's vulnerability to the risk of childhood illnesses and the child's chances of survival.[3-5] In most instances low birth weight (LBW), <2500g, is linked with high morbidity and mortality during the neonatal period and later life.[5-7] LBW babies are at higher risk of early growth retardation, infectious diseases, and neurologic, neurosensory, and developmental delays.[7-10]

Although every country has a public interest in generating birth weight data, in many developing countries the majority of newborns are not weighed at birth because of the fact that most childbirths are occurring at home.[11] According to the 2011 Ethiopian Demographic and Health Survey (EDHS) report, only 5% of children in Ethiopia are weighed at birth [5], a figure which has grown to 14% in the most recent EDHS report. Thus, information on mothers' subjective estimates of their babies' birth sizes is the only means of addressing the birth characteristics of 86% of newborns of unknown birth weight in Ethiopia.[1] For this reason, in many large community based surveys including the Demographic and Health Surveys (DHS), mother reported birth size data are collected to use it as a proxy indicator of birth weight in low and middle income countries.[1 11]

While a mother's subjective assessment of the size of her baby at birth is still a useful proxy indicator in the absence of measured birth weight [5], it can be influenced by societal and contextual factors. The average size of infants in the community around a newborn and the characteristics of the infant and its parents influence the accuracy of the assessment.[12 13] Wide variability is also observed in the distribution of maternal perceptions of baby size at birth between countries.[12] Studies evaluating the relationship between maternal perceptions of baby size and actual birth weight concluded that maternal recall of baby size is an imprecise proxy indicator of birth weight.[14 15]

Although maternal perceptions of baby size at birth is widely used proxy indicator for birth weight, the extent of agreement between these perceptions and recorded or recalled actual birth weight has not been examined in Ethiopia. This study fills this gap in the literature by evaluating the accuracy of maternal baby size assessments to predict LBWs obtained from record or maternal recall. On top of this, investigating the level of accuracy of maternally perceived birth size as proxy indicator of low birth weight is very important to inform the health policy makers, health care programmers and managers, and responsible others for informed decision. The study also examined the factors influencing the agreement between maternal baby size assessments and recorded or recalled birth weights in Ethiopia.

METHODS

Study setting and design

This study was a secondary analysis based on the 2016 EDHS data. The sampling frame used for the 2016 EDHS is based on the 2007 Ethiopia Population and Housing Census (PHC) conducted by the Ethiopia Central Statistical Agency. Multi-stage stratified cluster sampling was used to recruit the sample population. The detailed sampling procedure was published in the DHS country report.[1]

This study was based on a total of 11,023 live births during the five years preceding administration of the survey. Only singleton births (10,731) were included in this study. From singleton births, 1,455 children who had both birth weight and birth size data were considered for the final analysis (Figure 1).

Description of variables measurement

A multinomial logistic regression model was used to identify factors influencing discordance between birth size and birth weight.

i. Explanatory variables

The explanatory variables included were educational status, maternal age, marital status, pregnancy (wanted/unwanted), antenatal care, place of delivery, child's sex, birth order, child's survival status, media exposure, place of residence and wealth quintile. Wealth index scores were created based on the number and kinds of consumer goods in a household, ranging from a television to a bicycle or car; housing characteristics such as the source of drinking water and toilet facilities; and flooring materials. Detail on the DHS wealth index construction can be found in Rutstein 2004 and EDHS 2016 report.[1 16]

ii. Outcome variables

a) Baby size: The 2016 EDHS has a question designed to assess maternal perceptions of baby size at birth for all live births occurred during the last five years preceding the survey. The mothers were asked to retrospectively classify their babies' sizes at birth as "very large," "larger than average," "average," "smaller than average," or "very small". Then we recoded into two categories; very large, larger than average and average responses were categorised as "average or above average" category whereas smaller than average and very small responses were categorised as "small".

b) Birth weight: The 2016 EDHS collect birth weight data in grams from written records or mother's recall. Then, the birth weight obtained from record or mother's recall was classified using the WHO cutoff point as "LBW" if birth weight <2500g or normal birth weight "NBW" if birth weight ≥2500g.[17] Furthermore, the birth weight data was normalized and categorised into five categories based on standard deviation (SD). Thus, the categories were: birth weight greater than +2SD from the mean taken as "very large", between +2SD and +1SD from the mean as "larger than average", between +1SD and -1SD from the mean as "average", between -1SD and -2SD from the mean as "smaller than average", and less than -2SD from the mean as "very smaller" categories.[12] This statistical categorization of the measured birth weight into five categories using the standard deviation was done in order to test the agreement of the measured birth weight with mother's perceived baby size category at birth. Then, we matched to generate new variable with three response categories; if the mother's response on perceived baby size agree with the response categories obtained from the birth weight considered as "*concordant*", and if the responses not agree further classified as "*underestimate*" if the mother's response is smaller than birth weight category, and *"overestimate*" if it is larger than birth weight category.

In the DHS questionnaire, the questions on birth size and birth weight were ordered in a way that minimizes bias. The question which assess mother's perceived baby size precede the question on birth weight to minimize the influence of maternal knowledge about birth weight on assessment of size at birth.

Data analysis

Data were analysed using STATA version 14.0 statistical software package. We used the "svy" command in STATA to weight the survey data.

The Boerma et al. (1996) sensitivity-specificity analysis approach was applied to measure indicator accuracy.[18] Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were analysed to evaluate maternal perceptions of baby size at birth as an indicator of LBW. In this study, sensitivity is the proportion of actual LBW newborns who are accurately identified as small in size by mothers and specificity is the proportion of actual normal birth weight

(NBW) newborns who are accurately identified as "average or above average" by their mothers. PPV is the proportion of actual LBW babies among those identified as small by their mothers and NPV is the proportion of actual NBW babies whom mothers reported as "average or above average" in size.

Kappa statistics was used to evaluate the extent of agreement between birth weights and birth sizes as a measure of LBW.[19] The Landis and Koch (1977) benchmark was applied to judge the relative strength of agreement associated with kappa statistics.[20] One-way analysis of variance (ANOVA) was also performed to evaluate the presence of significant mean birth weight differences between birth size categories.

Multinomial logistic regression model was used to identify predictor variables as the outcome variable follows a multinomial probability distribution.[21] Our outcome variable was categorised as concordant, underestimate, or overestimate. Concordant was the base outcome category of the outcome variable. A Wald test was executed to test the significance of the independent variables in the model. Variables with p-value lower than 0.25 were selected as candidate variables in the multivariable multinomial logistic regression model.[22] An odds ratio with a 95% confidence interval was used to identify the factors associated with underestimate or overestimate responses as compared with concordant responses as indicators. Statistical significance for the explanatory variables was declared at P-values lower than 0.05.

The authors followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for writing this manuscript (supplementary table 1)

Ethical considerations

This study is based on secondary data. The 2016 EDHS data set were accessed after obtaining permission from The DHS Program. The primary data were collected in line with national and

167 international ethical guidelines. Reader can refer the 2016 EDHS report for further reading on the survey protocol.[1]

169 **Patient and Public Involvement**

170 We did not involve patients or the public in this work

171 RESULTS

172 Socio-demographic characteristics

173 From 1455 mothers, 57.8% were in the age group of 20-29 years. About 51.5% mothers were rural residents. More than half (53%) of mothers were from richest wealth quintile. Ninety two percent of the mothers were married at the time of the survey and 29% of mothers had no formal education. The mean birth weight with standard deviation (SD) was 3332.4g ($\pm$940.3g); the smallest and largest birth weights were 500g and 6000g, respectively. About 12% of the babies weigh <2500g and 40.7% were perceived as average size baby at birth (Table 1).

179 Table 1: Socio-demographic characteristics of women and index child, EDHS 2016 (n=1455)

Variables	**Frequency**	**Percentage**
Mother's age		
$\leq$ 19	58	4.0
20-29	841	57.8
30-39	483	33.2
40-49	73	5.0
Residence		
Urban	705	48.5
Rural	750	51.5

Wealth index quintile		
Poorest	103	7.1
Poorer	147	10.1
Middle	201	13.8
Richer	233	16.0
Richest	771	53.0
Marital status		
Never married	34	2.3
Currently married	1,345	92.4
Formerly married	77	5.3
Mother's education		
No education	425	29.2
Primary	551	37.9
Secondary	262	18.0
Higher	217	14.9
Sex of child		
Male	745	51.2
Female	710	48.8
Birth weight		
<2500g	180	12.3
$\geq$2500g	1,275	87.7
Mean (SD)=3332.4g ($\pm$940.3g)		
Source of birth weight data		

Written card	107	7.4
Mother's recall	1,348	92.6
Perceived baby birth size		
Very large	411	28.3
Larger than average	204	14.0
Average	592	40.7
Smaller than average	98	6.7
Very small	150	10.3

Evaluation of birth weight data for potential measurement error

We evaluated the presence of digit preference in the recording of birth weight. Digit preference or also called heaping is a common measurement error that can be introduced into birth weight data because of the tendency of enumerators or respondents to report certain digits at the expense of others.[23 24] Eighty-one percent of the birth weight data had a digit preference to multiple of 500g and 9% had a digit preference at exactly 2500g (Figure 2). All the birth weight data were heaped to terminal digits "0" or "5". Since we found that majority of the birth weight data were heaped at multiple of 500g, we examined if there was an association between source of birth weight data and presence of digit preference to multiples of 500g. The analysis showed that there was no association between digit preference and source of birth weight data, i.e., whether obtained from a written card or maternal recall.

Accuracy of mothers' perceived baby size to predict LBW

Maternal perceptions of baby size followed a trend that was similar to that for mean birth weights. As maternally perceived size at birth goes from very large to very small, mean birth weight also consistently goes down from 4057.6g to 2423.5g (supplementary table 2). The results obtained from a one-way ANOVA also indicated the presence of significant mean birth weight differences between perceived birth-size groups (F=254.4, P< 0.001). The post-hoc analysis ascertained that the mean differences were significant across all birth size categories (P < 0.001) except between small size and very small size categories (P > 0.05).

Sensitivity, PPV, specificity, and NPV were determined through comparison of mother-reported baby size at birth with birth weights categories. Maternally perceived birth-size responses of "very small" or "smaller than average" were used to measure LBW and the remaining response categories were used to measure NBW. As indicated in table 2, maternal birth size recall correctly identified only 57% (103/180) of actual LBWs and only 41% (103/248) of babies perceived as small by their mothers were actually in the LBW category. Specificity and NPV were nearly 89% (1130/1275) and 94% (1230/1207), respectively, which are higher than sensitivity and PPV.

Table 2: Accuracy of mothers' perceived baby birth size to predict low birth weight, EDHS 2016.

Variables	**Birth weight**		**Total (%)**
	<2500g (%)	>=2500g (%)	
Perceived baby size at birth			
Small size	103(57.1)	145(11.4)	248(17.0)
Normal (average or above)	77(42.9)	1130(88.6)	1207(83.0)
Total (%)	180(100.0)	1275(100.0)	1455(100.0)
Indicator accuracy with 95% CI			
Sensitivity	57.05(47.78,65.85)		
PPV	41.32(32.80,50.41)		
Specificity	88.59(85.63,91.01)		
NPV	93.61(91.45,95.25)		

CI confidence interval; PPV positive predictive value; NPV negative predictive value

Babies are categorized into low birth weight and normal birth weight based on quantitative birth weight data (<2500gram vs >=2500gram) and maternally perceived birth size (Small size vs normal (average or above)). Based on this categorization, the percent agreement between maternally perceived baby birth size and birth weight was 86% and kappa statistics indicated a moderate level of agreement (kappa=0.41, P < 0.001) (supplementary table 3).

Factors influencing concordance of mothers' perceived baby birth size with birth weight

In EDHS data, maternally perceived newborn size was assessed with five ordered categories ("very large," "larger than average," "average," "smaller than average" and "very small") while birth weights based on mothers self-report or medical record were captured in grams. To compare perceived size and birth weight, the birth weight obtained from card or mother's recall was normalized and classified into five categories based on standard deviation. Then, matching was done across the categories. Thus, the proportion of concordant responses were 45%. Further classification of the discordant showed that 15.8% of the maternally perceived sizes were underestimates while 39.2% of the maternally perceived sizes were overestimates (Figure 3).

We also evaluated the level of agreement between maternal assessments of birth size and birth weight across five ordered categories using kappa statistics. We found concordance between the two measurements of 46%, with the kappa coefficient indicating slight agreement (kappa=0.15, P < 0.001) (supplementary table 3).

A multinomial logistic regression model was fitted to identify factors that influence the incorrect assessment of baby size at birth. Taking "concordant" as the base outcome category, comparisons were made with the remaining response categories. The results indicate that maternal age, household wealth index quintile, marital status, and maternal education were significant predictors of discordance (underestimates or overestimates) between birth size and birth weights as compared with concordant responses. Mothers in the 20–29 age group (AOR 0.28, 95% CI 0.10, 0.79) and the 30–39 age group (AOR 0.24, 95% CI 0.08, 0.72) were less likely to underestimate size than to report concordant size as compared with mothers younger than 20 years of age. Mothers from higher wealth quintile were three times more likely to underestimate baby size at birth compared with mothers from the lowest wealth quintile (AOR 3.11, 95% CI 1.34, 7.25). Similarly, mothers from higher wealth quintiles were more likely to overestimate baby size at birth compared with mothers from the poorest wealth quintile (AOR 2.34, 95% CI 1.22, 4.51; Table 3).

Mothers who were married at the time of the survey were 68% less likely to underestimate their babies' sizes at birth than to offer concordant estimates (AOR 0.32, 95% CI 0.17, 0.61) compared with mothers who had never been married. Mothers who had completed secondary education were less likely than uneducated mothers to overestimate infant size at birth than to offer a concordant estimate (AOR 0.47, 95% CI 0.26, 0.83; Table 3).

Table 3: Factors associated with discordance between mother's reported baby size and birth weight, EDHS 2016.

Explanatory variables	**Mother's estimation(Concordant as base outcome)**	
	Underestimate	**Overestimate**
	Adjusted OR(95% CI)	Adjusted OR (95% CI)
Mother's age		
< =19	1.00 (Reference)	1.00 (Reference)
20-29	0.28(0.10,0.79)[a]	1.33(0.48,3.72)
30-39	0.24(0.08,0.72)[a]	1.26(0.45,3.57)
40-49	0.33(0.08,1.31)	1.47(0.44,4.92)

Residence		
Urban	1.00 (Reference)	1.00 (Reference)
Rural	1.12(0.62,2.03)	0.75(0.42,1.34)
Wealth index quintile		
Poorest	1.00 (Reference)	1.00 (Reference)
Poorer	1.74(0.65,4.71)	1.57(0.80,3.06)
Middle	2.40(0.96,6.00)	1.24(0.61,2.55)
Richer	3.11(1.34,7.25)[a]	2.34(1.22,4.51)[a]
Richest	2.05(0.87,4.83)	1.44(0.68,3.08)
Sex of child		
Male	1.00 (Reference)	1.00 (Reference)
Female	1.20(0.78,1.85)	0.74(0.53,1.03)
Place of delivery		
Home	1.00 (Reference)	1.00 (Reference)
Health facility	0.79(0.32,1.99)	1.70(0.75,3.87)
Marital status		
Never married	1.00 (Reference)	1.00 (Reference)
Currently married	0.32(0.17,0.61)[a]	0.83(0.40,1.71)
Formerly married	0.45(0.18,1.07)	0.56(0.21,1.50)
Mother's education		
No education	1.00 (Reference)	1.00 (Reference)
Primary	0.64(0.36,1.15)	0.64(0.40,1.03)
Secondary	0.55(0.26,1.17)	0.47(0.26,0.83)[a]

Higher	0.69(0.30,1.58)	0.59(0.33,1.07)

[a] variables significantly associated at p-value less than 0.05; OR odds ratio; CI confidence interval

DISCUSSION

This study revealed two pertinent findings. First, we found that only 57% of the mothers identified actual low birth weight implying that a considerable proportion of LBW infants could be misclassified. Second, maternal characteristics were the main factors associated with incorrect estimation of birth size, suggesting that anyone using maternally perceived birth size assessment as a proxy indicator should consider the characteristics of the mothers involved in the study.

This study had limitations that should be considered in the interpretation of the findings. First, we compared estimated newborn birth size against birth weight without considering other size dimensions that likely affect a mother's judgment of birth size. As Channon 2011 noted, a mother's judgment of her newborn's birth size depends not only on birth weight but also on other size dimensions such as length and subcutaneous fat [13], which were not captured in the DHS data. We also assumed that reported birth weight is correctly measured or recalled. But our analysis suggest digit preferences on birth weight data that could be introduced because of the tendency of enumerators or respondents to report certain digits at the expense of others.[24] The level of missing birth weights (85%) might also limit this study because weighed and non-weighed children might have different characteristics. Black et al. revealed that those who were weighed were more likely to have mothers who live in urban areas and who are educated and born in a healthcare facility.[11] Moreover, the current analysis included higher proportion of children from the top wealth quintile because of the fact that children with birth weight data were from households with good socio-economic status.

This study found that mother perceived birth size had low sensitivity and positive predictive value to identify low birth weight babies in Ethiopia. Ethiopian mothers can correctly identify only 57% of actual LBW newborns (sensitivity=0.57) as small size babies and only 41% of newborns perceived as small size by their mothers were actually LBW babies (PPV =0.41). Maternally perceived baby birth size had high specificity and negative predictive values to identify normal birth weight babies. This implies that Ethiopian mothers can correctly identify larger newborns as large but they are less likely to identify smaller newborns as small. The high specificity of maternally perceived birth size might contribute to the overall high percent agreement (86%) between maternally perceived birth size and birth weight in categorizing the newborns into low birth weight and normal birth weight babies. The percent agreement (46%) between these two measurements was low when evaluated based on five level categories of maternally perceived birth size and birth weight with the kappa coefficient indicating slight agreement (kappa=0.15, $P < 0.001$). Therefore, using maternally perceived birth size as proxy indicator to quantify the prevalence of LBW underestimates the magnitude which might lead to underestimation of the contribution of low birth weight for child mortality and future health and economic burden. Moreover underestimation of the true low birth weight prevalence is another reason for LBW newborns not to get priority in nutrition and public health intervention. Our findings are consistent with study done in Cameroon with comparable sensitivity (60%), specificity (93%), NPV (96%), and PPV (44%) scores.[25] Our results are also consistent with others[11 14] that have noted that maternally perceived small birth size as reported in surveys is not a sensitive indicator of LBW. Studies done in Nepal, Uganda and Colombia found relatively higher sensitivity (66-76%) than our study.[15 26 27]

The use of maternal birth-size assessment as a proxy indicator of birth weight might be affected by various factors. Our study found that maternal age was significantly associated with accurate estimation of birth size. Older mothers were less likely than younger mothers to underestimate birth size. Previous studies examining the association between maternal age and correct estimation of birth size have reported mixed results. Channon 2007 reported that, in Malawi, mothers who were younger than 20 years of age were more likely to classify their infants as smaller than their actual correct sizes compared with mothers aged 20–29 years. The same study revealed that older mothers were more likely to overestimate their baby's sizes in Malawi while in Cambodia mothers were less likely to overestimate their newborns' birth sizes.[12] The association of maternal age and perceived baby size warrants further investigation.

In this study wealth index quintile was significantly associated with misclassification of newborn birth size. As compared to the poorest wealth quintile mothers, being in richer wealth quintile was associated with both under and over estimation of birth size. This may reflect the fact that well-to-do mothers are more likely to perceive their newborns as normal, presumably because of good prenatal care, perhaps in their minds reducing the chance of bearing a LBW newborn. Alternatively, the tendency to misclassify birth size among wealthier mothers in our study could also be due to social desirability bias, as evidenced in Tate et al., who found that mothers with smaller newborn tended to overestimate the babies' weight while those with larger newborns tended to underestimate the babies' weight.[28] The association of richer wealth quintile with both under and over estimation of the birth size as compared to the poorest wealth quintile might also attributed to the fact that majority of the women included in this analysis were from the highest wealth quintile. However still this needs further investigation to characterize which of the mothers from rich wealth quintile underestimate or overestimate the baby birth size.

We found that currently married mothers were less likely to underestimate their newborn's sizes than never married mothers. similarly, in Kazakhstan, never married mothers were less likely to correctly assess their babies' sizes than currently married counterparts.[12] We also found that better maternal education was significantly associated lower odds of overestimation of birth size. Educated mothers had lower odds to overestimate their newborn's size than uneducated mothers, but underestimation did not associate with maternal educational status. A similar finding was reported from Gabon, Uganda, Cameroon and Nepal which showed that mothers with better educational status were more likely to give accurate estimate than non-educated mothers.[12 15 25 26] This might reflect the fact that educated women are well informed about the relationship between newborn size and birth weight, a benchmark which likely influences their ability to estimate correctly. In addition, numerical recall might be better among educated women. For example, a study relating birth weight recall and educational level revealed that fewer years of education were significantly associated with greater birth weight recall bias.[27]

CONCLUSIONS

Maternal assessment of birth size is a less sensitive proxy indicator of LBW in Ethiopia. Hence, estimation of the prevalence of LBW based on maternal assessment of birth size underestimates the magnitude of the actual problem. Maternal characteristics such as age, wealth status, marital status, and education were significant predictors of discordant birth-size assessments. It is recommended that maternal recall on birth-size should be used as a proxy indicator with caution and researchers and healthcare workers should consider differences in maternal characteristics such as age, wealth status, marital status, and education.

ACKNOWLEDGEMENTS

The authors thank ICF Macro-international for allowing us to use the 2016 Ethiopian Demographic and Health Survey data set for free. We would also like to thank Patricia Malloy (Assistant professor) at the University of Saskatchewan for English language editing.

FUNDING

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

COMPETING INTEREST

The authors declare that we have no competing interests.

AUTHORS' CONTRIBUTIONS

DN conceived the study, performed the data analysis, contributed in the interpretation of data and drafting the manuscript, and critically reviewed the manuscript. DH conceived the study, contributed in the interpretation of data, and critically reviewed the manuscript. BG contributed in the interpretation of data, drafted the manuscript, and critically reviewed the manuscript. YT contributed in the interpretation of data, and critically reviewed the manuscript. All authors read and approved the final manuscript.

CHECKLIST AND FLOW DIAGRAM FOR THE APPROPRIATE REPORTING

We used the STROBE 2007 (v4) statement - checklist for reporting cross-sectional study.

PATIENT CONSENT

Not applicable

DATA AVAILABILITY

The data were obtained from The Demographic and Health Survey Program repository. The authors have no mandate to share the data set or make it publicly available. The data can be accessed by requesting from the DHS Program website (Available at: https://www.dhsprogram.com/data/available-datasets.cfm).

REFERENCES

1. Central Statistical Agency (CSA) [Ethiopia] and ICF-International. Ethiopia Demographic and Health Survey 2016. Addis Ababa, Ethiopia and Rockville, Maryland, USA, 2016.
2. Mukuria A, Aboulafia C, Themme A. The Context of Women's Health: Results from the Demographic and Health Surveys, 1994-2001. Calverton, Maryland, USA: ORC Macro 2005.
3. Wilcox AJ. On the importance and unimportance of birthweight. International Journal of Epidemiology 2001;**30**:1233-41
4. Milde SH. Birth weight predicts brain development. ScienceNordic 2012
5. Central Statistical Agency (CSA) [Ethiopia] and ICF-International. Ethiopia Demographic and Health Survey 2011. Addis Ababa, Ethiopia and Rockville, Maryland, USA, 2012.
6. O'Leary M, Edmond K, Floyd S, Newton S, Thomas G, Thomas SL. A cohort study of low birth weight and health outcomes in the first year of life, Ghana. Bull World Health Organ 2017;**95**:574-83 doi: http://dx.doi.org/10.2471/BLT.16.180[published Online First: Epub Date]|.
7. Lemons JA, Bauer CR, Oh W, et al. Very Low Birth Weight Outcomes of the National Institute of Child Health and Human Development Neonatal Research Network, January 1995 Through December 1996. Pediatrics 2001;**107**(1)
8. World Health Organization (WHO). Guidelines on optimal feeding of low birthweight infants in low-and middle-income countries. Geneva, Switzerland, 2011.

9. Ballot DE, Ramdin T, Rakotsoane D, et al. Assessment of developmental outcome in very low birth weight infants in Southern Africa using the Bayley Scales of Infant Development (III). BMJ Paediatrics Open 2017;**1** doi: doi:10.1136/bmjpo-2017-000091[published Online First: Epub Date]|.

10. Vohr BR, Wright LL, Dusick AM, et al. Neurodevelopmental and Functional Outcomes of Extremely Low Birth Weight Infants in the National Institute of Child Health and Human Development Neonatal Research Network, 1993-1994. Pediatrics 2000;**105**(6):1216-26 doi: DOI: 10.1542/peds.105.6.1216[published Online First: Epub Date]|.

11. Blanc AK, Wardlaw T. Monitoring low birth weight: an evaluation of international estimates and an update estimation procedures. Bull World Health Organ 2005;**83**(3):178-85

12. Channon AR. Birth Weight Data in 15 Demographic and Health Surveys. University of Southampton, 2007.

13. Channon AR. Can mothers judge the size of their newborn? Assessing the determinants of a mother's perception of a baby's size at birth. Journal of Biosocial Science 2011;**00**:1–19

14. Islam MM. Can Maternal Recalled Birth Size be Used as a Proxy Measure of Birth Weight? An Evaluation Based on a Population Health Survey in Oman. Matern Child Health J 2014;**18**:1462-70 doi: 10.1007/s10995-013-1386-7[published Online First: Epub Date]|.

15. Shakya K, Shrestha N, Bhatt M, Hepworth S, Onta S. Accuracy of low birth weight as perceived by mothers and factors influencing it: A facility based study in NepaL. International Journal of Medical Research & Health Sciences 2015;**4**(2):274-80 doi: 10.5958/2319-5886.2015.00051.X[published Online First: Epub Date]|.

16. Rutstein SO, Johnson K. The DHS Wealth Index. DHS Comparative No. 6. Calverton, Maryland: ORC Macro, 2004.

17. World Health Organization. ICD-10 : international statistical classification of diseases and related health problems. Thenth revision, 2nd ed. Geneva: World Health Organization, 2004.

18. Boerma JT, Weinstein KI, Rutstein SO, Sommerfelt AE. Data on birth weight in developing countries: can surveys help? Bulletin of the World Health Organization 1996;**74**(2):209-16

19. Cohen J. A Coefficient of Agreement for Nominal Scales. Educational and Psychological Measurement 1960;**20**(1):37-49

20. Landis JR, Koch GG. The Measurement of Observer Agreement for Categorical Data. International Biometric Society 1977;**33**(1):159-74

21. Ben-Akiva M, Lerman S. *Discrete choice models*: London: MIT Press, 1985.

22. Hosmer DW, Lemeshow S. *Applied Logistic Regression*. 2nd ed. New York, United State of America: John Wiley & Sons, Inc., 2000.

23. Emmerson AJ, Roberts SA. Rounding of birth weights in a neonatal intensive care unit over 20 years: an analysis of a large cohort study. BMJ open 2013;**3**(12):e003650 doi: 10.1136/bmjopen-2013-003650[published Online First: Epub Date]|.

24. Siegel JS, Swanson DA. *The methods and materials of demography*. 2nd ed. USA: Elsevier Academic Press, 2004.

25. Mbuagbaw L, Gofin R. Can recall of birth size be used as a measure of birthweight in Cameroon? Paediatric & Perinatal Epidemiology 2010;**24**(4):383-9 doi: 10.1111/j.1365-3016.2010.01128.x.[published Online First: Epub Date]|.

26. Lule SA, Webb EL, Ndibazza J, et al. Maternal recall of birthweight and birth size in Entebbe, Uganda. Tropical Medicine and International Health 2012;**17**(12):1465-69 doi: 10.1111/j.1365-3156.2012.03091.x[published Online First: Epub Date]|.

423 27. Boeke CE, Marín C, Oliveros H, Mora-Plazas M, Agudelo-Cañas S, Villamor E. Validity of Maternal Birthweight Recall Among Colombian Children. Maternal and Child Health Journal 2012;**16** (4):753-59

426 28. Tate AR, Dezateux C, Cole TJ, Davidson L, the-Millennium-Cohort-Study-Child-Health-Group. Factors affecting a mother's recall of her baby's birth weight. International Journal of Epidemiology 2005;**34**:688-95

431 **Figures legends**

432 Figure 1: Flow chart showing the study population, EDHS 2016

433 Figure 2: Percentage distribution of birth weight data showing digit preference to multiple of 500g,
434 EDHS 2016

435 Figure 3: Percentage distribution of agreement between birth weight and maternal assessment of
436 baby birth size, EDHS, 2016

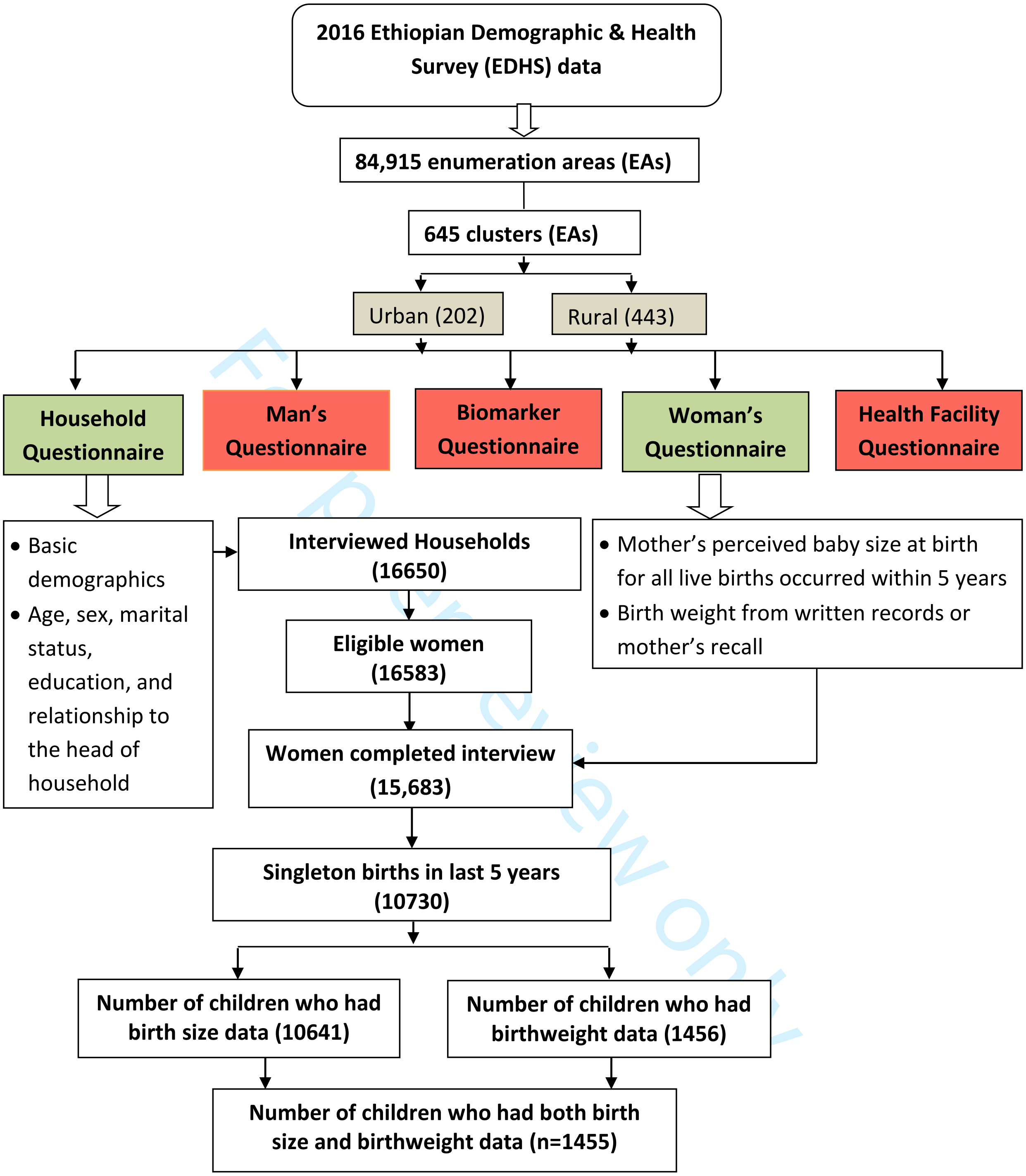

Figure 1: Flow chart showing the study population, EDHS 2016

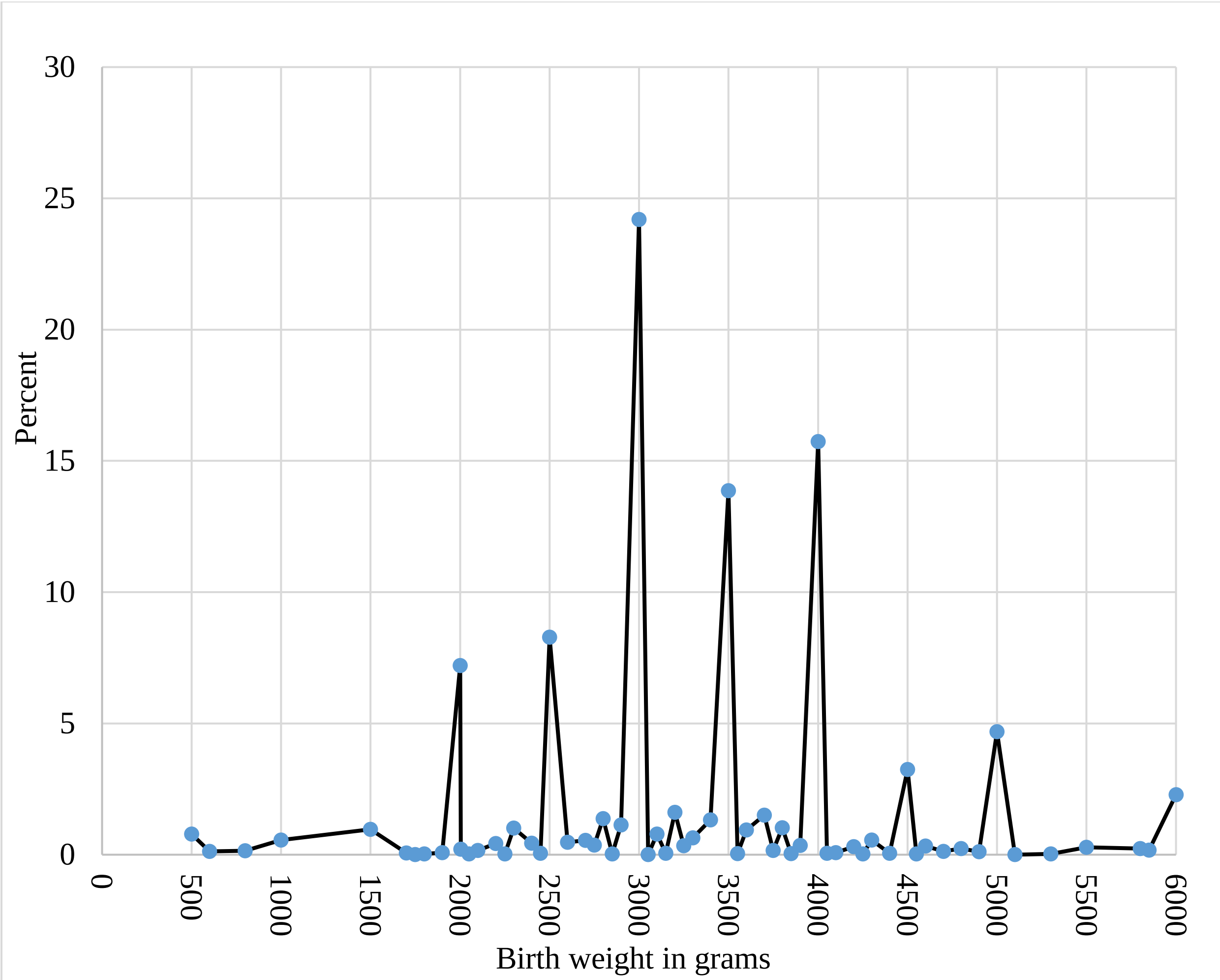

Figure 2: Percentage distribution of birth weight data showing digit preference to multiple of 500g, EDHS 2016

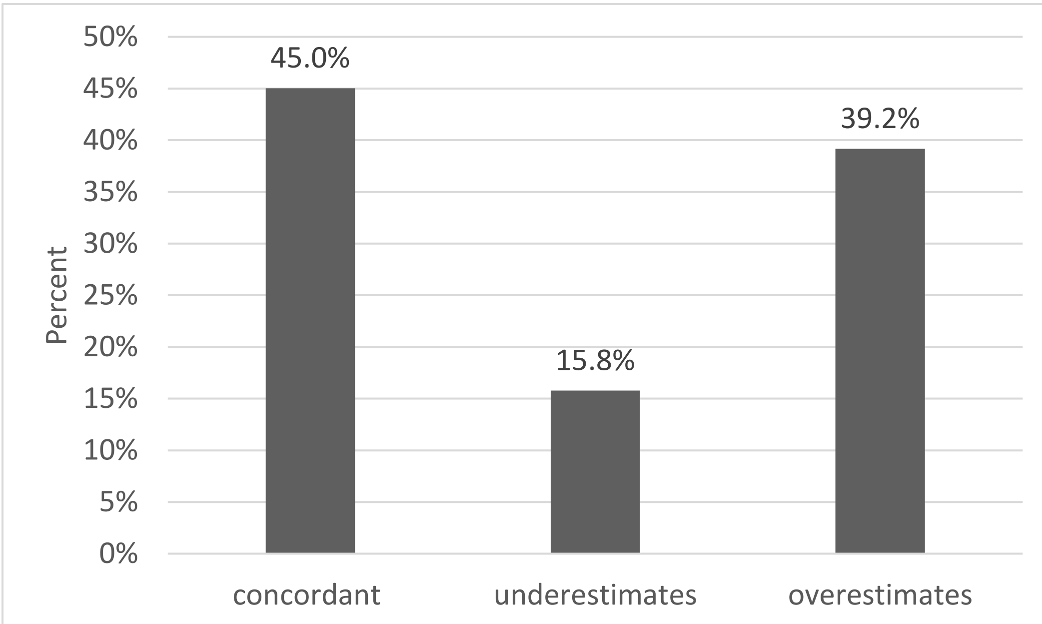

Figure 3: Percentage distribution of agreement between birthweight and maternal assessment of baby birth size, EDHS, 2016

Supplementary table 1**: STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of cross-sectional studies**

Title of the study: Predictive Accuracy of Perceived Baby Birth Size for Birth Weight: A Cross-sectional Study from the 2016 Ethiopian Demographic and Health Survey

Section/Topic	**Item #**	**Recommendation**	**Reported on page #**
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5

Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	5-6
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible,	8

		examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-10
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	10-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14
		(*b*) Report category boundaries when continuous variables were categorized	9-10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	16

Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	N/A

N/A, not applicable

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Supplementary table 2: Mean birth weight by mother's perceived baby size at birth, EDHS 2016.

Mother's perceived baby size at birth	Mean	SE	95%CI
Very large	4057.75	84.34	3891.98, 4223.52
Larger than average	3552.69	64.86	3425.20, 3680.19
Average	3111.33	35.07	3042.40, 3180.26
Smaller than average	2560.58	80.97	2401.42, 2719.73
Very small	2423.47	102.40	2222.20, 2624.74

SE standard error, CI confidence interval

Supplementary table 3: The agreement between birth size and birth weight both at aggregate level and across five categories level using Kappa statistics.

Variables considered	Agreement	Expected agreement	Kappa coefficient	z	P-value
Birth weight versus Birth size*	86.24%	76.64%	0.41	19.13	<0.001
Birth weight versus Birth size**	46.03%	36.40%	0.15	15.13	<0.001

* Birth weight is aggregated as low birth weight (<2500g) or normal birth weight (≥2500g) and the birth size also reduced from five categories to binary categories (small size or normal size)

** Both birth weight and birth size were compared across five categories (very large, larger than average, average, smaller than average or very smaller)