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DETERMINANTS OF LOW BIRTH WEIGHT: COMPARISON BETWEEN PERCEPTION AND RECORDS USING THE INDONESIAN DEMOGRAPHIC HEALTH SURVEY DATA

Ahmad Ridoi Yuda Prayogi[1], *Susy Katikana Sebayang[1,2], Mu Li[3]

[1]Faculty of Health, Medicine and Life Sciences, Universitas Airlangga, 68425 Banyuwangi, East Java, Indonesia
[2]Research Group for Health and Wellbeing of Women and Children, 68425 Banyuwangi, East Java, Indonesia
[3]Sydney School of Public Health, University of Sydney, Camperdown, New South Wales 2050 Sydney, Australia
***Corresponding Author**: Susy Katikana Sebayang ; **Email**: sksebayang@fkm.unair.ac.id

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ABSTRACT

Measuring birth weight in low resource settings is problematic. Mothers' perception of newborn's size is often used as a proxy. This study examines the correlation between weight measured at birth and the mother's perception of her child's size and compare the determinants of low birth weight (LBW) and small birth size using both measures. This study analyzed the 2017 Indonesian Demographic and Health Survey data and examined the list of determinants associated with birth weight. There was a strong correlation between newborn's weight measured at birth and mother's perception of birth size and a high agreement between LBW and perceived small birth size. Both measures, birth order was a significant child factor, and the number of antenatal care (ANC) visits was an important ANC factor. Maternal education was a significant socioeconomic determinant of LBW, while household wealth and improved household latrine were significant determinants of perceived birth size. Mother's perception of birth size can be used as a proxy measurement for a child's birth weight for programmatic purposes in low resource settings where birth weight was difficult to measure.

Keywords:
Birth size,
Low Birth Weight,
Child health,
Low resource setting

ABSTRAK

Mengukur berat lahir di wilayah dengan sumber daya terbatas sulit dilakukan. Persepsi ibu mengenai ukuran bayi baru lahir sering digunakan sebagai proksi. Studi ini bertujuan menilai korelasi antara berat lahir bayi hasil penimbangan dengan persepsi ibu terhadap ukuran bayinya dan membandingkan antara determinan berat badan lahir rendah (BBLR) dan determinan persepsi ukuran lahir kecil dengan menggunakan kedua ukuran tersebut. Studi ini menganalisis data Survei Demografi dan Kesehatan Indonesia 2017dan mengkaji determinan berat lahir. Ada korelasi yang kuat antara berat lahir hasil penimbangan dan persepsi ibu tentang ukuran bayi saat lahir, dan terdapat kesesuaian yang tinggi antara BBLR dengan persepsi ukuran bayi lahir kecil. Urutan kelahiran merupakan faktor anak yang signifikan, dan jumlah kunjungan pemeriksaan kehamilan merupakan faktor layanan antenatal yang penting bagi kedua ukuran tersebut. Pendidikan ibu merupakan faktor penentu sosial ekonomi BBLR, sedangkan status ekonomi rumah tangga dan kualitas jamban rumah tangga merupakan faktor penentu ukuran kelahiran. Persepsi ibu mengenai ukuran bayi lahir dapat digunakan sebagai proksi pengukuran berat lahir anak untuk digunakan dalam program kesehatan di wilayah dengan sumber daya rendah di mana berat badan lahir sulit diukur.

***Kata Kunci**:*
Ukuran lahir,
Berat Lahir Rendah,
Kesehatan Anak,
Wilayah dengan sumber daya rendah

INTRODUCTION

Globally, 19.8 million babies were born with low birthweight in 2020, or 14.7% of all babies born worldwide in that year (1). The prevalence of low birth weight in 2020 was lower than in 2019 (454.6 million infants, or 10% of all babies) in Indonesia, with 449.6 million infants or about 9.9% of all infants experiencing low birth weight (2). Another report shows that 12.54% of women aged 15-49 who gave birth in the previous two years delivered LBW babies (3). The prevalence of LBW in Indonesia is among the highest in South-East Asian countries, following the Philippines 15% (4), Myanmar (2) and Timor Leste (18.2%) (2).

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Low birth weight babies are at a greater risk for childhood morbidity and mortality than babies born with normal birth weight (5). Additionally, LBW is a factor in the sequelae of stunting (6); LBW babies are 1.2 times more likely to experience stunted development (7). The high prevalence of stunting, 28% in 2019, may be one of the consequences of LBW in Indonesia (8). Recent studies have indicated that LBW also elevates the risk of non communicable diseases such as diabetes and cardiovascular diseases in adulthood (9,10). The target set by the World Health Organisation for a 30% reduction of LBW by 2025 (11) is still relevant in many low and middle income countries (LMICs), including Indonesia.

Newborns whose mothers live in urban areas or close to health facilities and higher education levels are more likely to be weighted. This may be because these mothers have better knowledge about fulfilling the nutritional needs of their pregnancy (12). However, weighing newborns at birth is more challenging in rural settings. A study in India found that many women (58%) gave birth at home, and the newborns were not weighted (13). Another study in Ethiopia reported that only 5% of children were weighed at birth (14). Mothers in rural area perceive her child's birth size and physical descriptor as "weighs very light", "weighs like a bird or doll", "weak", "looks normal or big", have often been used as descriptors for baby's weight (15). Research in developing countries has also often used a mother's perception of birth size as an indicator. However, there are some concerns for the determination of LBW from the mother's perception of her newborn's size (16). A study in Nepal, for example, reported that the sensitivity of a mother's perception of LBW was 75% (17).

If a mother's perceived size of her newborn is an acceptable measure to identify LBW its determinants remain a relevant research question, especially for programmatic purposes in LMICs. The high health facility birth rate in Indonesia and the availability of the latest 2017 Indonesian Demographic and Health Survey (IDHS) allow for exploring the correlation between LBW based on a mother's perception of her child's size at birth and the measured birth weight. This study aims to assess this correlation and compare the determinants of measured LBW and mother perceived small birth size, using the 2017 IDHS data. The findings will shed some light on the usefulness and validity of a mother's perception of birth size as a proxy for determining LBW in settings where health facility delivery or weighing the newborn at birth are not yet possible.

METHODS

Data source

This study used deidentified IDHS 2017 dataset for the secondary data analysis. Thus ethics approval is not required. Details of sampling and data collection method are available from the IDHS country report at DHS website (www.dhsprogram.com). The analysis included data from women age 15-49 years who had the last-born singleton child born in the five years before the survey in the analysis. Data from 12,323 children were available for analysis.

Main outcomes and determinants

The main outcomes of the study were mother's perception of birth size and birth weight. Mother's perception of birth size was categorized into small size, which included very small and smaller than average, and normal size, which included average, larger than average, and very large. Birth weight data was a combination of information taken from official health records if available and from mother's recall, if the health records were not available. Birth weight was categorized into normal weight or above (≥ 2,500 grams) and Low Birth Weight (<2,500 grams).

This study examined a range of previously reported determinants associated with birth weight and perceived birth size (18,19). Child factors included sex and birth order. Maternal health history included history of miscarriage, abortion, or stillbirth. Social and economic status included mother's education level, father's education, household wealth (measured from ownership of household assets), source of drinking water (improved sources included piped into dwelling, piped to yard or plot, public tap or standpipe, piped - public tap or standpipe, tube well or borehole, protected well, rainwater, tanker truck, cart with small tank, and bottled water), sanitary latrines ownership (improved latrines includes flush to a septic tank, flush without septic tank, shared

or public flush toilet, and ventilated improved pit latrine), and source of indoor smoke.

Access to media information included access to the radio, television, the internet, and magazine. Demographic factors included residence, mother's age, the age difference between father and mother, and distance to health services (a problem or not a problem). Utilization of health care services included number of ANC visits, the timing of the first antenatal check, and quality of ANC (0- 5 types, 6-7 types, and> 7 types of services). ANC quality was calculated by adding the total number of ANC health services (height, weight, and blood pressure measurement, urine and blood test, abdominal exam, tetanus injection, and received or bought iron supplements) a woman received during pregnancy.

Statistical Analysis

The correlation between birth weight and five categories of mothers' perceived birth size (very small, smaller than average, average, larger than average, and very large) was assessed using Spearman Correlation Test. Agreement between the measured LBW (< 2500 grams) and small birth size was tested using Gwet's AC_1 to anticipate a high agreement and a low kappa paradox that may occur as most of the observations fall into the category of normal birth weight or normal birth size. This study used logistic regression to determine the relationship between LBW and it's determining factors. Covariates with p-value of <0.25 in univariable analyses were included in the initial multivariable models. Using the backward elimination method, only factors with p-values of <0.05 were retained in the final model. Analyses was performed using the Statistical Software for Data Science (STATA 14) and Survey (SVY) command to adjust for the complex sampling design.

RESULTS

Characteristics of samples

The total sample was 12,323, 51.4% of which were boys, and one-third of children were the second child of the family (33.8%). The sample spread evenly between urban and rural residences; most children's mothers and fathers completed secondary education. A high proportion of households had access to television (84.9%). More than 90% of the children were from families with improved sanitation (91.4%), over 60% were exposed to indoor cigarette smoking. (Table 1).

Correlation between measured birth weight and mothers' perceived birth size

There was a strong correlation between measured birth weight and mothers' perceived birth size (Spearman's rho=0.67; p < 0.0001). The correlation was similar by respondents' characteristics but slightly lower in mothers from households with indoor pollution from kitchen smoke (Spearman's rho=0.61; p<0.0001) and women who never accessed television (Spearman's rho=0.61; p<0.0001) (Table 1). Six percent of newborns were classified as LBW by birth weight, while 12% of infants were categorized as small size at birth using mothers' perceived birth size. The agreement between the two measures was 91.3% (95%CI: 0.91 - 0.92, p= 0.003) with the Gwet's AC_1 coefficient of 0.90 (0.89- 0.90, p= 0.003).

Table 1. Characteristics of samples

Characteristics	Weighted N	Weighted Percentage
Birth Weight (grams)		
Normal weight	11,529	93,6%
Low Birth Weight (<2,500)	794	6,4%
Perceived Birth Size		
Normal Size (average, larger than average, very large)	10,796	87,6%
Small size (very small, smaller than average)	1,527	12,4%
Baby Factors		
Gender		
Male	6,337	51,4%
Female	5,986	48,6%

Characteristics	Weighted N	Weighted Percentage
Birth Order		
3+	4,338	35,2%
Second child	4,165	33,8%
First child	3,820	31%
Maternal Health History		
Never Had any	11,340	92,%
Had any	983	8%
Social and Economy		
Mother's educational		
Higher education	2,275	18,5%
Secondary education	7,139	57,9%
Primary education	2,909	23,6%
Father's educational		
Higher education	1,941	15,8%
Secondary education	7,211	58,5%
Primary education	3,171	25,7%
Wealth index		
High economy	4,656	37,8%
Medium economy	2,465	20,%
Low economy	5,202	42,2%
Source of drinking water		
Improved	6,391	51,9%
Unimproved	5,932	48,1%
Sanitary latrines ownership		
Improved	11,268	91,4%
Unimproved	1,055	8,6%
Smoke Source		
Not both	2,412	19,6%
kitchen smoke	318	2,6%
Cigarette smoke	7,499	60,8%
Both	2,094	17,%
Acces to media Information		
Access to Media Radio		
Often	1,393	11,3%
Rarely	3,663	29,7%
Never	7,267	59%
Access to Media Television		
Often	10,463	84,9%
Rarely	1,404	11,4%
Never	456	3,7%
Access to Media Internet		
Often	3,842	31,2%
Rarely	1,669	13,5%
Never	6,812	55,3%

Characteristics	Weighted N	Weighted Percentage
Access to Media Magazine		
Often	1,249	10,1%
Rarely	4,196	34,1%
Never	6,878	55,8%
Factor Demography		
Residence		
Urban	6,365	51,7%
Rural	5,958	48,3%
Mother's age		
15-19	272	2,2%
20-24	1,886	15,3%
25-29	3,111	25,3%
30-34	3,262	26,5%
35-39	2,494	20,2%
> 40	1,298	10,5%
Father and mother age difference		
0-4 years	7,346	59,6%
5-7 years	2,604	21,1%
> 7 years	2,373	19,3%
Distance to health services		
Not a problem	11,042	89,6%
A problem	1,281	10,4%
History of Antenatal Care (ANC)		
Number of ANC visits		
4+	11,458	93%
Less than 4	865	7%
First ANC visit		
<4 months	10,246	83,2%
4+ months	2,077	16,8%
Quality of ANC		
> 7 services	4,808	39%
6-7 services	5,724	46,5%
0-5 services	1,791	14,5%

Source: Secondary Data Indonesian Demographic and Health Survey 2017

Determinants of Low birth weight

Univariable analysis on birth weight showed that the first-born children were 14% more likely of being born LBW than the third and later children (AOR = 1.14, 95% CI 0.92, 1.41, p = 0.24) (Table 2). Other significant determinants of LBW in the univariate analysis were mother and father's education level, household wealth, ownership of sanitary latrines, type of indoor smoke sources, access to media information (television and internet), distance to health services, and the number of ANC visits (Table 2).

Significant determinants of LBW after multivariate analysis were birth order, mother's education, and the number of ANC visits. The first children were 32% more likely to be LBW than the third and later children (AOR = 1.32, 95% CI [1.06, 1.63], p = 0.01) (Table 2). The

higher the education level, the less likely a mother would give birth to LBW children. Mothers with only primary education had a 79% likelihood of giving birth to a LBW child compared to mothers with higher education levels (AOR = 1.79.95% CI [1.34, 2.40], p <0.0001) (Table 2). Mothers who had less than four ANC visits in their last pregnancy had twice the likelihood of giving birth to LBW children compared to mothers who had four or more ANC visits (AOR = 2.02, 95% CI [1.49, 2.73], p <0.0001) (Table 2).

Table 2. Determinants of Low Birth Weight (N=12,323)

Factor	Univariable				Multivariable			
	OR	**95% CI**	**p value**	**F test**	**OR**	**95% CI**	**p value**	**F test**
Baby Factors								
Gender								
Male	Ref			0.33				
Female	1.09	0.91 - 1.32	0.34					
Birth Order								
3+	Ref			0.0004	Ref			0.0001
Second child	0.73	0.58 - 0.91	0.01		0.80	0.64 - 1.00	0.05	
First child	1.14	0.92 - 1.41	0.24		1.32	1.06 - 1.63	0.01	
Maternal Health History								
History Miscarriage, Abortion of Stillbirth								
Never	Ref			0.84				
Had any	1.03	0.74 - 1.44	0.84					
Social and Economy								
Mother's education								
Higher	Ref			<0.0001	Ref			<0.0001
Secondary	1.18	0.54 - 0.82	<0.0001		1.16	0.89 - 1.51	0.26	
Primary	1.78	0.42 - 0.75	<0.0001		1.79	1.34 - 2.40	<0.0001	
Father's education								
Higher	Ref			0.0002				
Secondary	1.51	1.12 - 2.04	0.01					
Primary	1.91	1.40 - 2.61	<0.0001					
Household Wealth								
High	Ref			0.002				
Medium	1.19	0.93 - 1.52	0.16					
Low	1.45	1.18 - 1.78	<0.0001					
Source of drinking water								
Improved	Ref			0.78				
Unimproved	1.03	0.86 - 1.23	0.78					
Sanitary latrines ownership								
Improved	Ref			0.001				
Unimproved	1.54	1.20 - 1.97	0.001					
Smoke Source								
Not both	Ref			0.03				
Kitchen smoke	1.15	0.65 - 2.04	0.62					
Cigarette smoke	1.23	0.98 - 1.56	0.08					
Both	1.55	1.16 - 2.07	0.003					
Acces to media Information								
Access to Media Radio								
Often	Ref			0.43				

Factor	Univariable				Multivariable			
	OR	95% CI	p value	F test	OR	95% CI	p value	F test
Rarely	0.89	0.65 - 1.22	0.47					
Never	1.02	0.76 - 1.37	0.88					
Access to Media Television								
Often	Ref			0.03				
Rarely	1.35	1.04 - 1.75	0.02					
Never	1.45	0.91 - 2.33	0.12					
Access to Media Intern								
Often	Ref			0.03				
Rarely	1.13	0.83 - 1.54	0.44					
Never	1.32	1.07 - 1.62	0.01					
Access to Media Magazine								
Often	Ref			0.08				
Rarely	1.18	0.83 - 1.68	0.35					
Never	1.38	0.99 - 1.92	0.06					
Factor Demography								
Residence								
Urban	Ref			0.67				
Rural	1.04	0.87 - 1.23	0.67					
Mother's age								
15-19	Ref			0.69				
20-24	1.02	0.55 - 1.91	0.94					
25-29	0.97	0.52 - 1.82	0.93					
30-34	0.88	0.47 - 1.65	0.70					
35-39	1.05	0.56 - 1.95	0.89					
> 40	1.14	0.59 - 2.20	0.70					
Father and mother age difference								
0-4 years	Ref			0.13				
5-7 years	0.84	0.66 - 1.07	0.15					
> 7 years	1.12	0.89 - 1.41	0.32					
Distance to health services								
Not a problem	Ref			0.02				
A problem	1.41	1.05 - 1.88	0.02					
History of Antenatal Care (ANC)								
Number of ANC visits								
4+	Ref			<0.0001	Ref			<0.0001
Less than 4	2.14	1.58 - 2.88	<0.0001		2.02	1.49 - 2.73	<0.0001	
First ANC visit								
<4 months	Ref			0.09				
4+ months	1.23	0.97 - 1.55	0.09					
Quality of ANC								
> 7 service	Ref			0.79				
6-7 service	1.05	0.83 - 1.42	0.56					
0-5 service	0.97	0.78 - 1.36	0.85					

Source: Secondary Data Indonesian Demographic and Health Survey 2017

Determinants of small birth size

Univariable analysis showed several significant determinants of babies born small size perceived by the mothers, including birth order, mother and father's education level, household wealth, ownership of sanitary latrines, types of sources of smoke in households, access to internet media, distance to health service, the number of ANC visits and the timing of the first ANC visits (Table 3).

The significant determinants of small birth size babies identified from the multivariable analysis were similar to those found for LBW. Birth order and the number of ANC visits were substantial determinants for small birth size babies. Household wealth and ownership of sanitary latrines were significant socioeconomic determinants of babies born small size. The first born had a 10% greater likelihood of being in a small birth size (AOR=1.10, 95% CI [0.94-1.29], p=0.24) than the third and later child. Babies who were born to low economy households had a 32% greater likelihood of being small birth size (AOR = 1.32, 95%CI [1.13-1.55], p<0.0001) than high economy households. Similarly, women of households with unimproved sanitary latrines had a 31% greater likelihood of giving birth to small birth size children (AOR=1.31, 95%CI [1.04-1.67], p=0.03) compared to those with improved latrines. Mothers who had less than four ANC visits during her last pregnancy had a 47% greater likelihood of giving birth to small babies compared to mothers who had four or more visits (AOR = 1.47, 95% CI [1.16, 1.85], p = 0.001) (Table 3).

DISCUSSION

The study showed a strong correlation and high agreement between measured (recorded/recalled) birth weight and mothers' perception of birth size. Although using perceived birth size resulted in more newborns classified as small size at birth, the multivariable analysis revealed that the determinants of measured LBW and perceived small birth size were very similar. Birth order was a significant child factor, and the number of ANC visits was a significant factor of utilization of health care services for both measures. However, maternal education was a critical socioeconomic determinant for LBW, while household wealth and improved latrine in households were significant socioeconomic determinants for perceived small birth size.

Similarly, research from Zanzibar reported that in the absence of birth weight data, maternal recall of birth size was relatively a good proxy for birth weight (20). However, a recent study in Ethiopia reported that maternal perception of birth size was not an accurate proxy for birth weight (21). Bangladesh data shows that recall of birth size has a low sensitivity and positive predictive value but a high specificity and negative predictive value for predicting LBW (22). Other studies from both developed and developing countries using either birth weight or perceived birth size also reportedly shared similar determinants for small babies. These included birth order (18,23), the number of ANC visits (24,25), maternal education and household wealth (19).

The strength of this study is that a large nationally representative data was used. However, the birth weight data were either recorded or recalled, thus we could not assess the sensitivity and specificity of the data against a gold standard measure.

Although mothers were often asked to estimate the size of their babies at birth, their ability to assess it correctly depends on their experience seeing other babies in their environment. This could be one explanation for the lower association between birth weight and perceived birth size in those with limited access to information and lower social-economic status. A study in Bangladesh showed that overestimation of child size is more common among adolescent mothers and mothers with low education and low exposure to media (22). LBW and perceived small birth size shared similar determinants, suggesting similar underlying biological and social factors. Apart from this cognitive bias, socio-cultural and emotional stress may also affect mother's perception of birth size.

Although the maternal recall of birth weight could be accurate (17,21), it can also be problematic. Accurate birth weight measurement is difficult to obtain in low resource settings where the health service cannot reach most of the population and where family economic situation prevents mothers from giving birth in health facilities. Birth weight measurement heaping to the nearest 500

grams is common in developed and developing countries (26,27). Government should continue to improve maternal health care coverage and support accurate measurement of birth weight, including providing calibrated equipment and training staff. Meanwhile, perceived birth size is valuable in maternal and child health planning and programming in settings with limited resources.

Table 3. Determinants of Perceived Small Birth Size (N=12.323)

Factor	Univariable				Multivariable			
	OR	**95% CI**	**p value**	**F test**	**OR**	**95% CI**	**p value**	**F test**
Baby Factors								
Gender								
Male	Ref			0.08				
Female	1.13	0.99 - 1.28	0.08					
Birth Order								
3+	Ref			0.002	Ref			0.003
Second child	0.82	0.70 - 0.97	0.02		0.84	0.72 - 0.99	0.04	
First child	1.08	0.92 - 1.26	0.33		1.10	0.94 - 1.29	0.24	
Maternal Health History								
History Miscarriage, Abortion of Stillbirth								
Never	Ref			0.45				
Had any	0.91	0.71 - 1.16	0.45					
Social and Economy								
Mother's educational								
Higher	Ref			0.0002				
Secondary	1.25	1.03 - 1.51	0.02					
Primary	1.54	1.25 - 1.90	<0.0001					
Father's educational								
Higher	Ref			0.001				
Secondary	1.20	0.98 - 1.46	0.07					
Primary	1.47	1.19 - 1.82	<0.0001					
Household Wealth								
High	Ref			<0.0001	Ref			0.001
Medium	1.29	1.08 - 1.54	0.005		1.25	1.05 - 1.49	0.01	
Low	1.44	1.24 - 1.66	<0.0001		1.32	1.13 - 1.55	<0.0001	
Source of drinking water								
Improved	Ref			0.63				
Unimproved	1.03	0.90 - 1.18	0.63					
Sanitary latrines ownership								
Improved	Ref			0.0002	Ref			0.025
Unimproved	1.52	1.22 - 1.90	<0.0001		1.31	1.04 - 1.67	0.03	
Smoke Source								
Not both	Ref			0.007				
Kitchen smoke	1.25	0.79 - 1.98	0.34					
Cigarette smoke	1.29	1.09 - 1.53	0.003					
Both	1.44	1.15 - 1.79	0.001					
Acces to media Information								
Access to Media Radio								
Often	Ref			0.79				
Rarely	1.05	0.83 - 1.33	0.67					
Never	1.08	0.87 - 1.33	0.50					
Access to Media Television								
Often	Ref			0.46				
Rarely	1.14	0.92 - 1.41	0.24					
Never	1.10	0.74 - 1.64	0.63					

Access to Media Internet								
Often	Ref			0.002				
Rarely	1.05	0.84 - 1.31	0.67					
Never	1.28	1.11 - 1.48	0.001					
Access to Media Magazine								
Often	Ref			0.54				
Rarely	1.03	0.81 - 1.31	0.80					
Never	1.10	0.88 - 1.39	0.40					
Factor Demography								
Residence								
Urban	Ref			0.54				
Rural	1.04	0.91 - 1.19	0.54					
Mother's age								
15-19	Ref			0.98				
20-24	1.09	0.67 - 1.77	0.73					
25-29	1.06	0.65 - 1.71	0.82					
30-34	1.03	0.64 - 1.67	0.89					
35-39	1.05	0.65 - 1.71	0.84					
> 40	1.13	0.69 - 1.84	0.64					
Father and mother age difference								
0-4 years	Ref			0.81				
5-7 years	0.97	0.83 - 1.14	0.70					
> 7 years	1.04	0.87 - 1.23	0.68					
Distance to health services								
Not a problem	Ref			0.03				
A problem	1.27	1.02 - 1.57	0.03					
History of Antenatal Care (ANC)								
Number of ANC visits								
4+	Ref			0.0001	Ref			0.001
Less than 4	1.61	1.28 - 2.03	<0.0001		1.47	1.16 - 1.85	0.001	
First ANC visit								
<4 months	Ref			0.01				
4+ months	1.24	1.04 - 1.47	0.01					
Quality of ANC								
> 7 service	Ref			0.16				
6-7 service	1.15	0.99 - 1.33	0.07					
0-5 service	1.16	0.94 - 1.43	0.18					

Source: Secondary Data Indonesian Demographic and Health Survey 2017

CONCLUSIONS AND SUGGESTIONS

Conclusion

Measured birth weight and mothers' perceived birth size were correlated. Additionally, LBW and small birth size shared similar determinants. Thus, maternal perception of small birth size can be a proxy for detecting LBW in low resource settings.

Suggestions

Government can use perceived birth size as a proxy in low resource settings to find clusters in their population of possible LBW and design evidence-based programs for LBW reduction. However, more funding should be invested to develop innovation for simple and accurate measurement of birth weight.

This study findings suggest the government programs of reducing LBW in Indonesia should focus on the primiparous mothers, mothers of poor household, low education, and mothers who might find it challenging to visit ANC.

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AUTHOR CONTRIBUTIONS

ARYP helped design the study, conducted data cleaning and analysis and drafted the manuscript; SKS designed the study, supervised the analysis, and reviewed and edited the manuscript; ML helped design the study and reviewed and edited the manuscript.

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