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ORIGINAL ARTICLE

MAGNITUDE AND CORRELATES OF VERY LOW BIRTH WEIGHT NEWBORNS IN INDIA: INSIGHTS FROM NATIONAL FAMILY HEALTH SURVEY 2019-2021

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ABSTRACT

Background. Estimate of very low birth weight (VLBW) and low birth weight (LBW) newborns is a key maternal and child health indicator. It is often associated with higher child mortality in low-middle-income countries (LMICs), which account for 95% of the global LBW babies born annually.

Objective. This analysis aims to ascertain the occurrence and determinants of VLBW newborns in India.

Material and Methods. Data was taken from the 5th National Family Health Survey (2019-2021), which included 91,821 women aged 15-49 with a singleton pregnancy in last year, having recorded child birth weight. Information from 727 Indian districts was collected through cross-sectional design using census blocks/villages, for socio-demographic, antenatal, and reproductive variables from adult women in each household. Maternal socio-demographic, and reproductive factors were analyzed for association with VLBW birth using Chi-square tests and multivariate logistic regression using STATA 16 software.

Results. The occurrence rate of LBW babies has been 17.4% in present analysis, within which VLBW newborn constituted 1.1% – representing 6.3% of all LBW births. Key predictors for VLBW babies included maternal factors like illiteracy, anemia, underweight, prenatal tobacco use, lack of antenatal care, low economic status, high parity, female babies, and alcohol consumption during pregnancy. However, illiteracy, anemia, underweight, and prenatal tobacco use emerged as significant risks for occurrence VLBW births.

Conclusions. Most of the socio-demographic and prenatal maternal predictors for VLBW babies are amenable to reformation within existing social frame. This merits attention towards social application of preventive strategies comprehensively at grass-root level to modify the preventable risks of birth of LBW babies. There is nothing more self-explanatory and decisive than the role played by health-workers in improving antenatal care in urban slums and rural areas to reduce LBW/VLBW estimates in India.

Keywords: *India, antenatal care, very low birth weight, low birth weight, maternal-child health*

INTRODUCTION

The Global Nutritional Target (2014) proclaimed a 30% decrease in low birth weight (LBW) newborns between 2012 and 2030; however, the outcome has not been promising so far due to inadequate progress over the past two decades [1]. It is imperative to invest in primary prevention throughout the lifespan of women, especially for adolescent girls and females of child-bearing age group in the affected low-middle-income countries (LMIC) to accelerate the progress undoubtedly. The growing number of deliveries in the health-care settings and institutions in the recent years with relentless advances in the modern electronic health data communication technology generally resulted in improved quality, superiority and availability of information on LBW babies thus guiding research scholars to the reality.

LBW has been illustrated as the birth weight of a newborn less than 2500 g i.e. 2499 g or less, measured within one hour of delivery, and it continues to be one of the significant global health problems, undeniably remain as a major health burden in India [2]. Very low birth weight (VLBW) and extremely low birth weight (ELBW) babies are sub-groups of LBW neonates with birth weight less than 1500 g (1499 g or less) and less than 1000 g (999 g or less) respectively; are potentially high-risk groups with significantly high mortality and morbidity [2]. LBW is generally due to preterm delivery (short gestation less than 37 weeks), intrauterine growth restriction (IUGR), or both in the single-ton pregnancy. Advances in critical neonatal

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care, progressive management and treatment spectrum in neonatal illnesses, and easy availability of the services at the community level over the recent years, enhanced the chance of survival of both LBW and VLBW babies all over the world. However, the LBW babies are often fraught with neonatal complications like respiratory distress, septicaemia, and recurrent infective spells resulting in repeated hospitalisations with chance of development of neuro-developmental disorders like intellectual, emotional and learning disabilities along with many chronic ailments in later life viz. hypertension, dyslipidaemia and insulin resistance precipitating cardiovascular, metabolic and renal diseases in the adulthood.

Overall, the domain of LBW and its constituent subsets viz. VLBW and ELBW comprise an arduous social burden for the indigent group in LMICs culminating in compulsive financial outlay and excessive out of the pocket expenditure not merely in repeated hospitalisation but definitely in procuring improved techniques of raising these children with good nutrition, sanitation, healthy and disease free life. Low birth weight is a critical community health indicator that provides incisive analytics into several counts related to mother and child health, nutrition, healthcare delivery, and poverty [2]. It is a significant indicator for estimating the neonatal survival trend and overall health of the newborns. [3] As the birth weight of the newborn is strongly linked with the mothers' general health and nutritional status, therefore, it closely reflects the collective health status of the communities in which these children are born.

Rationale of the work validates that studying VLBW newborns is essential for improving neonatal survival, reducing healthcare costs, addressing health disparities, and safeguarding healthier long-term outcomes with quality of life for individuals and communities. It may help notify public health policymakers possibly culminating in better maternal and child health strategies locally, regionally and nationally. Early attention to cognitive impairments, developmental delays, and anticipated chronic ailments like cardiovascular, metabolic, and renal diseases among VLBW babies can help shape lifelong well-being and reduce health burden. In-depth contemplation of maternal nutrition, prenatal care, gestational lifestyle modification, and infection control may assist in preventing VLBW births and therefore, need exploration to uncover newer strategies for preventive health campaigns.

The novelty of this intent is attributed to the fact that India has a comparatively reasonable occurrence of VLBW neonates; therefore, a national appraisal of the issue is intended to underscore the significance. To date, there are not many studies available on this topic in the Indian context; therefore, attention is needed to bring out the reality to highlight the preventative strategies. Since the NFHS-5 dataset is rich and nationally representative, it would offer robust and significant opportunities for inferential analytics and geo-social insights. A composite index for quality of prenatal care using variables like number of antenatal visits, IFA (iron and folic acid) consumption, tetanus immunization, mode of delivery, and gestational complications would be a guiding link to the VLBW rates to help discern the most influential of the multiple predictors. Changes in VLBW occurrence from NFHS-4 to NFHS-5 would provide a real-time disclosure of the current state to justify the multitude of social efforts being dispensed by the national government in India. Socio-economic intersectionality due to education, economic status, and caste/tribe is likely to offer an 'Inequality Concentration Index' justifying the merit of future attention in social dimensions. The environmental health reflects in the perspective of socio-economic-literacy state may provide insight relating to availability of water-hygiene-sanitation in the context of VLBW, marking the possible need for prospective improvement.

Aim of this cross-sectional observational study is to ascertain the occurrence of VLBW babies by analysing the recent data of the 5th National Family Health Survey, India (2019-2021) along with its magnitudes and correlates in the context of consistent governmental efforts to elevate the nutritional status of women in the child-bearing age group to enhance the gestational outcome.

MATERIAL AND METHODS

Framework

The study was planned by the incumbent during March 2025 and the baseline data was acquired from the 5th National Family Health Survey report (NFHS-5), 2019-2021 published by MOHFW, GOI including comprehensive socio-demographic and economic attributes of the diversified national communities at the basic grass-root level. The NFHS-5 data acquisition was carried out in two phases. Phase-I covered 17 states and 5 Union Territories (UTs); and was completed by the NFHS team from June 2019 to January 2020. This was followed by Phase-II, which encompassed 11 states and 3 UTs, and was conducted from January 2020 to April 2021 [4, 5].

Study setting and design

This study utilized data from the National Family Health Survey (NFHS-5), conducted across India covering all 28 states and 8 Union Territories (UTs), comprising 727 districts. The survey adopted a cross-sectional design with data collection using a pretested, structured instrument administered to adult women in each selected household. The sampling strategy followed the 2011 Census framework, with Primary Sampling Units (PSUs) defined as Census Enumeration Blocks (CEBs) in urban, semi-urban and rural areas. A two-stage stratified sampling approach was used, ensuring adequate representation across regions. To ensure sufficient sample size, PSUs with fewer than 40 households were merged with adjacent units. The Probability Proportional to Size (PPS) method guided the selection of PSUs to minimize sampling errors.

Blueprint of selection

To facilitate the easy identification of rural houses or units during subsequent phases of the survey, household mapping and listing were conducted before the census based on prominent local landmarks. To select Primary Sampling Units (PSUs) or villages, systematic random sampling was employed, including probability proportional to size (PPS) technique. The second phase included a random selection of 22 households from each PSU or village. The National Report (2021) of the NFHS-5 provides detailed and comprehensive explanations of the sampling technique, PPS calculations, and methods to minimize sampling errors. In the present analysis, 91,821 women aged 15-59 years were included. A schematic illustration of the blueprint for sample selection is presented in Figure 1.

Inclusion benchmark:

- Only children born within the last 12 months were included in order to avoid changes in maternal characteristics over time.
- Only children delivered in institutions and health facilities with birth record cards were taken into consideration in order to eliminate inaccurate birth weight measurements made at home.
- Only singleton neonates were considered because twins or triplets may affect birth weight.

Sampling technique

A two-stage stratified sampling technique was employed to select primary sampling units (PSUs), comprising villages in rural areas and census enumeration blocks (CEBs) in urban areas. Data collection for NFHS-5 was carried out by trained personnel using a comprehensive, pretested, and structured questionnaire, following the acquisition of written informed consent from all respondents. At every stage of data collection, stringent measures were taken to ensure the confidentiality of participant information. A detailed description of the sampling framework, household selection criteria, and data collection methodology is available in the published NFHS-5 report [4].

Study procedure

176,843 (24.4%) of the 724,115 women who participated in the survey reported that they had recently given birth in the 12 months preceding the health survey. Among them, 155,624 (21.5%) had delivered in hospitals or health care facilities. Of these, 154,147 (21.1%) had singleton deliveries. However, only 91,821 women (12.7%) were able to present a Hospital Birth Report Card that included a recorded birth weight, and these women were included in the final analysis for the study.

A total of 547,272 (75.5%) women with a history of childbirth in the distant past (beyond the last 12 months) were excluded, of whom 21,219 (2.9%) had home deliveries, 1477 (0.2%) had twins, 2714 (1.76%)

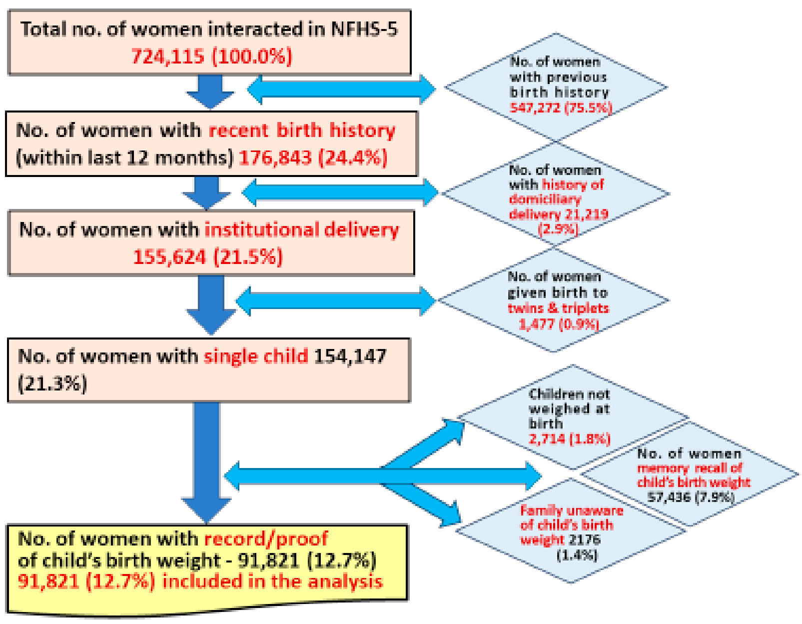

Figure 1. Blueprint of sample selection

had babies not weighed at birth, and 2136 (1.39%) did not know the exact weight of the child.

Dependent and independent variables

Newborn babies with a recorded birth weight of 1499 g or less were endorsed as ‘very low birth weight’ (VLBW) and the same was considered a dependable variable.

The study used a range of social correlates as independent variables, including maternal age at interview, educational level, economic status, marital status, religion, and residence. Various reproductive attributes like maternal age at birth, birth order, birth interval, complications during pregnancy as well as antecedent behaviours like smoking and alcohol consumption were taken into account as independent variables. Antenatal elements like the total no. of antenatal visits, tetanus vaccination during antenatal care (ANC), the place of childbirth, and accessibility to maternity services constituted other independent variables in the analysis. The optimum no. of ANC visits was considered to be 4 or more [6].

Various categories of maternal BMI grade, like underweight (< 18.5 kg/m²), normal (18.5-24.9 kg/m²), overweight (25.0-29.9 kg/m²), and obese (≥ 30.0 kg/m²), were analysed, studied, and derived from the data set available in the NFHS-5 record [6]. Anaemia in a pregnant woman has been considered when her blood haemoglobin level is found to be ≤ 10.99 g/dL. Mild, moderate, and severe grade of anaemia in pregnant women have been further categorised as 10.0-10.9 g/dL, 7.0-9.9 g/dL, and < 7.0 g/dL, respectively [7].

Data analysis

Descriptive statistics, including frequencies (no.), percentages, means, and standard deviations (SD) were utilized to summarize the data. Inferential statistics were applied using the *Chi*-square (χ^2) test to evaluate associations between categorical variables. All data were systematically organized and presented in tabular format. A p-value of ≤ 0.05 was considered indicative of statistical significance. Multiple logistics regression analysis was applied to ascertain the most important predictor of VLBW births.

Ethical consideration

The data utilized in this analysis were obtained from the 5th National Family Health Survey (NFHS-5, 2019-2021), which is freely available in the public domain. The dataset contains no identifiable personal information, ensuring participant anonymity. As the data are secondary in nature and have already been published, therefore, ethical clearance was not sought from any institutional review board. The original source has been duly acknowledged and cited in the present work.

RESULTS

Study coverage and participant profile

The NFHS-5 survey encompassed 636,699 households nationwide, yielding responses from 724,115 adult women and 101,839 men. For this analysis, data from 91,821 women aged 15-59 years with recorded singleton births in the preceding 12 months were included. The sample frame spanned both urban and rural PSUs, with an initial listing and mapping of households conducted to ensure systematic selection. From each PSU, 22 households were randomly chosen, adhering to Probability

Table 1. Social and demographic characteristics of study respondents

Sociodemographic traits of women participants (n = 91,821)		No. (%) of women
Age at the time of interaction	15-24 years	30,302 (33.0)
	25-34 years	49,220 (53.6)
	35-59 years	12,299 (13.4)
Residence	Urban	32,276 (35.2)
	Rural	59,545 (64.8)
Caste and tribe	Scheduled caste	22,510 (24.5)
	Scheduled tribe	11,730 (12.8)
	Other backward class (OBC)	40,224 (43.8)
	Higher caste	17,357 (18.9)
Educational status	No formal education	13,301 (14.5)
	Primary education	11,823 (12.9)
	Secondary education	45,659 (49.7)
	Higher secondary and above	21,038 (22.9)
Nutritional profile	Underweight	17,352 (18.9)
	Normal	59,523 (64.8)
	Overweight	11,722 (12.8)
	Obese	3224 (03.5)
Religion	Hindu	74,628 (81.3)
	Muslim	13,300 (14.5)
	Christian	2220 (02.4)
	Other religions	1673 (01.8)
Employment status	Never employed	77,563 (84.5)
	Currently unemployed	11,156 (12.1)
	Currently employed	3102 (03.4)
Economic class	Poorest	17,349 (18.9)
	Poorer	21,036 (22.9)
	Middle	21,036 (22.9)
	Rich	22,139 (24.1)
	Very rich	10,261 (11.2)

Proportional to Size principles (PPS) to reflect the population representation accurately.

Table 1 reflects that the majority of the women respondents belonged to 25-34 years age group (53.6%), staying in rural area (64.8%), hailing from other backward class (OBC – 43.8%), educated to secondary level (49.8), underweight (19%), following Hinduism (81.3%), never employed (84.5%), and allied to lower economic strata (41.8%).

Table 2. Low birth weight (LBW) & very low birth weight (VLBW) child birth according to sociodemographic attributes of study subjects

Sociodemographic traits		Normal birth weight (NBW)	Low birth weight (n = 16,011)		p-value
Sub-attributes (n = 91,821)		NBW ≥ 2500 g (n = 75,810) No. (%)	LBW 1500-2499 g (n = 15,001) No. (%)	VLBW ≤ 1499 g (n = 1010) No. (%)	
Age in years at delivery [No. (%)]					
15-24 years	30,301 (33.0)	24,191 (79.8)	5655 (18.7)	455 (1.5)	χ^2 = 334.6 p = 0.00001 V_C = 0.04
25-34 years	49,222 (53.6)	41,399 (84.1)	7470 (15.2)	353 (0.7)	
≥ 35 years	12,298 (13.4)	10,220 (83.1)	1876 (15.3)	202 (1.6)	
Residence [No. (%)]					
Urban	32,276 (35.2)	26,473 (82.0)	5460 (16.9)	343 (1.1)	χ^2 = 2.3 p = 0.0021 V_C = 0.01
Rural	59,545 (64.8)	49,338 (82.9)	9540 (16.0)	667 (1.1)	
Caste [No. (%)]					
Scheduled caste	22,510 (24.5)	18,383 (81.7)	3915 (17.4)	212 (0.9)	χ^2 = 82.6 p = 0.00001 V_C = 0.02
Scheduled tribe	11,730 (12.8)	9473 (80.8)	2136 (18.2)	121 (1.0)	
OBC	40,224 (43.8)	33,525 (83.3)	6235 (15.5)	464 (1,1)	
Higher caste	17,357 (18.9)	14,429 (83.1)	2715 (15.6)	213 (1.2)	
Literacy standard [No. (%)]					
Illiterate	13,302 (14.5)	10,105 (76.0)	2746 (20.6)	451 (3.4)	χ^2 = 82.6 p = 0.00001 V_C = 0.02
Primary class	11,821 (12.9)	9329 (78.9)	2280 (19.3)	212 (1.8)	
Sec. education	45,661 (49.7)	38,080 (83.3)	7335 (16.1)	246 (0.6)	
Higher sec./more	21,037 (22.9)	18,296 (86.9)	2640 (12.6)	101 (0.5)	
Nutritional status [No. (%)]					
Underweight	17,352 (18.9)	13,848 (79.8)	3051 (17.6)	453 (2.6)	χ^2 = 444.5 p = 0.00001 V_C = 0.04
Normal	59,523 (64.8)	49,240 (82.7)	9864 (16.6)	419 (0.7)	
Overweight	11,724 (12.8)	9952 (85.0)	1665 (14.2)	107 (0.9)	
Obese	3222 (3.5)	2770 (86.0)	421 (13.1)	31 (1.0)	
Religion [No. (%)]					
Hindu	74,628 (81.3)	61,576 (82.5)	12,326 (16.5)	726 (1.0)	χ^2 =126.9 p = 0.00001 V_C = 0.02
Muslim	13,303 (14.5)	10,905 (81.8)	2150 (16.1)	248 (1.9)	
Christian	2218 (2.4)	1848 (83.3)	345 (15.6)	25 (1.1)	
Others	1672 (1.8)	1481 (88.6)	180 (10.8)	11 (0,66)	
Employment status [No. (%)]					
Never employed	77,564 (84.5)	63,451 (81.8)	13,216 (17.0)	897 (1.2)	χ^2 = 201.8 p = 0.00001 V_C = 0.03
Currently unemployed	11,156 (12.1)	9693 (86.9)	1380 (12.4)	83 (0.7)	
Currently employed	3101 (3.4)	2666 (86.0)	405 (13.1)	30 (0.9)	
Economic class [No. (%)]					
Poorest	17,349 (18.9)	13,879 (80.0)	3071 (17.7)	399 (2.3)	χ^2 = 562.1 p = 0.00001 V_C = 0.05
Poorer	21,036 (22.9)	16,946 (80.6)	3825 (18.2)	265 (1.3)	
Middle	21,036 (22.9)	17,446 (82.9)	3460 (16.5)	130 (0.6)	
Rich	22,139 (24.1)	18,659 (84.2)	3355 (15.2)	125 (0.6)	
Very rich	10,261 (11.2)	8880 (86.5)	1290 (12.6)	91 (0.9)	

Percentage calculated as per sub-groups (column-wise); χ^2 – *Chi*-square; V_C – Cramer's V coefficient

Nearly 45% of VLBW babies (above 450 of 1010) were born among young, underweight, and illiterate mothers showing statistically significant associations of moderate to weak strength (V_C 0.04-0.02) (Table 2). A striking 89% of VLBW births (897 of 1010) were borne by mothers who were never employed, while 40% (399 of 1010) occurred among those hailing from the most impoverished economic strata, both reflecting associations of moderate strength (V_C 0.03-0.05). VLBW babies from mothers of rural areas, OBC lineage, and following Hinduism showed significant but weaker associations. A large proportion of LBW

Table 3. Low birth weight (LBW) &very low birth weight (VLBW) child birth according to reproductive and antenatal attributes of study subjects

Reproductive traits		Normal birth weight	Low birth weight ,(n = 16,011)		p-value
Sub-attributes (n = 91,821)		NBW ≥ 2500 g (n = 75,810) No. (%)	LBW 1500-2499 g (n = 15,001) No. (%)	VLBW ≤ 1499 g (n = 1010) No. (%)	
ANC visits [No. (%)]					
No visit	4132 (4.5)	3006 (72.7)	1065 (25.8)	61 (1.5)	χ^2 = 321.6, p = 0.00001 V_C = 0.04
< 4 visits	44,158 (48.1)	36,904 (83.5)	6741 (15.3)	513 (1.2)	
4 visits	43,531 (47.4)	35,900 (82.5)	7195 (16.5)	436 (1.0)	
Anaemia [No. (%)]					
Severe	2111 (2.3)	1665 (78.9)	349 (16.5)	97 (4.6)	χ^2 = 830.4, p = 0.0001 V_C = 0.07 Z = 13.8, p < 0.0001
Moderate	26,720 (29.1)	22,083 (82.6)	4367 (16.3)	270 (1.0)	
Mild	24,608 (26.8)	20,013 (81.3)	4035 (16.4)	560 (2.3)	
Normal	38,382 (41.8)	32,049 (83.5)	6250 (16.2)	83 (0.2)	
Birth order [No. (%)]					
1	33,974 (37.0)	27,859 (30.3)	5780 (17.0)	335 (1.0)	χ^2 = 26.5, p = 0.00002 V_C = 0.01
2/3	48,665 (53.0)	40,392 (44.0)	7715 (15.8)	558 (1.1)	
4	9182 (10.0)	7559 (8.2)	1506 (16.4)	117 (1.3)	
Birth interval [No. (%)]					
< 24 month	25,030 (27.3)	20,000 (79.9)	4722 (18.9)	308 (1.2)	χ^2 = 169.4, p = 0.00001 V_C = 0.04
> 24 month	66,791 (70.6)	55,810 (83.5)	10,279 (15.4)	702 (1.1)	
Gender of the newborn [No. (%)]					
Male	49,378 (53.8)	41,614 (84.3)	7350 (14.9)	414 (0.8)	χ^2 = 242.3, p = 0.00001 V_C = 0.05
Female	42,443 (46.2)	34,196 (80.6)	7651 (18.0)	596 (1.4)	
Pregnancy complications [No. (%)]					
No	21,119 (23.0)	17,619 (83.5)	3302 (15.6)	198 (0.9)	χ^2 = 17.3, p = 0.0001 V_C = 0.01
Yes	70,702 (77.0)	58,191 (82.3)	11,699 (16.6)	812 (1.1)	
Caesarean section [No. (%)]					
No	67,304 (73.3)	55,706 (82.8)	10,892 (16.2)	706 (1.0)	χ^2 = 10.9, p = 0.004 V_C = 0.01
Yes	24,517 (26.7)	20,104 (82.0)	4109 (16.8)	304 (1.2)	
Iron-folic acid supplement [No. (%)]					
No	9184 (10.1)	7347 (80.0)	1725 (18.8)	112 (1.2)	χ^2 = 46.8, p = 0.00001 V_C = 0.02
Yes	82,637 (89.9)	68,463 (82.8)	13,276 (16.1)	898 (1.1)	
Tetanus injection [No. (%)]					
No	3765 (4.1)	3049 (81.0)	671 (17.9)	45 (1.1)	χ^2 = 6.8, p = 0.03 V_C = 0.01
Yes	88,056 (95.9)	72,761 (82.6)	14,330 (16.3)	965 (1.1)	
Use cigarette/tobacco [No. (%)]					
Yes	2556 (2.8)	2055 (80.4)	430 (16.8)	71 (2.8)	χ^2 = 69.2, p = 0.00001 V_C = 0.03
No	89,265 (97.2)	73,755 (82.6)	14,571 (16.3)	939 (1.1)	
Consume alcohol [No. (%)]					
No	91,454 (99.6)	75,526 (82.6)	14,925 (16.3)	1003 (1.1)	χ^2 = 7.7, p = 0.02 V_C = 0.01
Yes	367 (0.4)	284 (77.4)	76 (20.7)	7 (1.9)	

Percentage calculated as per sub-groups (column-wise); χ^2 – *Chi*-square; V_C – Cramer's V coefficient; Z – Cochran Armitage trend test for VLBW trend babies were born to mothers from younger age groups, scheduled caste communities, and those who had never been employed. Similarly, factors like low economic status, undernutrition, and rural residence showed significant associations with occurrence of LBW births.

Table 3 shows that large proportion of mother who did not avail the antenatal visits at all, gave birth to statistically significant percent of LBW babies (26%). Severely anaemic mothers had the significant LBW rate (17%). Tobacco use and alcohol consumption among mothers resulted in significantly higher percent of LBW babies in the measures of around 17% and 21% respectively. Higher birth order (16%) and shorter birth interval (19%) among mothers were also important determinants for LBW babies. Large percentage of mothers with gestational complications, caesarean section, no iron supplementation, and lack of TT vaccination contributed significantly in the birth of around 17-19% of the LBW babies.

Severe anaemia among mothers accounted for significant occurrence of VLBW babies (4.6%) along with a statistically significant graded trend according to the categories of anaemia. Maternal tobacco use and alcohol consumption were associated with significantly higher rates of birth of VLBW babies, approximately 2.8% and 1.9% respectively. The absence of antenatal care, female sex of the newborn, higher birth order, short inter-pregnancy intervals, and lack of iron supplementation were all significantly associated with the birth of VLBW babies, with occurrence rates ranging from 1.5% to 1.2% in the respective groups. Gestational complication, caesarean section and lack of anti-tetanus shot were also found significantly associated with VLBW occurrence.

Regional occurrence of LBW and VLBW births

Rural areas consistently report higher LBW and VLBW percentages across all regions compared to urban areas (Figure 2). The highest LBW occurrence is seen in Central rural India (20.7%), while the lowest is in Northeast urban sector (10.8%). VLBW prevalence shows a similar trend with rural areas slightly exceeding urban in every region. The rural-urban gap is most evident in the Central and West regions, indicating implication of local factors and influences.

A combination of socio-demographic and maternal reproductive correlates observed significantly associated with an increased risk of both LBW and VLBW in newborns is depicted in (Table 4 and Figure 3). Among these, certain determinants emerge as particularly influential like illiteracy (3.42), anaemia (3.36), undernutrition (3.11), tobacco use (2.41) lack of antenatal care (1.98), and economic status (1.85) reflecting significant risks for birth of VLBW babies. Risk prediction for LBW babies included lack of antenatal care (1.36), anaemia (1.28), economic status (1.25), illiteracy (1.21), short birth spacing (1.18), young age maternity (1.15), and lack of iron supplement (1.14). Analysis indicates the weightage of risks are neither equal nor universal for LBW and VLBW occurrence.

DISCUSSION

Global and Indian trends of LBW – VLBW

Around the world, 14.6% of the neonates are born with low birth weight (LBW), constituting 25 million cases every year; 95% of that occurs in LMICs, with South Asia collectively sharing for 52% of the total burden [8]. Data analysis from the National Family

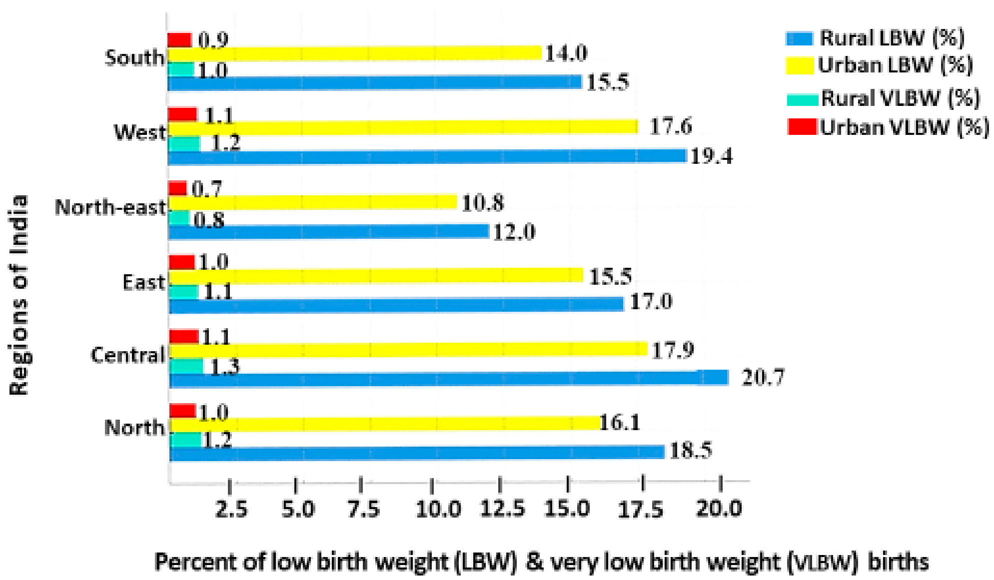

Figure 2. Region wise percentage of LBW and VLBW births

Table 4. Adjusted Odds Ratios (AOR) and 95% CI for socio-demographic and reproductive predictors of low birth weight (LBW) & very low birth weight (VLBW)

Predictor	Category	LBW AOR (95% CI)	p-value	VLBW AOR (95% CI)	p-value
Age at delivery	15-24 years	1.15 (1.09-1.22)	< 0.001	1.95 (1.75-2.15)	< 0.001
Caste	Scheduled tribe	1.10 (1.04-1.18)	< 0.001	1.28 (1.08-1.48)	0.02
Literacy	Illiterate	1.21 (1.11-1.32)	< 0.001	3.42 (3.21-3.63)	< 0.001
Nutritional status	Underweight	1.08 (1.02-1.14)	0.01	3.11 (2.90-3.32)	< 0.001
Economic class	Poorest	1.25 (1.17-1.34)	< 0.001	1.85 (1.69-2.01)	< 0.001
ANC visits	No visits	1.36 (1.27-1.46)	< 0.001	1.98 (1.77-2.19)	< 0.001
Anemia	Severe	1.28 (1.15-1.43)	< 0.001	3.36 (3.22-3.50)	< 0.001
Tobacco use	Yes	1.12 (1.01-1.23)	0.03	2.41 (2.22-2.60)	< 0.001
Iron supplement	No	1.14 (1.07-1.22)	< 0.001	1.18 (1.07-1.29)	0.04
Birth interval	< 24 months	1.18 (1.12-1.26)	< 0.001	1.29 (1.11-1.47)	0.006

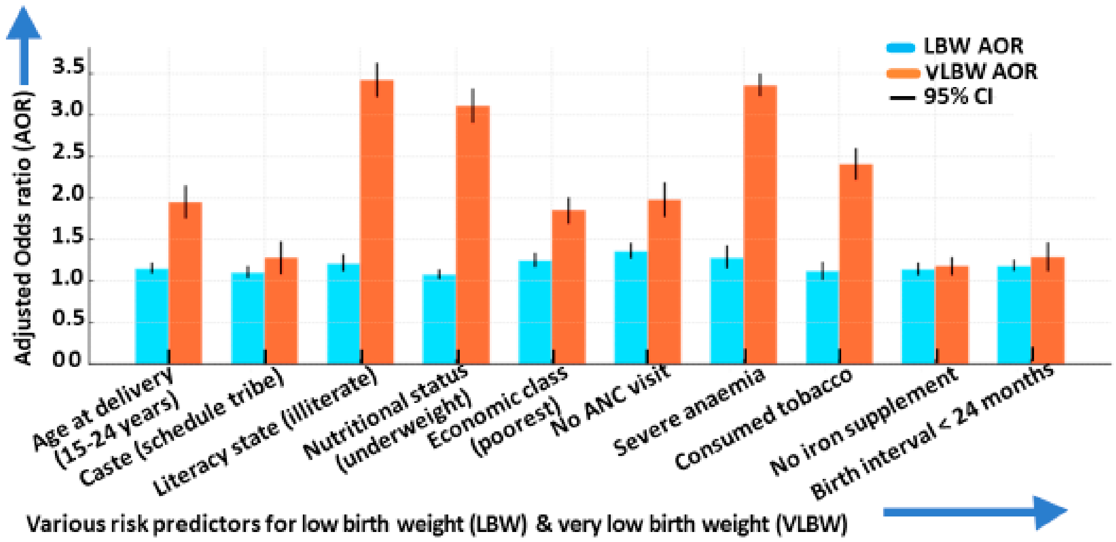

Figure 3. AOR of low birth weight (LBW) and very low birth weight (VLBW) according to the socio-demographic predictors

Health Survey (NFHS) in India exhibited a decline in LBW load from 22% in 2005-2006 (NFHS-3), to 17.5% in 2015-2016 (NFHS-4) [9]; however, this was not enough to achieve the desired 30% fall in LBW burden by 2030 [1]. Studies from the recent past depicted an occurrence of very low birth weight (VLBW) neonates during NFHS-4 (2015-2016) has been 1.2% which is significantly high, a cause of concern and imperative for forecasting further interventions to plummet the accompanying morbidity and mortality [10]. Regional work in Theni district of Western Tamil Nadu unveiled that LBW accounted for 16.3% of neonates and just above 1% of the new born babies were VLBW. Based on the trend analysis, the proportion of LBW babies born has steadily amplified since 2018 with an insignificant dip in 2022, while that of VLBW babies has consistently spiked since 2018 [11]. CDC US documented LBW and VLBW births as 8.6% and 1.36% of the total babies born in 2022 respectively indicating an upward swing for both [12]. The proportion of LBW babies born in England has been 7.2% in 2022, an increase from 2021 (6.8%); however, it remained unchanged at around 7.4% between 2011 and 2018. Percent of VLBW babies born in England has been 1% in 2022 and remained stable since 2020. Birth of LBW and VLBW babies has been higher in deprived sectors being 9.2% and 1.3% respectively against 5.6% and 0.8% in the developed areas of United Kingdom [13].

Intersecting social axis for LBW and VLBW risk

The present analysis reveals crucial sociodemographic and maternal health determinants associated with the occurrence of LBW and VLBW babies in the study population. The striking over-representation of young women aged 25-34 years

(53.6%), residing in rural areas (64.8%), belonging to OBC category (43.8%), educated up to secondary level (50%), unemployed (81%), and economically disadvantaged (42%) align with national demographic trends, where indigent and marginalized communities often exhibit poor gestational outcome due to limited access to the healthcare and social support services intended for expectant as well as prospective mothers [5]. Consequently, the crucial intersection of poverty, limited education, caste-based disparities, and rurality emerges as a powerful axis along which maternal and neonatal vulnerabilities are reproduced.

The analysis discerned that the burden of LBW among the representative Indian population during the study tenure of 2019 to 2021 stood at a notable 17.4%, within which VLBW newborns constituted 1.1% – representing 6.3% of all LBW births, resonating harmoniously with the patterns observed in parallel scholarly investigations on NFHS-4 data further reaffirming the persistence of this public health concern [10, 11]. Rural areas consistently reflected higher LBW and VLBW percentages across all regions compared to urban areas. The highest LBW occurrence is seen in Central rural India, while the lowest is in North-east urban sector. Beyond the clinical implications, it highlights the limited progress in addressing maternal and neonatal health disparities as well as calls for renewed and targeted interventions in maternal health care to curb the intergenerational cycle of poor gestational outcome.

Imprint of maternal disadvantage on birth weight

The finding of the disproportionate concentration of VLBW births borne by young, illiterate, and underweight mothers aligns with an extensive body of literature emphasizing the critical influence of maternal age, educational attainment, and nutritional status as key determinants of adverse neonatal outcomes. Younger maternal age and lack of formal education have been consistently associated with diminished awareness and utilization of antenatal care services, alongside inadequate nutritional practices [14, 15]. Moreover, maternal undernutrition evidenced by a considerable prevalence of underweight women represent a formidable public health challenge in rural India, is akin to the findings of the current analysis. Such nutritional deficiencies are strongly implicated in intrauterine growth restriction, thereby increasing the likelihood of both LBW and VLBW deliveries [16]. These findings underscore the urgent need for targeted interventions that address the intersecting vulnerabilities of youth, illiteracy, and malnutrition among pregnant women in resource-constrained environments. A tripartite strategy encompassing enlightened education, tailored adolescent maternal care, and community engagement stands paramount in augmenting antenatal cognizance, nutritional prudence, and equitable healthcare access among the expectant mothers.

A substantial majority of VLBW births have been reported among the unemployed mothers, indicating a strong and significant association that emphasizes the impact of socioeconomic disadvantage on gestational outcomes aligning with the current findings. Unemployed women, particularly in rural contexts, often lack financial autonomy and face barriers in accessing quality health services, resulting in delayed or inadequate ANC [17]. Furthermore, the pronounced concentration of VLBW births (40%, 399 of 1010) among mothers from the poorest households reinforces the existing evidence that economic hardship restricts access to adequate nutrition and timely medical care, thereby exacerbating the risk of adverse birth outcomes [18].

Beyond biology: grip of social stratification on neonatal health

Rural residence, identity of OBC, and Hinduism have been moderately associated with VLBW, albeit with comparatively smaller effect sizes. These demographic characteristics often intersect with entrenched structural determinants – such as social marginalization, limited geographical accessibility, and systemic deficiencies within healthcare infrastructure that collectively influence adverse maternal and neonatal health outcomes. A recent work highlighted significant caste and regional disparities in the utilization of maternal and child healthcare services in India, noting that individuals from disadvantaged social groups, including OBCs and rural residents, face substantial barriers in accessing complete healthcare [19]. Similarly, a recent review reflected that rural residence and belonging to socially backward castes are consistently linked to lower utilization of maternal health services, further exacerbating health inequities [20].

Invisible barriers and structural shadows – unseen hand of disparity

The patterns of LBW births closely echo those observed for VLBW occurrence, particularly among socioeconomically vulnerable groups. Women who are younger, unemployed, and economically disadvantaged consistently exhibit surged rate of LBW births, highlighting the critical intersection of age, employment status, and income with gestational outcomes and consequences [20]. Statistically significant associations between LBW and its determinants such as maternal undernutrition, low socioeconomic status, and rural residence have been consistently documented across South East Asia. These variables are salient contributors to intrauterine growth restriction and preterm delivery. Although effect sizes remain modest in the present analysis, the consistency and directional alignment of these associations elucidate the compounded disadvantage experienced by rural, socioeconomically marginalized, and vulnerable undernourished women as reflected by other scholars [21, 22]. Of particular concern is the disproportionately high concentration of LBW births, borne by the women belonging to the Scheduled Castes (SC); this finding is especially salient in the Indian context, where SC communities continue to face entrenched social exclusion, economic marginalization, and systemic blockades to access basic healthcare services [23]. The persistent caste-based inequities in maternal and neonatal health outcomes are well-documented and can be attributed to a combination of historical disadvantage and contemporary institutional neglect. Scholars have argued that caste, in conjunction with gender and economic class, constitutes a fundamental axis of stratification that determines access to healthcare resources, nutritional adequacy, and exposure to environmental risks during pregnancy [24]. These intersecting inequalities manifest not only in differential axis to antenatal care, but also portray disparities in health literacy, autonomy in health decision-making, and exposure to psychosocial stressors – all of which contribute cumulatively to adverse birth outcomes [19].

The silent burdens: unmet antenatal needs and maternal anaemia

The most salient determinant discerned in the analysis was the absence of antenatal care, that resonates with an expansive corpus of contemporary research underlining the indispensable role of ANC in safeguarding maternal-fetal health. A recent systematic review revealed that women who did not attend any ANC visits had a 54% higher risk of delivering LBW neonates compared to those who had at least one ANC visit [25]. Similarly, a retrospective study demonstrated that inadequate ANC – defined as fewer than four visits or initiation after the first trimester – was associated with increased odds of LBW [26]. Through timely surveillance of gestational progress, judicious management of obstetric complications, and optimization of maternal nutrition, ANC emerges as a linchpin in mitigating intrauterine growth restriction thereby curtailing the risk of LBW and VLBW outcomes.

Severe maternal anemia was another strong contributor to LBW and VLBW, showcasing a clear gradient correlation with the severity of anemia – analogous to consistent findings by many scholars. Severe maternal anemia stands as a formidable determinant of adverse neonatal outcomes, notably LBW and VLBW babies. Empirical evidence from a recent study in India, reveals that severe anemia in pregnant women is significantly associated with increased risks of preterm birth and LBW, with the risk intensifying in correlation with the severity of anemia. Specifically, the study found that women with severe anemia had higher odds of delivering LBW infants compared to non-anemic counterparts [27]. Anemia during pregnancy compromises oxygen transport to the fetus, leading to intrauterine growth restriction and preterm birth, both of which are direct causes of LBW and VLBW newborns. These findings accentuate the imperative of routine hemoglobin monitoring and the administration of iron-folic acid supplementation throughout pregnancy. The World Health Organization advocates for daily supplementation with 60 mg of elemental iron and 500 µg of folic acid as part of standard antenatal care to mitigate the risks associated with maternal anemia [28].

Toxic choices from womb to world

Maternal substance use during prenatal period, particularly tobacco and alcohol remains a significant determinant of adverse gestational outcomes, notably LBW and VLBW that is similar to the findings of the current intent [29, 30]. Tobacco exposure impairs fetal development via placental insufficiency and fetal hypoxia; nicotine and carbon monoxide induce vasoconstriction, compromising uteroplacental perfusion and nutrient transfer to foetus. Likewise, alcohol traverses the placenta and accumulates in amniotic fluid, disrupting cellular differentiation and organogenesis contributing to growth restrictions and increasing the risk of LBW and VLBW [31]. Concomitant use of both substances, tobacco as well as alcohol, exacerbates these effects, highlighting the imperative for integrated maternal health interventions [32]. This evidence potentiates the imperative for nuanced public health policy that seamlessly embeds maternal substance use prevention within the broader continuum of reproductive care. Strategic community engagement, regulatory oversight of substance marketing, and equitable access to support services must converge to arrest the intergenerational toll of LBW and VLBW occurrence.

Birth order, intervals, and neonatal risk

Higher birth order and short birth intervals (BIs) are significantly associated with increased risks of LBW and VLBW in the present work; and commensurate with annotation from NFHS-4 indicating around 12% of births occurred within six months of a previous pregnancy resulted in 19.4% of LBW babies. This is notably higher compared to the 16.0% observed in births with BIs of 18-23 months [33]. The compounded effect of higher birth order and short birth intervals places additional strain on maternal resources and reduces physiological recovery time between pregnancies, thereby elevating the risk of adverse birth outcomes [33]. Recent studies have reported that mothers who consumed fewer than 100 IFA tablets or received fewer than two TT (tetanus toxoid) injections had 1.2 times higher risk each of delivering LBW and VLBW babies resonating similarly with the findings of the present analysis [33]. These findings highlight the critical role of comprehensive antenatal care, including adequate IFA supplementation and TT vaccination, in enhancing pregnancy outcomes.

Influence of neonatal sex and obstetric factors on birth weight

Interestingly, the female sex of the newborn found modestly associated with LBW and VLBW occurrence in this research; and is consistent with previous research indicating that male foetuses tend to exhibit a slightly higher in-utero growth trajectory [6, 34]. This increased growth potential may lower the likelihood of male newborns being classified as LBW or VLBW compared to their female counterparts [35]. Gestational complications and caesarean deliveries have been consistently associated with LBW and VLBW newborns, pointing towards the clinical management strategies often employed in high-risk pregnancies. These associations, however, should not be interpreted as causal; rather, they reflect underlying maternal or fetal conditions – such as preeclampsia, intrauterine growth restriction (IUGR), or fetal distress – that necessitate medical intervention [34, 36]. Moreover, a retrospective cohort study demonstrated that aesarean delivery was associated with lower neonatal morbidity in VLBW infants, suggesting that the mode of delivery is often a response to pre-existing complications rather than a direct cause of low birth weight [37]. Therefore, while these associations are evident, they primarily reflect the underlying conditions prompting medical intervention rather than indicating a direct causal relations.

Complex risk differentials

A complex interplay of socio-demographic and maternal reproductive factors significantly elevates the risk of both LBW and VLBW births. Key contributors to VLBW include maternal illiteracy (AOR: 3.42), anaemia (AOR-3.11), tobacco use (AOR-2.41), lack of antenatal care (AOR-1.98), and low economic status (AOR-1.85), reinforcing findings from global studies [6]. For LBW, moderate risks are observed with limited antenatal care, anaemia, economic status, and illiteracy – factors commonly reported in LMICs [38]. These patterns highlight that risk intensity is neither uniform nor universal for LBW and VLBW. The differential strength and nature of these risks highlight the necessity for stratified prevention strategies that distinguish the aetiologies of LBW and VLBW, mitigating them as diverse group of risks.

Compound vulnerabilities vs. social consumption of health

The short and long term ramifications of LBW/VLBW neonates substantially amplify healthcare-related social expenditure, particularly in impoverished and socioeconomically vulnerable communities. In the immediate term, LBW/VLBW newborns are disproportionately afflicted by recurrent childhood morbidities such as ARI (acute respiratory infection), diarrheal diseases, pneumonia, PEM, and septicaemia. Over time, these children often endure a pernicious cycle of malnutrition and infection that may extend to adulthood, culminating in a heightened susceptibility to chronic non-communicable diseases including adult-onset insulin resistance, type-2 diabetes mellitus, CHD, and obesity. The advent of advanced treatment modalities and neonatal care technologies, has markedly escalated the cost of nurturing and sustaining LBW/VLBW babies – imposing a significant financial burden on already strained household resources. Although healthcare utilization patterns may appear comparable between LBW/VLBW and NBW neonates, the former invariably incur higher out-of-pocket expenditures owing to their increased vulnerability to illness. Indeed, annual healthcare costs related to common childhood morbidities among LBW children have been observed to exceed those of NBW counterparts by nearly 13%. This reality imposes an urgent and compelling imperative: the seamless integration of anticipatory prevention and robust primary healthcare into the very fabric of community life – particularly at the grassroots – where lies the transformative potential to mitigate, if not preclude, the avoidable risks associated with VLBW and to safeguard the delicate promise of life from its very inception.

Strengths of the study

The paramount distinction of this scholarly endeavour lies in its exceptionally large and meticulously curated sample, derived through a scientifically rigorous and methodologically sound sampling framework – ensuring an unparalleled degree of national representativeness. The estimation of birth weight is relied upon meticulously documented maternal records, a methodological refinement that likely confers superior precision and fidelity in capturing the true magnitude of the burden across the diverse socio-geographic spectra of rural and urban India. Furthermore, as the data emanate from authoritative records duly accredited by health centres and hospitals, their authenticity, reliability, and overall evidentiary integrity may be regarded as exemplary and beyond reproach.

Limitations of the study

As an inherently cross-sectional inquiry, this study is limited in its capacity to infer definitive causal relationships or establish the temporality of associations observed. Moreover, the analysis did not incorporate a range of critical socio-environmental determinants intimately linked with VLBW/LBW, including water quality, sanitation, kitchen hygiene, maternal dietary practices, and the extent of psychosocial support accessible to mothers – factors which may exert a profound and multifaceted influence on neonatal outcomes. A further limitation arises from the reliance on self-reported data for several variables, rendering the findings vulnerable to considerable recall error and social desirability bias, particularly in relation to culturally sensitive behavioural risk factors such as tobacco and alcohol consumption. These methodological constraints, while not uncommon in large-scale epidemiological research, italicize the necessity for future studies with more comprehensive and rigorously controlled data to illuminate the complex aetiology of VLBW/LBW with greater clarity and empirical precision.

CONCLUSIONS

Approximately one in every six women in India gives birth to either LBW or VLBW infant, with the burden disproportionately borne by illiterate women from impoverished and socially marginalized communities. This inequity reveals a deeply entrenched nexus between LBW/VLBW and pivotal social determinants – most notably maternal literacy, chronic under-nutrition, and economic deprivation. Alarmingly, the prevalence of LBW has shown minimal attenuation over recent years, despite the Government of India's unwavering commitment and steadily escalating investments in nutritional supplementation and food security initiatives targeting underserved populations. This troubling persistence signals a pressing need for the innovation and deployment of a more incisive, integrative, and empirically grounded nutritional support framework – tailored to the physiological and socio-economic realities of expectant mothers. Within this, critical public health endeavour, the time-honoured trios of state benevolence – manifest in transformative initiatives such as the Integrated Child Development Services (ICDS), the Janani Suraksha Yojana (JSY), and the Janani Shishu Suraksha Karyakram (JSSK) – stand not merely as bureaucratic instruments, but as luminous beacons of promise and catalytic agents of social upliftment. To actualise the potential of these interventions, a renewed emphasis on strategic implementation, inter-sectoral synergy, and community engagement is indispensable. Notably, the sustained surge in institutional deliveries, coupled with remarkable strides in digital health communication, has cast a spotlight on the quality and worth of LBW data – offering an unprecedented opportunity to anchor evidence-based, precision-targeted interventional research within the realities of public health practice.

Conflict of interest

The author declares no conflict of interest.

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