Estimating the burden of 'weighing less': A systematic review and meta-analysis of low birth-weight in India

MEENAKSHI BHILWAR, RAVI PRAKASH UPADHYAY, KAPIL YADAV, RAKESH KUMAR, PALANIVEL CHINNAKALI, SMITA SINHA, SHASHI KANT

ABSTRACT

Background. The National Family Health Survey-3 (NFHS-3; 2005–06) reports that the prevalence of low birth-weight babies is 22% in India. This old figure is probably an underestimate as this nationwide survey acquired information on birth-weight of only 34% of babies. We aimed to make a fresh estimate of the proportion of low birth-weight babies.

Methods. A systematic search was done through PubMed, Google Scholar, Cochrane Library, Medline, IndMed, Embase, WHO and Biomed Central databases. Studies published from 2004 to 2014 were included. Study quality was assessed using the adapted Mirza and Jenkins checklist. An 'adjustment' of 24% was applied to the published estimates where data were collected through records or through a combination of records and anthropometry. The adjustment was done to account for the heaping of birth-weight data at 2500 g. Meta-analysis using both random and fixed effects model was done to derive an estimate.

Results. Nineteen studies with 44 133 subjects were included in the review. The pooled estimate for the prevalence of low birth-weight was 27% (95% CI 24%–30%) and the 'adjusted' pooled prevalence was 31% (95% CI 28%–33%). The prevalence in urban and rural areas was 30% (95% CI 23%–38%) and 26% (95% CI 22%–30%), respectively. Region-wise estimates revealed that the prevalence at 33% was comparatively higher in eastern regions (95% CI 29%–37%).

Conclusion. The pooled prevalence of low birth-weight is higher than that reported by NFHS-3. Updated estimates should be used to guide future interventions and policies.

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Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India
MEENAKSHI BHILWAR, RAVI PRAKASH UPADHYAY
Department of Community Medicine

All India Institute of Medical Sciences, New Delhi, India
KAPIL YADAV, RAKESH KUMAR, SHASHI KANT
Centre for Community Medicine

All India Institute of Medical Sciences, Rishikesh, Uttarakhand, India
SMITA SINHA Department of Community Medicine

Jawaharlal Institute of Postgradaute Medical Education and Research, Puducherry, India
PALANIVEL CHINNAKALI Department of Preventive and Social Medicine

Correspondence to MEENAKSHI BHILWAR;
dr.meenakshi.bhilwar@gmail.com

INTRODUCTION

Low birth-weight (LBW), defined as weight <2500 g at birth can result from preterm birth and/or intrauterine growth restriction (IUGR).[1–3] Birth-weight is a strong indicator of a newborn's chances for survival, growth, long-term health and psychosocial development.[4–8] Therefore, prevalence of LBW is considered a sensitive index of a nation's health and development. Reducing the incidence of babies with LBW has been a goal of several public policies targeting infant health.

An estimated 20 million babies worldwide are born each year with LBW, of which 95.6% are in developing countries.[2] India is home to nearly 40% of all LBW babies in the developing world.[2] An estimated 12.8 million babies were born small-for-gestational age in India alone (95% CI 11.5–14.3 million), with a prevalence of 47%.[9] Reliable nationwide data on birth-weight in different states and districts are not available because a majority of births (52.3%) occur at home and these infants are not weighed or are weighed much later after birth.[10] In addition, when information on birth-weight is gathered from either records or self-reported by mothers or family members, the readings tend to heap around multiples of 500 g. As a result, a certain proportion of infants whose birth-weights are exactly 2500 g actually weigh <2500 g.[2,11] This further underestimates the incidence of LBW.

Till now, statistics on LBW in India are from those documented by the National Family Health Survey-3 (NFHS-3; 2005–06).[12] Birth-weight in the NFHS-3 questionnaire was recorded for births in the 5 years preceding the survey, i.e. from 2000 to 2004. Additionally, data were collected either from a written record or mother's recall. Since birth-weight was not known for many babies, the mother's estimate of the baby's size at birth was obtained for all births.[12] Also, the sample of births for which weights were reported was only one-third of all births (34% of the babies), consequently results of this survey on birth-weight need to be interpreted with caution. Ironically, for India, the data generated by NFHS-3 are largely used not only for policy-making but also for assessing the impact of major interventions.

Current estimates are available for empowered action states (i.e. states with high neonatal mortality rates and burden of LBW) through annual health surveys and, therefore, the need for nationwide data to implement policies is debatable in this era of decentralization. We believe that an updated nationwide estimate will help in international comparisons and will also aid in monitoring the progress made in addressing the problem of LBW babies. Hence, this review aimed to make fresh estimates on the burden of LBW babies in India.

METHODS

Data sources and search strategy

A systematic search was done by two of the authors independently (MB and RPU) using electronic as well as manual methods. The electronic search was done with PubMed, Google Scholar, Cochrane Library, Medline (Ovid), IndMed, Embase, WHO and Biomed Central databases. Search strategies used subject headings and keywords (weight, birth-weight, low birth-weight, very low birth-weight, extremely low birth-weight, small-for-gestational age, intrauterine growth restriction, term birth, full-term birth, preterm birth, undernutrition, anthropometry, neonate, newborn, infant, community-based survey, household survey, India) with no language restrictions. The bibliographies of relevant guidelines, reviews and reports were also read to identify relevant primary reports. Manual search was done at the B.B. Dikshit Library of the All India Institute of Medical Sciences, New Delhi; institutional library of Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi and the National Medical Library, New Delhi. These libraries had an updated catalogue of theses and scientific reports (published as well as unpublished) both in hard copy and also as an electronic database. The records were maintained year-wise and the authors performed an electronic search using the keywords mentioned in Fig. 1. The hard copies of the identified relevant materials were then read and the main findings relevant to this review were gathered.

For unpublished studies and grey literature, Dissertation Abstracts International (DAI), Information and Library Network Centre (INFLIBNET), Scholarius and Eldis were searched.[13–16] The search in the above-mentioned portals/websites was performed similar to the electronic search for published articles and using the same set of keywords, as mentioned in Fig. 1 (e.g. low birth-weight AND full-term AND neonate AND community-based study AND India). Online searches of major conference proceedings were also made to identify unpublished literature. Also, 'ResearchGate', which is a networking site for scientists and researchers to share research findings, was used to get information on unpublished literature.[17] For studies with data missing or requiring clarification, the principal investigators were contacted. The last date of literature search was 31 May 2014.

Study selection and data extraction

Strict criteria were followed to determine the inclusion of the available literature. The study had to meet the following criteria to be included: original research, community/population-based study; conducted in India; study period from 2004 to 2014. Further, the articles whose full texts were reviewed were subjected to a quality scoring assessment and only those that scored ≥4 were finally included in the meta-analysis. Articles in any language were considered for the review. Further, the study should have provided information on study setting, sample size, data collection method(s) adopted, and prevalence of LBW. Only community-based studies were included as the data from hospital-based studies might have suffered from selection bias and would not be adequately representative compared to community-based studies.

After initial screening of the titles and abstracts, full-text publications of studies for possible inclusion were reviewed. Discrepancies about inclusion of studies and interpretation of data were resolved by discussion among the reviewers. Data from all studies meeting the inclusion criteria were summarized and arranged into a table. Abstraction of key variables with regard to the study identifiers and context, sample size, response rate, data collection method(s) and reported prevalence of LBW was done.

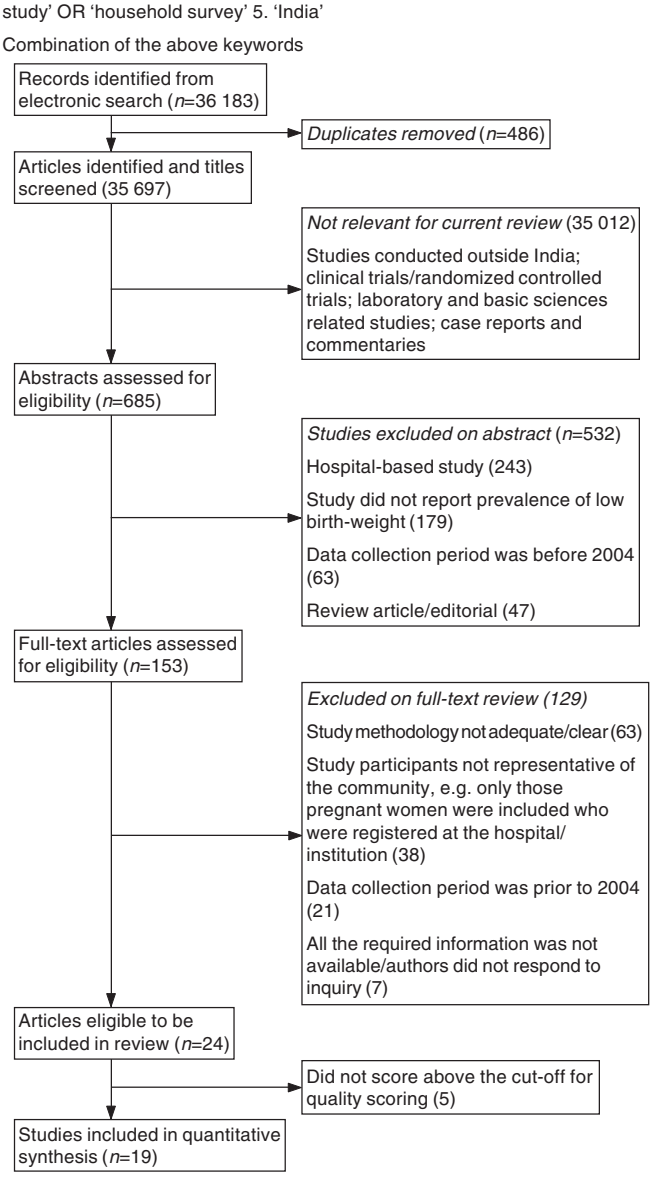

FIG 1. Flowchart depicting the selection process of articles to be included in the review

Quality assessment of studies

Study quality was assessed by two authors (MB and RPU) independently using the adapted Mirza and Jenkins checklist.[18,19] Adaptations were made based on the principles appropriate for the aims of this review, with more importance given to the methodological rigor of the study. The checklist included the following quality criteria: (i) Aims/objectives clearly mentioned; (ii) adequate sample size or justification; (iii) representative sample, with justification; (iv) clear inclusion and exclusion criteria; (v) important operational definitions such as LBW, small-for-gestational age (SGA), prematurity, IUGR clearly

defined; (vi) response rate and reason(s) for non-response provided; (vii) data collection method(s); and (viii) appropriateness of statistical analyses applied. One point was given for a 'yes' and none for a 'no'. We included studies that scored ≥4, of the maximum possible score of 8 points. Differences were discussed with senior investigators (KY, PC and RK) and a consensus reached.

The final set of studies was also categorized according to the type of sampling adopted (probability, non-probability, universal sampling or the sampling strategy not mentioned); method of data collection (from records, through anthropometry or using both these methods); and response rate (>80%, 60%–80% or response rate not mentioned).

Data analysis

Meta-analysis on reported prevalence of LBW was performed. Region-wise and urban–rural estimates were calculated. Further, 'adjustments' were made to the reported proportions (only for studies that collected information on birth-weight either through records/as reported by mothers/family members; and those that used both records and anthropometry for data collection. There were 10 such studies. Adjustments were not made for 9 studies that used only anthropometry by trained data collectors or field staff for recording birth-weight) in order to take into account the heaping of birth-weight data at 2500 g, as suggested by Unicef.[2,11] An 'adjustment' of 24% was applied to these published estimates.[2] Meta-analysis on adjusted prevalence was also conducted. Sensitivity analysis was done by discarding studies with comparatively low quality (i.e. those with a quality assessment score of 4 and 5); birth-weight data obtained solely through records; sample size ≤200 and those with non-probability sampling or the sampling strategy not mentioned.

Both the random and fixed effects models were used. The I^2 statistic was used to estimate heterogeneity in pooled studies. Forest plots were generated to show prevalence proportions with corresponding 95% CIs for each study and the overall random/fixed effects pooled estimate. 'StatsDirect' software was used to perform meta-analysis and generate forest plot.[2] Also, for trend analysis, the entire period from 2004 to 2014 was stratified into three groups (2004–07, 2008–11 and 2012–2014) and point estimates were calculated for each group. These point estimates were plotted and trend analysis tool of Microsoft Office Excel 2007 was used for adding the trend line and calculating R^2. Tukey–Kramer multiple comparisons test in conjunction with ANOVA was applied to test the statistical significance of the variation in the pooled estimates across the years.

RESULTS

Description of the included studies

We screened the 36 183 titles of articles identified through the electronic literature search. Of these, after reviewing the abstracts of the 685 articles that appeared relevant, we assessed 153 full-text articles for eligibility and included 19 (with 44 133 subjects) in our final analysis (Fig. 1). All the studies were in English and most of them were done during 2009–12 (*n*=11/19; 58%). A majority of the studies (*n*=15/19; 79%) were done in rural areas (Table I). Five studies were from northern India; 6 from southern India; 5 from eastern India; and 3 from western India. The sample size of the included studies ranged from 120 to 17 318 (Table I). Around 48% (*n*=9/19) studies used anthropometric measures to

TABLE I. Studies included in the review that report the prevalence of low birth-weight (LBW) in India (2004–2014)

Author(s)	Year of study	Study setting	Location	Method of data collection on birth-weight	Sample size	Response rate (%)	Reported prevalence (%)	Adjusted prevalence (%)†	Score*
Biswas *et al.*[21]	2004–05	Rural	West Bengal	For institutional delivery, data on birth-weight obtained from documents/certificates/ records; in home deliveries, recorded within 48 hours by trained field workers.	487	95.1	31.3	38.8	7
Joseph *et al.*[22]	2004–06	Rural	Karnataka	House-to-house visits were made and information was collected using a pretested proforma. Birth-weight was taken by the study investigators.	194	NR	24.8	Not done	6
Kutty *et al.*[23]	2004–08	Rural	Gujarat	Data were collected by the trained *Arogyasakhis* (health workers) of the project area.	10 908	80.1	31	Not done	7
Ranchi low birth-weight project[24]	2003–09	Rural	Jharkhand	*Sahiyya*, a voluntary female health worker followed third trimester pregnant women till their delivery, through regular house-to-house visits and collected information on birth-weight.	996	74.4	41.7	Not done	6
Bækgaard[25]	2004–13	Rural	Tamil Nadu	Data were derived from the records at the local hospital. The study was conducted in the catchment area of the hospital where records of all the newborn babies was well maintained.	2873	78.7	28.3	35.1	6

(continued)

TABLE I. Studies included in the review that report the prevalence of low birth-weight (LBW) in India (2004–2014) (*continued*)

Author(s)	Year of study	Study setting	Location	Method of data collection on birth-weight	Sample size	Response rate (%)	Reported prevalence (%)	Adjusted prevalence (%)†	Score*
Das *et al*.[26]	2005–09	Urban slums	Mumbai	Birth-weights were copied from record cards of deliveries.	17 318	86	22.3	27.6	6
Jha *et al*.[27]	2006–07	Rural	Uttar Pradesh	Babies were weighed within 1 hour of birth in institutional delivery and within 48 hours in home delivery.	298	95.8	27.9	Not done	7
Metgud *et al*.[28]	2008–09	Rural	Karnataka	Weight was recorded using standard measurement techniques by trained personnel.	1138	NR	22.9	Not done	5
Sengupta *et al*.[29]	2009	Urban slum	Punjab	A pre-tested questionnaire was used to collect data from the mothers of under-five children. Weight was measured using Salter's scales using standard guidelines.	200	67	27.6	Not done	7
Kant *et al*.[30]	2009–12	Rural	Haryana	Data were procured from Health Management Information System (HMIS). HMIS included birth-weights of infants, as recorded by the trained field staff (in case of home delivery) and from hospital records (in institutional delivery).	6625	83.3	17.3	21.5	6
Manna *et al*.[31]	2010	Rural	West Bengal	House-to-house visits were made and birth-weight was obtained from records	540	NR	30.9	38.3	6
Narayanamurthy *et al*.[32]	2010	Rural	Mysore	Semi-structured proforma was used to collect information on birth-weight and its determinants from the mothers.	293	97	20.1	24.9	6
Upadhyay[33]	2010	Rural	Haryana	Data on birth-weight was obtained from the institutional discharge cards; in home deliveries, the birth-weight was recorded as reported by the family members.	415	72	18.9	23.4	7
Hayat *et al*.[34]	2010–11	Urban	Srinagar	Birth-weight was taken from the records available with the mother.	500	NR	26.8	33.2	4
Nair *et al*.[35]	2010–11	Rural	Rajasthan	Survey questionnaire was administered to mothers through house-to-house visits. Weight of infants was measured by study researchers using standard measurement techniques.	528	89.6	44.1	Not done	8
Dasgupta *et al*.[36]	2011	Rural	West Bengal	Birth-weight recorded by trained personnel by house-to-house visits.	253	NR	28.8	Not done	7
Siddalingappa *et al*.[37]	2011	Rural	Mysore	Pre-tested semi-structured questionnaire used to gather information from mother. Hospital records were referred wherever available.	314	97.3	20.1	24.9	6
Sathyanath *et al*.[38]	2012	Rural	Mangalore	Pre-tested proforma were used to collect data on birth-weight from the mothers.	133	66.5	18.0	22.3	5
Mandal *et al*.[39]	2012	Urban slum	Kolkata	Anthropometric measurements were taken by trained field staff using standard guidelines.	120	NR	47.5	Not done	6

* quality assessment of the studies was done using adapted Mirza and Jenkins's checklist. Scores were assigned to each study. Maximum attainable score was 8. Only those studies were included in the review that attained a score of ≥4 † average adjustment of 24% applied to published estimates in studies that collected birth-weight information either solely through records or through a combination of records and anthropometry. No adjustment was done for studies that used trained staff to weigh babies, i.e. only anthropometry. This adjustment was done to account for the heaping of survey data on 2500 g, as suggested by Unicef. NR not reported

collect birth-weight data, while 42.1% (*n*=8/19) relied on records only (Table II). A small percentage of 10.5% (*n*=2/19) used both records and anthropometry. A majority of the studies included had either a universal sampling (42.1%) or probability sampling strategy (36.8%; Table II). Around two-fifths had a response rate ≥80%, while six studies (31.6%) did not mention it. On quality assessment using Mirza and Jenkins checklist, most of the studies (*n*=16/19; 84.2%) obtained a total score of ≥6. The mean score of all the studies included was 6.31 (Table I).

Estimated pooled prevalence of LBW

The prevalence of LBW reported by the studies ranged from 17.3% to 47.5% (Table I). The pooled estimate of the 'unadjusted' prevalence was 27% (95% CI 24%–30%) using the random effects model whereas it was 25% (95% CI 24%–25%) through the fixed effects model. The 'adjusted' prevalence was 31% (95% CI 28%–33%) and 29% (95% CI 28%–29%) using the random and fixed effects models, respectively (Figs 2 to 5). There was a high degree of heterogeneity among the studies I^2=97.4% (95% CI 97%–97.8%).

TABLE II. Quality of the papers (*n*=19) included in the systematic review and meta-analysis

Quality variable	Category	Number of studies	Proportion (%)
Type of sampling	Probability	7	36.8
	Non-probability	1	5.3
	Universal sampling	8	42.1
	Not mentioned	3	15.8
Method of data collection	Records/as reported by mothers or family members	8	42.1
	Anthropometry	9	47.4
	Both	2	10.5
Response rate (%)	>80	8	42.1
	60–80	5	26.3
	Not mentioned	6	31.6

Sub-group and sensitivity analysis

Region-wise estimates revealed that the pooled prevalence in eastern regions was 33% (95% CI 29%–37%). For the western parts of India it was 32% (95% CI 24%–40%). In the northern and southern regions, it was 23% (95% CI 18%–29%) and 23% (95% CI 19%–26%), respectively. The pooled prevalence in urban and rural areas was 30% (95% CI 23%–38%) and 26% (95% CI 22%–30%), respectively.

After excluding the studies in which birth-weights were extracted solely from records, the pooled estimate was 29% (95% CI 23%–35%). Pooling of studies with quality assessment score of ≥6 led to an estimate of 28% (95% CI 24%–31%). Thus, removal of three low-quality studies (i.e. those with a quality assessment score of 4 and 5) did not affect the original estimate. Also, removal of studies with sample size ≤200 led to an estimate of 27% (95% CI 23%–30%) and removal of studies with non-probability sampling and those which did not mention sampling strategy led to an estimate of 28% (95% CI 24%–31%), and both these estimates are nearly similar to the original estimate.

The four studies[24,25,30,33] which were not published and included as a part of the 'grey literature' were removed and re-analysis was

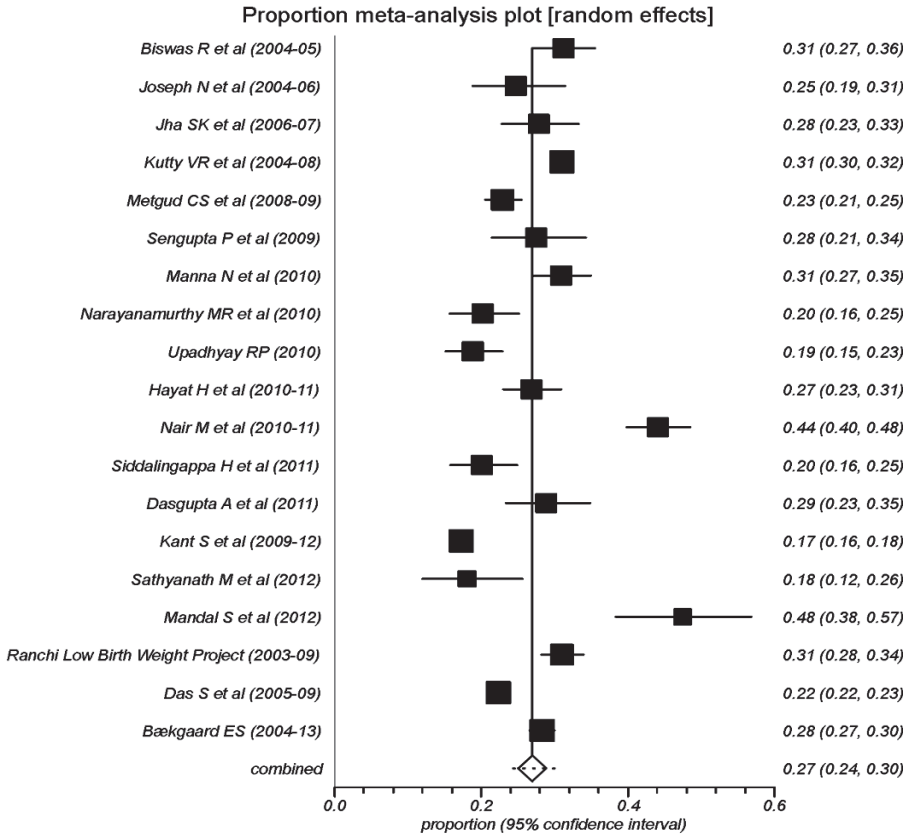

FIG 2. Forest plot showing 'unadjusted' estimate of low birth-weight obtained by pooling of studies during 2004–14, using the random effects model

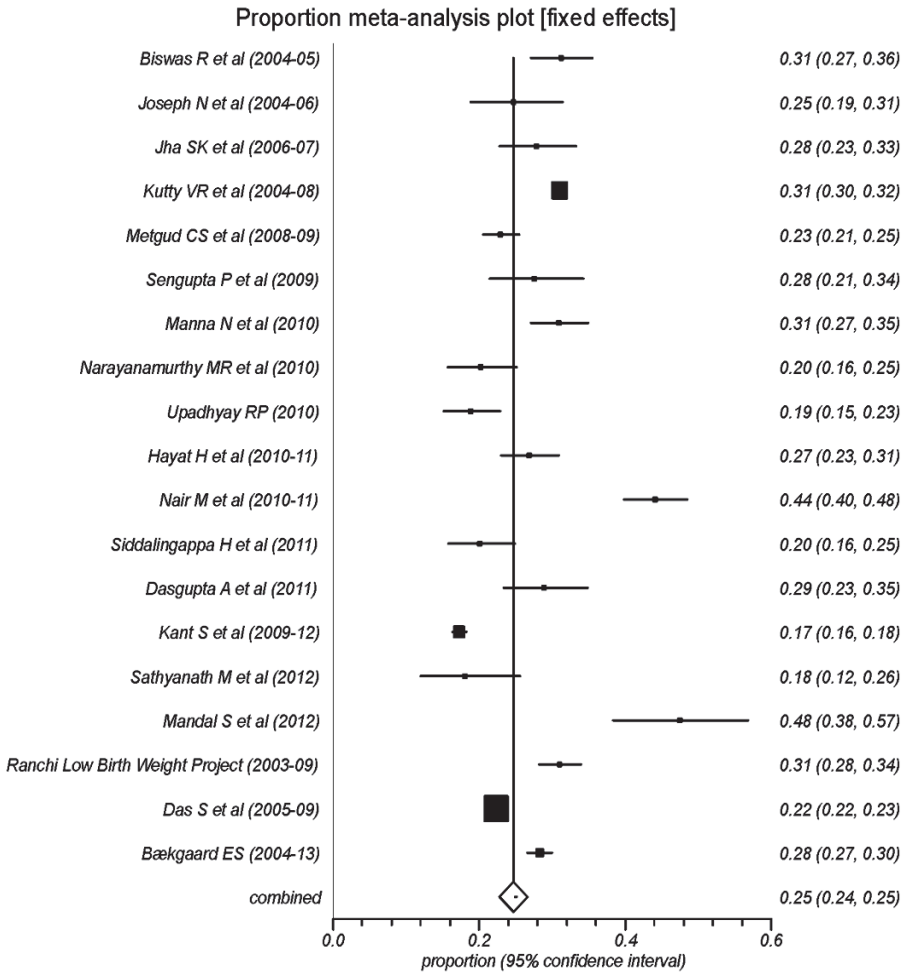

FIG 3. Forest plot showing 'unadjusted' estimate of low birth-weight obtained by pooling of studies during 2004–14, using the fixed effects model

done to see if this affected the overall estimate. The 'unadjusted' estimates came to be 26.3% (95% CI 25.8%–26.8%) and 27.8% (95% CI 24.5%–31.4%; fixed *v*. random effects model). The 'adjusted' estimates were 29.3% (95% CI 28.8%–29.8%) and 30.7% (95% CI 28.3%–33.3%; fixed *v*. random effects model).

Trend analysis

There were four studies in the period 2004–07, 10 studies in 2008–11 and only two studies in 2012–14. Three studies were not included in the trend analysis as their period of data collection overlapped/spanned across more than one group.[24–26] The pooled prevalence for the periods 2004–07 and 2008–11 were 30% (95% CI 28%–32%) and 25% (95% CI 20%–31%), respectively (Fig. 6). There was an observed increase, i.e. 32% (95% CI 8%–63%) in the period 2012–14 but this increase was not statistically significant (p=0.574).

DISCUSSION

The Millennium Development Goal-4 aimed to reduce mortality among children under 5 years of age by two-thirds.[40] For India, the United Nations estimated the under-5 mortality rate in 2011 at 61 per 1000 live-births, with an average annual reduction of 3% (range 3.4% to 2.3%) between 1990 and 2011.[41] The neonatal period represents the most critical period for a child's survival as nearly 44% of under-5 deaths occur during this period. Thus, reducing neonatal mortality is increasingly important.[40] LBW is one of the leading causes of neonatal mortality, consequently it is imperative to address this problem.[42,43] The first step towards this would be to have an updated estimate of the burden of LBW babies, as this will not only guide designing of interventions but also allow an assessment of the progress made. According to the NFHS-3 (2005–06), 22% of births in India are LBW which is probably an underestimate as birth-weight was recorded for only 34% of babies.[10] Moreover, the data produced by NFHS-3 are over a decade old and no new nationwide survey has been done recently. Further, an estimation of term and preterm babies born SGA in 138 low- and middle-income countries in 2010 found that India has the highest prevalence of SGA at 46.9%.[9]

We found the pooled prevalence of LBW to be 27%, which is a nearly 23% increase over the prevalence reported by NFHS-3. There is a need to effectively monitor the recording of birth-weight data to ensure both quality and comparability with international data. In India, a large proportion of the deliveries are at home and this poses a hurdle in obtaining birth records for all newborns.[9] Despite the existing schemes at the national and state level, such as *Janani Suraksha Yojna* (JSY), *Mamta* Scheme, *Janani Shishu Suraksha Karyakram* (JSSK), *Vande Matram* Scheme, etc. to provide allowances to women belonging to poor households for prenatal and/or postnatal care in India, the number of home deliveries remains high.[44–47] This calls for shifting of

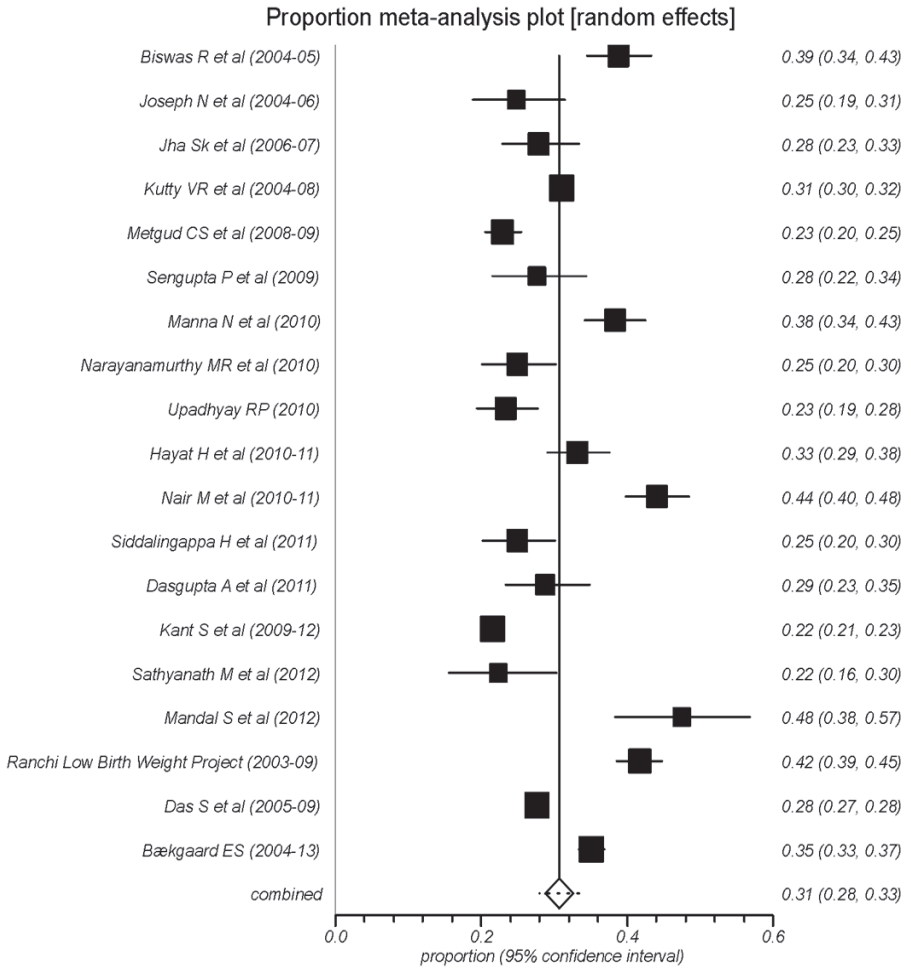

FIG 4. Forest plot showing 'adjusted' estimate of low birth-weight obtained by pooling of studies during 2004–14, using the random effects model

pregnancy case-finding and acquisition of information on birth-weight to the community level. An example of this is from rural Kenya where village elders were engaged to assist in case-finding for pregnancies and births, to obtain accurate birth-weights of all infants.[48] All elders were provided with weighing scales and mobile phones as tools to assist in subject enrolment and data recording. Village chiefs and elders were trained to use phones and weighing scales, including how to operate, maintain and store these.[48]

In India, under the National Rural Health Mission (NRHM), the accredited social health activist (ASHA) and *Anganwadi* worker have been assigned the task to measure birth-weight of babies born at home, within 2 days of delivery. Studies have shown that these health workers can be useful to maintain records of birth-weight in the community setting, if adequate training and supportive supervision are ensured.[49,50] Thus, with the present scenario of a high number of home deliveries, the above two interventions can strengthen the data management system for monitoring of LBW by substantially increasing the recording as well as maintenance of birth-weight data at the community level. Further, it has been emphasized that the estimates of LBW preferably should be generated by using data from an ongoing system of data management rather than through periodic surveys as studies suggest that estimates of LBW derived from surveys in developing countries are likely to provide an over-optimistic picture of the health status of children and women.[51]

Web-enabled mother and child tracking system (MCTS) has been initiated under NRHM with an intention to track every pregnant woman, infant and child up to the age of 3 years, in order to ensure delivery of services such as timely antenatal care, institutional delivery and postnatal care for the mother.[45] Initiatives like this would probably ensure that most newborns are delivered at a health institution and that their birth-weight would be recorded. There should also be routine reporting of the proportion of infants who were not weighed at birth so that efforts could be directed to target those newborns. Additionally, digitalization of hospital records and linking them with a central database would ensure readily available birth-weight data for the purpose of planning and policy-making.

The main strength of our review is that it has provided an updated estimate of LBW in India as the estimate generated by the NFHS-3 data is over a decade old. Our review had a large sample size which resulted in a reasonably precise pooled estimate. However, our study has limitations too. First, there were studies which collected data through records. Prior literature has questioned the quality of data maintained in developing countries.[52,53] Consequently, the use of such data by studies might affect the estimates generated. Second, there was a large degree of

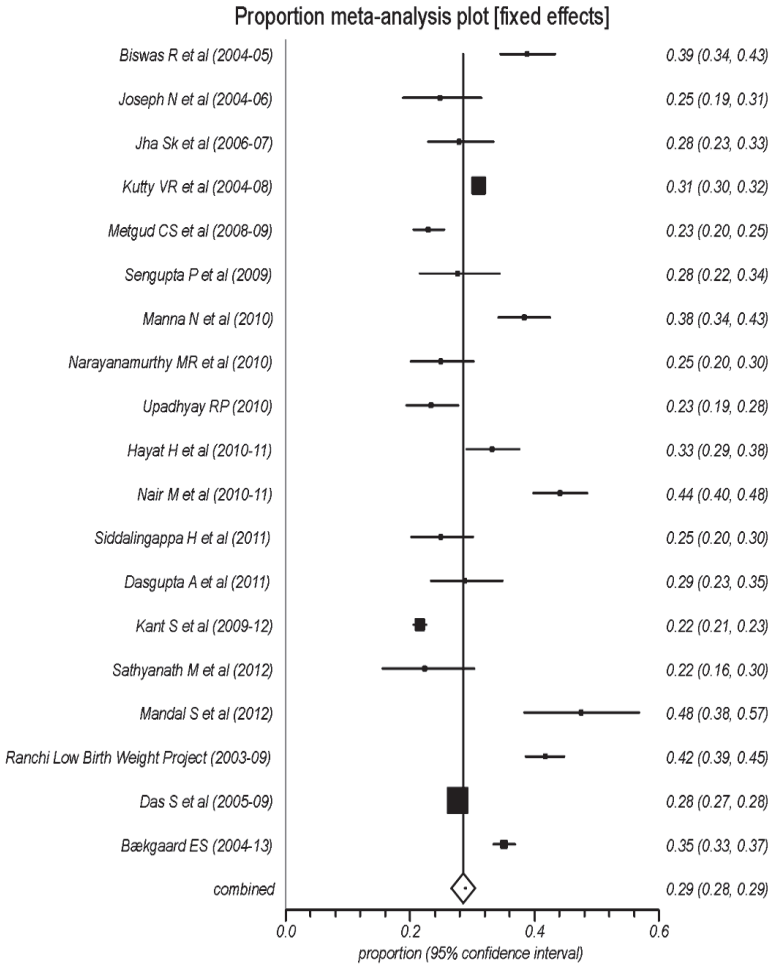

FIG 5. Forest plot showing 'adjusted' estimate of low birth-weight obtained by pooling of studies from 2004 to 2014, using the fixed effects model

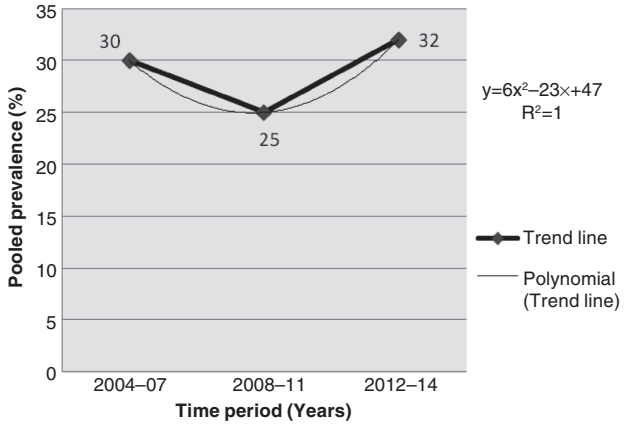

FIG 6. Polynomial trend in the weighted prevalence of low birth-weight across three time periods

heterogeneity among studies and probably a meta-regression, to understand how much of the observed heterogeneity was explained by the variables considered in the current review, was needed. As the primary focus of the current meta-analysis was largely on estimating the pooled prevalence of LBW, we did not consider many variables that could have explained the observed heterogeneity. We have done subgroup analysis based on urban/rural area, regions, quality of studies, sample size and type of sampling but did not see how much of these contribute to the heterogeneity. Third, in about half the studies included, either the response rate was not mentioned or was <80%. In the absence of adequate information on the response rate and reasons for non-response, it would be difficult to generalize the findings of the studies. Fourth, we have not looked at the two main categories of LBW, i.e. prematurity and SGA. These are overlapping yet distinct groups and public health strategies to tackle these in the medium- or long-term may be different. Also, in trend analysis, the estimates for earlier (2004–07) and later (2012–14) time periods were based on fewer studies when compared to estimates for 2008–11, which might not reflect the true trend and the statistical significance, if any, would have been masked.

Conclusion

Our review shows that the prevalence of LBW in India remains high. Reducing the prevalence of LBW would be one of the initial steps in achieving our sustainable development goal of reducing child mortality and thus its burden cannot be ignored. There is a need to have nationally representative data for prevalence of LBW, generated from community-based surveys. The proportion of LBW babies at the community level is a proxy indicator for poor maternal nutrition and inadequate healthcare services. These factors may independently or congruently lead to higher proportion

of LBW babies and thus they demand prompt attention as well. The prevalence of LBW estimated in the current review is higher than that reported in NFHS-3, emphasizing that important decisions and policies on critical issues such as LBW should be based on more recent estimates and that there is a need to constantly update the current trends of LBW in India.

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