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Iron deficiency anaemia and low BMI among adolescent girls in India: the transition from 2005 to 2015

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Abstract

Objective: The current study explored changes in trend of anaemia and BMI among currently pregnant nullipara adolescent women against socio-economic determinants in India from 2005 through 2015. The association between anaemia in currently pregnant nullipara adolescent women *v.* currently pregnant nullipara older women of reproductive age was also explored.
Design: We used the 2005 and the 2015 nationally representative Indian Demographic and Health Surveys (DHS). The outcomes of interest, anaemia and BMI, were measured based on the DHS methodology following WHO standards and indicators. Place of residence, educational attainment and wealth quintiles were used as determinants in the analysis.
Setting: India.
Participants: In total, 696 adolescent girls from the India 2005 DHS and 3041 adolescent girls from the India 2015 DHS.
Results: The 10-year transition from 2005 to 2015 showed differences between the least and most wealthy sections of society, with heaviest gains in anaemia reduction over time among the latter (from 50·0 to < 40·0 %). The odds of anaemia were significantly higher among the adolescent population when compared with adult women both in 2005 and in 2015 (OR = 1·2).
Conclusions: Despite an overall improvement in the prevalence of both BMI < 18·5 and anaemia among adolescents nullipara in India, the adjusted risk of anaemia in the latter category was still significantly higher as compared with their adult counterparts. Since the inequalities evidenced during the first round of DHS remained unchanged in 2015, more investments in universal health care are needed in India.

Keywords
Adolescent girls
Anaemia
Demographic health survey

Anaemia is a major and global public health problem that affects around a third of the world's population and is defined as a level of Hb:

<13 g/dl in men older than 15 years;

<12 g/dl in non-pregnant women older than 15 years and

<11 g/dl in pregnant women[1].

In 2016, anaemia affected a total of 430 million adolescents, almost one in four adolescents globally, and had increased by 20 % since 1990. While the increase had largely been driven by changing demography, decrease over the years has been slow, with < 0·5 % reduction observed since 1990[2].

Most cases of anaemia worldwide have a primary nutritional origin; therefore, anaemia can be a useful indicator of undernutrition, particularly relevant for adolescents in the context of rapid growth and menstruation[3]. At the same time, previous studies reported strong association between BMI and anaemia status[4].

Micronutrient deficiencies are a leading risk factor for the global burden of disease and iron deficiency anaemia account for the majority of disability-adjusted life years

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associated with micronutrient deficiencies (>2500 disability-adjusted life years per 100 000 adolescents)[5], especially among young girls[6].

More than one in three pregnant women worldwide has iron deficiency anaemia[7], which is known to negatively impact the course and outcome of future pregnancies[7], especially in the first and second trimester, enhancing the risk of low birth weight, premature birth and increased risk of infectious diseases and perinatal mortality in both the mother and the child. Anaemic mothers are 30–45 % less likely to incur favourable pregnancy outcomes, and their infants are estimated to have less than a half of normal iron reserves[8].

Almost 200 million adolescents (45 % globally) with anaemia live in India and China and young girls are at higher risk[2].

Despite having had an anaemia control programme for 50 years, India has the highest burden of the disease, and the lack of anaemia reduction in the country is surprising, considering India's rapid economic growth during the last 20 years, as anaemia rates are expected to decline approximately a quarter as fast as income increases[9].

As pointed out by a recent analysis, research is needed around factors influencing anaemia over time at individual, household and community levels[9]. Also, given that only 25 %[10] to 50 %[3] of anaemia is thought to be due to iron deficiency, the traditional approach of iron supplementation might fall short and policy-makers are challenged to understand which investment will have the greatest impact on anaemia reduction in India in the future.

In view of the above, using the latest two rounds of India Demographic and Health Surveys (DHS) (2015 and 2015), this paper seeks to: (1) explore changes in trend of anaemia and BMI among currently pregnant nullipara adolescent women against socio-economic determinants, (2) explore the association between anaemia in currently pregnant nullipara adolescent women *v.* currently pregnant nullipara older women of reproductive age.

Methods

Population, setting and data

DHS are nationally representative household surveys targeting all or ever-married women of reproductive age (15–49 years)[11]. Questionnaire is administered face-to-face by trained personnel and is translated into major local languages. The core content for every round of DHS is standard to guarantee the information comparability across countries. At the same time, errors like non-sampling, coverage and data processing are minimised through extensively training data collectors/health investigators on the standard internationally recommended protocols and data confidentiality[12].

Women aged 15–49 years are identified for anaemia testing, which is conducted in the household by measuring Hb level in the capillary blood samples collected from a finger prick. Individuals eligible for anaemia testing are advised about the objectives, potential risks, voluntary participation in testing and confidentiality of the anaemia testing procedures, as part of the DHS informed consent process[13]. Parents or guardians of never-married adolescents aged 15–17 are asked for approval before consent of the adolescent is sought. After obtaining informed consent, a finger is cleaned with a swab, impregnated with 70 % isopropyl alcohol, allowed to air dry and pricked with a disposable self-retracting lancet. The first two blood drops are wiped away; the third drop is collected with a microcuvette for measurement of the Hb level using the HemoCue® Hb 201^{+} analyzer (www.hemocue.com) and results are provided to participants immediately[13].

DHS also collect the BMI for all participant women, calculated as weight (kg) divided by the square of height (m^2).

For the current study, we excluded data for ever pregnant as well as currently pregnant women. Missing data are flagged in the DHS and were excluded from the analysis.

Main outcome, exposure and other variables

A standard biomarker questionnaire is used in the DHS to record Hb that is used to categorise the degree of anaemia. A cut-off of Hb < 12·0 g/dl for non-pregnant women as recommended by WHO was considered for classifying anaemia in the study.

Also, the conventional threshold of a BMI < 18·5 (underweight) was traced as additional outcome.

We explored several covariates. Place of residence was split into urban and rural settings; a wealth index based on asset ownership and household characteristics data (categorised using the quintiles 'poorest', 'poorer', 'middle', 'richer' and 'richest') was considered as a proxy for socio-economic status[14]. As for literature[15], educational attainment was stratified in '0–6 years' and '>6 years'.

Statistical analysis

We use counts and percentages to describe the distribution of anaemia and BMI among 15–19 years old by residence, wealth and education, both for the India 2005 and the India 2015 DHS.

Chi-squared or Fisher exact and trend *P*-value tests were utilised to evaluate differences across the levels of the covariates. To evaluate the risk of anaemia by adolescent nullipara women *v.* older nullipara women, we computed unadjusted and adjusted OR by logistic regression. For multivariable analysis, we adjusted for residence, wealth and education. Within-DHS correlation was controlled for by running a non-linear mixed logistic random effect model[16].

We used Stata v13.1 SE (StataCorp. LP.) for statistical analysis.

Results

Anaemia prevalence among 696 adolescent girls in the India 2005 DHS ranged from around 61·7 % (*n* 87) in the

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Table 1 Prevalence of anaemia and BMI < 18·5 by wealth, residence and schooling among 696 nullipara adolescent girls of the India 2005 DHS and from 3401 nullipara adolescent girls of the India 2015 DHS

	India 2005							India 2015						
		Anaemia			BMI < 18·5				Anaemia			BMI < 18·5		
Factors	Total (*n* 696)	*n*	%	*P*	*n*	%	*P*	Total (*n* 3041)	*n*	%	*P*	*n*	%	*P*
Wealth														
Poorest	141	87	61·7	0·001	31	22·0	0·001	844	474	56·2	0·001	148	17·6	0·001
Poorer	146	83	56·8		32	21·9		927	453	48·9		175	18·9	
Middle	162	91	56·2		30	18·5		647	322	49·8		94	14·5	
Richer	161	84	52·2		29	18·0		430	200	46·5		69	16·1	
Richest	86	43	50·0		12	14·0		193	75	38·9		23	12·0	
Residence														
Urban	199	107	53·8	0·506	37	18·6	0·600	512	241	47·1	0·131	80	15·7	0·001
Rural	497	281	56·5		97	19·5		2529	1283	50·7		429	17·0	
Education														
0/6 years	385	223	57·9	0·199	83	21·6	0·030	991	536	54·1	0·002	174	17·6	0·001
>6 years	311	165	53·1		51	16·4		2050	988	48·2		335	16·3	

poorest wealth level to 50·0 % in the richest (*n* 43). Likewise, the low BMI prevalence significantly decreased with increasing wealth, from 22·0 % (*n* 31) to 14·0 % (*n* 12). While non-significant changes in anaemia prevalence were found when exploring residence (urban *v*. rural), stratification by years of schooling showed significant reduction of anaemia prevalence and low BMI with higher number of years of schooling (Table 1).

Findings from the India 2015 sample (3041 adolescent girls) showed a very similar trend. Prevalence of anaemia among the poorest and the richest was respectively 56·2 % (*n* 474) and 38·9 % (*n* 75). Also, a BMI < 18·5 significantly decreased from 17·6 % (*n* 148) to 12·0 % (*n* 23). Anaemia and BMI < 18·5 were significantly higher in adolescent girls living in rural areas and with fewer years of schooling (Table 1).

The 10-year transition from the 2005 to the 2015 DHS registered important improvements in terms of decreased anaemia prevalence, across all wealth categories. However, the time trend clearly shows the differences between the poorest and richest section of the society, with heaviest gains in anaemia reduction over time among the latter (from 50·0 to < 40·0 %) (Fig. 1). BMI also improved over the years, although much less in comparison with anaemia.

The prevalence trend stratified by education showed steady improvement, especially for anaemia, from 2005 to 2015 (Fig. 2). The reduction was slightly more pronounced among adolescent girls with more than 6 years of schooling (from around 55·0 % in 2005 to < 50·0 % in 2015).

Differences in the distribution of anaemia and low BMI held stable when investigating the place of residence (Fig. 3). While both indicators (anaemia and BMI) slightly improved from 2005 to 2015, adolescent girls living in rural areas showed higher prevalence of both anaemia and BMI < 18·5.

At multivariable regression, the odds of anaemia were significantly higher among the adolescent population

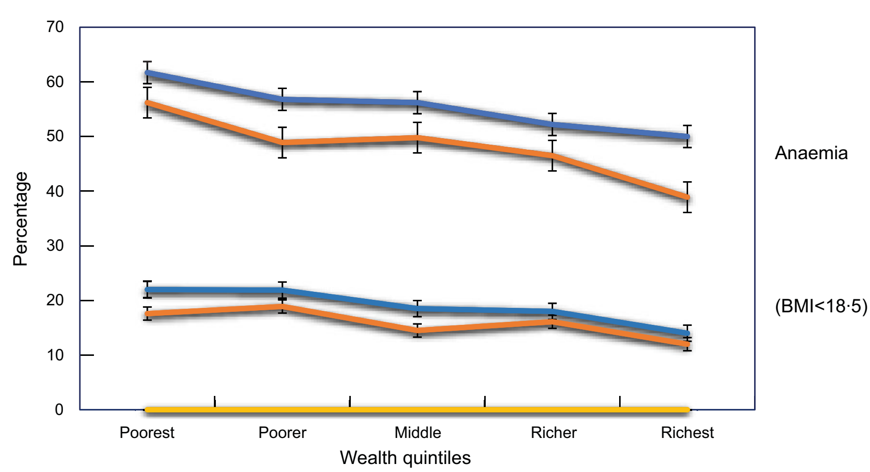

Fig. 1 Prevalence trend of anaemia and low BMI prevalence across wealth categories among nullipara adolescent girls in India from 2005 to 2015. —, 2000; —, 2015

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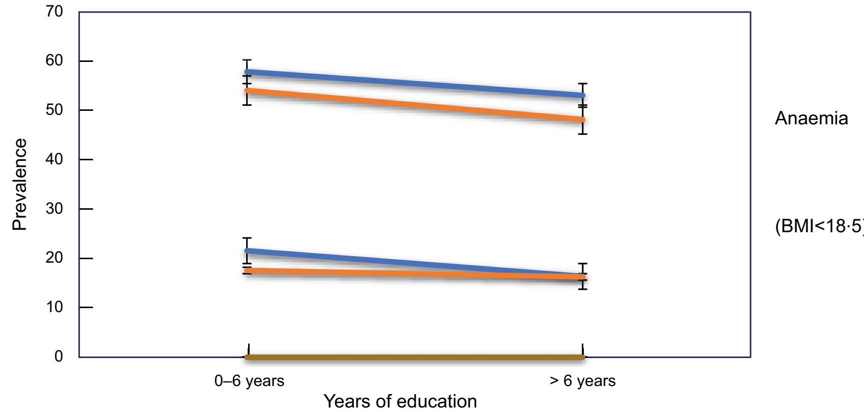

Fig. 2 Prevalence trend of anaemia and low BMI prevalence across education categories among nullipara adolescent girls in India from 2005 to 2015. —, 2000; —, 2015

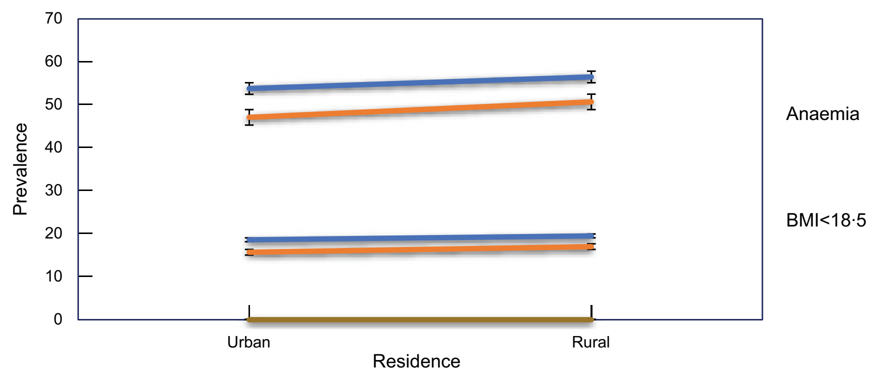

Fig. 3 Prevalence trend of anaemia and low BMI prevalence across residence categories among nullipara adolescent girls in India from 2005 to 2015. —, 2000; —, 2015

Table 2 Multivariable logistic model of anaemia (≥12·0 *v.* <12·0 g/dl) in adolescent girls compared with adult women for the India 2005 and the India 2015 DHS (model adjusted for age, place of residence, BMI, education)

		Hb					
	Age group	<12·0 g/dl	≥12·0 g/dl	OR	Range	*aOR	Range
India 2005	20–49 years	599	624	Reference		Reference	
	15–19 years	388	308	1·31	1·09–1·54	1·19	1·05–1·37
India 2015	20–49 years	4037	5292	Reference		Reference	
	15–19 years	1524	1517	1·32	1·19–1·43	1·16	1·03–1·31

*Logistic regression adjusted by wealth, education, residence and BMI.

when compared with adult women and the findings were almost the same when evaluating the India DHS 2005 and the India DHS 2015 (Table 2).

Discussion

Individual level data analysis using the two-consecutive population-based nationally representative India DHS surveys (2005 and 2015) revealed an overall improvement in both the prevalence of anaemia (from 55·6 to 50·1 %) and of BMI < 18·5 (from 19·2 to 16·7 %) for adolescent nullipara girls. Improvements in the level of anaemia were registered for almost all categories taken into consideration, particularly wealth and residence; on the other hand, the inequalities evidenced during the first round of DHS were also reported in the 2015 survey.

The impact of socio-demographic index on the variability years lived with disability (YLD) rates due to iron

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deficiency anaemia was confirmed on a global scale by the Global Burden of Disease project[17]. In 2016, iron deficiency anaemia showed a large decline in the expected YLD estimates with enhancing socio-demographic index [17].

The present study also confirms in both DHS surveys how adolescent nullipara girls are at significant higher risk of anaemia when compared with their adult counterparts. This last finding is in line with adolescent girls' physiology: iron requirements of 14-year-old girls are 30 % higher than the ones of their mothers[18]; in addition, energetic, proteic and mineral requirements increase significantly during adolescence due to rapid somatic growth and the beginning of menses. On the other hand, several factors like psychological changes and changes in eating habits also due to the influence of media and peer pressure contribute to make young girls vulnerable to diet-related anaemia[19].

Iron deficiency anaemia was among the ten causes with larger prevalence on a global scale in 2016, with 1·24 (1·21–1·28) billion prevalent cases, and among the seven main causes of YLD in the same year, contributing to 34·7 million (23·0–49·6 million (4·3 %, 3·5–5·2)) YLD[17]. In thirty-four out of 195 countries/territories, iron deficiency anaemia was the leading cause of age-standardised YLD rates for women in 2016. However, considering only low- and middle-income countries, iron deficiency anaemia was by far the leading cause of YLD in 2016, primarily in India, Bhutan, Sudan, Yemen and Mali[17]. In India and Bhutan, YLD due to iron deficiency anaemia was much higher than expected in 2016[17].

With more than 70 % of its women and children being anemic, India has the highest prevalence in the world[20], and up to 90 % of anaemia cases are estimated to be the result of iron deficiency[21], traditionally due to a diet based on a high consumption of cereals (which inhibit absorption of iron) and inadequate consumption of meat and vitamin C-rich foods (which enhance absorption of iron)[22]. Further factors contributing to anaemia in India are illiteracy, poor nutrition education, cultural taboos and social norms as women 'eating last'[20].

Despite Indian governments starting since the 1970s policies targeting nutrition education like the National Rural Health Mission and the National Nutritional Anemia Prophylaxis Programme, anaemia continues to remain a public health concern in the country. The recently released 'Adolescents, Diets and Nutrition: Growing Well in a Changing World' UNICEF report revealed that the governmental nutritional schemes are not reaching the adolescents, namely almost 25·0 % of girls do not receive any of the four school-based services (mid-day meal, biannual health check-ups, biannual deworming and weekly iron folic acid supplementation). Also, the report underlines how adolescent girls suffer from multiple nutritional deprivations when compared with young boys and investing on adolescent girls is crucial to break India's intergenerational cycle of malnutrition[23].

Overall, in low- and middle-income countries, 12 % low birth weight, 19 % preterm births and 18 % perinatal mortality are estimated to be linked to maternal anaemia[24]. Despite severely impacting the course and outcome of their pregnancies, women of low-income countries as India affected by iron deficiency anaemia may be unaware of their nutritional status during gestations. Universal health care coverage, with implementation of accessible and affordable primary health care, including reproductive health services, would ensure women to understand their nutritional status and adopt earlier measures to minimise the health risks associated with anaemia during their pregnancies[24].

The present study has several strengths. DHS questionnaires are standardised and pre-tested to ensure comparability over time and across populations; national coverage and response rates typically exceeding 90 %, together with standard collection procedures, guarantee reliability and representativeness of health status in a broad range of low- and middle-income countries[25].

The use of the outcome anaemia represents another strength as it is an objective measure, minimising the risk for bias.

The current study also has several limitations. No information was available regarding medical conditions causing iron deficiency anaemia such as haematological disorders, malaria and other infections. Similarly, no information was available for other conditions leading to iron deficiency, such as excessive menstrual blood loss and intensive physical activity. Furthermore, we were not able to control for dietary habits either.

In our analysis, we did not distinguish between girl users of contraception and non-users, especially in regard to oral contraception, which has been found to be protective against anaemia in the long run[26].

Conclusions

Despite an overall improvement in the prevalence of both BMI $< 18·5$ and anaemia among nullipara adolescents in India, the risk of anaemia in this category was still significantly higher when compared with their adult counterparts. While the change in the prevalence of BMI $< 18·5$ from 2005 to 2015 was influenced by all factors examined (wealth, years of schooling and residence), only wealth and years of schooling had a significant impact on the improvement of anaemia over time.

Since the inequalities evidenced during the first round of DHS remained unchanged in 2015, and since a lower socio-demographic index was consistently associated with anaemia and BMI $< 18·5$ in both surveys, more investments in universal health care are needed in India, with implementation of accessible primary care services enabling women to monitor their nutritional status and adopt prompt measures to minimise the health risks associated with eventual anaemia during their pregnancies.

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References

1. Goddard AF, James MW, McIntyre AS *et al.* (2011) British society of gastroenterology. Guidelines for the management of iron deficiency anemia. *Gut* **60**, 1309–1316.
2. Azzopardi PS, Hearps SJC, Francis KL *et al.* (2019) Progress in adolescent health and wellbeing: tracking 12 headline indicators for 195 countries and territories, 1990–2016. *Lancet* **393**, 1101–1118.
3. Kassebaum NJ (2016) GBD 2013 anemia collaborators. The global burden of anemia. *Hematol Oncol Clin North Am* **30**, 247–308.
4. Ghose B, Yaya S & Tang S (2016) Anemia status in relation to body mass index among women of childbearing age in Bangladesh. *Asia Pac J Public Health* **28**, 611–619.
5. Black RE, Victora CG, Walker SP *et al.* (2013) Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* **382**, 427–451.
6. Akseer N, Al-Gashm S, Mehta S *et al.* (2017) Global and regional trends in the nutritional status of young people: a critical and neglected age group. *Ann N Y Acad Sci* **1393**, 3–20.
7. Lewkowitz AK & Tuuli MG (2019) Iron-deficiency anemia in pregnancy: the role of hepcidin. *Lancet Glob Health* **7**, e1476–e1477.
8. Peña-Rosas JP, De-Regil LM, Garcia-Casal MN *et al.* (2015) Daily oral iron supplementation during pregnancy. *Cochrane Database Syst Rev* **7**, CD004736.
9. Nguyen PH, Scott S, Avula R, Tran LM *et al.* (2018) Trends and drivers of change in the prevalence of anemia among 1 million women and children in India, 2006–2016. *BMJ Glob Health* **3**, e001010.
10. Petry N, Olofin I, Hurrell RF *et al.* (2016) The proportion of anemia associated with iron deficiency in low, medium, and high human development index countries: a systematic analysis of national surveys. *Nutrients* **8**, 693.
11. Rustein SO & Rojas G (2003) *Guide to DHS Statistics*. Calverton, MD: ORC Macro, MEASURE DHS+.
12. MEASURE DHS/ICF International (2012) *Sampling and Household Listing Manual: Demographic and Health Surveys Methodology*. Calverton, MD: DHS/ICF International.
13. Kothari MT, Coile A, Huestis A *et al.* (2019) Exploring associations between water, sanitation, and anemia through 47 nationally representative demographic and health surveys. *Ann N Y Acad Sci* **1450**, 249–267.
14. Corsi DJ, Neuman M, Finlay JE *et al.* (2012) Demographic and health surveys: a profile. *Int J Epidemiol* **41**, 1602–1613.
15. Ackerson LK, Kawachi I, Barbeau EM *et al.* (2008) Effects of individual and proximate educational context on intimate partner violence: a population-based study of women in India. *Am J Public Health* **98**, 507–514.
16. Donner A & Klar N (1994) Methods for comparing event rates in intervention studies when the unit of allocation is a cluster. *Am J Epidemiol* **140**, 279–289.
17. GBD 2016 Disease and Injury Incidence and Prevalence Collaborators (2017) Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet* **390**, 1211–1259.
18. Hallberg L (2001) Perspectives on nutritional iron deficiency. *Annu Rev Nutr* **21**, 1–21.
19. Mariath AB, Henn R, Matos CH *et al.* (2006) Prevalence of anemia and hemoglobin serum levels in adolescents according to sexual maturation stage. *Rev Bras Epidemiol* **9**, 454–461.
20. Gupta S, Pingali P & Pinstrub-Andersen P (2019) Women's empowerment and nutrition status: the case of iron deficiency in India. *Food Policy* **88**.
21. Thankachan P, Muthayya S, Walczyk T *et al.* (2007) An analysis of the etiology of anemia and iron deficiency in young women of low socioeconomic status in Bangalore, India. *Food Nutr Bull* **28**, 328–336.
22. Underwood BA (2002) Health and nutrition in women, infants, and children: overview of the global situation and the Asian enigma. *Nutr Rev* **60**, Suppl. 2, S7–S13.
23. UNICEF (2020) Adolescent nutrition. *Investing in an Age of Opportunity to Break Cycles of Poverty and Inequity*. UNICEF; available at http://www.Unicef.org/india/what-we-do/adolescent-nutrition (accessed July 2020).
24. Rahman MM, Abe SK, Rahman MS *et al.* (2016) Maternal anemia and risk of adverse birth and health outcomes in low- and middle-income countries: systematic review and meta-analysis. *Am J Clin Nutr* **103**, 495–504.
25. Pullum TW (2008) *An Assessment of the Quality of Data on Health and Nutrition in the DHS Surveys, 1993–2003*. Calverton, MD: Macro International Inc.
26. Bellizzi S & Ali MM (2018) Effect of oral contraception on anemia in 12 low- and middle-income countries. *Contraception* **97**, 236–242.