Anaemia among men in India: a nationally representative cross-sectional study

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Summary

Background Population-based studies on anaemia in India have mostly focused on women and children, with men with anaemia receiving much less attention despite anaemia's adverse effect on health, wellbeing, and economic productivity. This study aimed to determine the national prevalence of anaemia among men in India; how the prevalence of anaemia in men varies across India among states and districts and by sociodemographic characteristics; and whether the geographical and sociodemographic variation in the prevalence of anaemia among men is similar to that among women to inform whether anaemia reduction efforts for men should be coupled with existing efforts for women.

Methods In this cross-sectional study, we analysed data from a nationally representative household survey carried out from January, 2015, to December, 2016, among men aged 15–54 years and women aged 15–49 years in all 29 states and seven Union Territories of India. Haemoglobin concentration was measured using the portable HemoCue Hb 201+ (HemoCue AB, Ängelholm, Sweden) and a capillary blood sample. In addition to disaggregating anaemia prevalence (separately in men and women) by state and age group, we used mixed-effects Poisson regression to determine individual-level and district-level predictors of anaemia.

Findings 106 298 men and 633 305 women were included in our analysis. In men, the prevalence of any anaemia was 23·2% (95% CI 22·7–23·7), moderate or severe anaemia was 5·1% (4·9–5·4), and severe anaemia was 0·5% (0·5–0·6). An estimated 21·7% (20·9–22·5) of men with any degree of anaemia had moderate or severe anaemia compared with 53·2% (52·9–53·5) of women with any anaemia. Men aged 20–34 years had the lowest probability of having anaemia whereas anaemia prevalence among women was similar across age groups. State-level prevalence of any anaemia in men varied from 9·2% (7·7–10·9) in Manipur to 32·9% (31·0–34·7) in Bihar. The individual-level predictors of less household wealth, lower education, living in a rural area, smoking, consuming smokeless tobacco, and being underweight and the district-level predictors of living in a district with a lower rate of primary school completion, level of urbanisation, and household wealth were all associated with a higher probability of anaemia in men. Although some important exceptions were noted, district-level and state-level prevalence of anaemia among men correlated strongly with that among women.

Interpretation Anaemia among men in India is an important public health problem. Because of the similarities in the patterns of geographical and sociodemographic variation of anaemia between men and women, future efforts to reduce anaemia among men could target similar population groups as those targeted in existing efforts to reduce anaemia among women.

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Introduction

An estimated 1·9 billion people—27% of the world's population—had anaemia in 2013.[1] Hence, anaemia is a major public health issue, and particularly so in low-income and middle-income countries where 93% of all cases of anaemia globally are thought to occur.[1] Studies on anaemia in low-income and middle-income countries have focused on women of reproductive age and their children because anaemia during pregnancy and early childhood is associated with important adverse effects for the child—including low birthweight,[2] poor mental and motor development,[3] and mortality[4]—and for the mother, particularly maternal mortality.[5] By contrast, anaemia in men has been studied much less extensively. Yet, anaemia in this population group is not inconsequential because the condition can cause fatigue, difficulty concentrating, and lethargy, which does not only reduce quality of life but is also thought to decrease economic productivity.[6]

Anaemia can have a variety of causes, including nutrient deficiencies, acute and chronic infections, and genetic haemoglobin disorders.[7] Although the degree to which anaemia in a population can be attributed to these causes varies across populations,[8] most cases of anaemia globally are thought to be due to iron deficiency, which can be prevented and treated effectively using iron

Research in context

Evidence before this study

We searched MEDLINE for articles with an English abstract published between Jan 1, 1966, and Aug 31, 2019, using the search terms "anaemia", "India", and "men". Of the studies we identified, those from India reporting on prevalence of anaemia among men used small health-care facility-based samples, which are unlikely to be representative of the general population, or were restricted to a specific area within one state of India. Large-scale population-based studies on anaemia in India have thus far focused on children and women of childbearing age.

Added value of this study

This study improves the existing evidence base in four important ways. First, we were able to estimate the prevalence of anaemia among men aged 15–54 years in India at the national level using a nationally representative household survey. Second, with data for each of India's states and Union Territories, we were able to estimate the state-level variation in the prevalence of anaemia among men in India, which is important for state governments. Third, because we had data from each of India's districts, we were able to identify both individual-level and district-level predictors of anaemia among men; information that can be of use for the targeting of appropriate interventions to those most in need. Finally, this study had data for both men and women from the same survey, so we were able to estimate to what degree state-level and district-level prevalence of anaemia among men aged 15–54 years correlates with that among women aged 15–49 years, and examined the association between anaemia and sociodemographic characteristics separately by sex. These analyses can inform whether anaemia programmes for men could target the same states, districts, and socioeconomic groups as programmes that already exist for women.

Implications of all the available evidence

While varying widely among states, the prevalence of anaemia among men aged 15–54 years in India is high, with almost one in four men estimated to have anaemia (whether mild, moderate, or severe). Given the substantial burden of anaemia on quality of life and economic productivity, efforts to reduce anaemia in India should not ignore men. Moving forward, coupling efforts to reduce anaemia among men with existing ones that target women could be particularly cost-effective for policy makers in India because district-level prevalence of anaemia among men was highly correlated with that among women, and the population groups within districts that tended to have anaemia were similar between men and women. More research is needed to identify how men can best be reached with anaemia prevention and treatment programmes.

supplementation and food fortification.[7] Similarly, inexpensive treatments exist for many other common causes of anaemia, especially anaemia caused by vitamin B12 or folic acid deficiency and by infection with intestinal nematodes.[9,10]

India is thought to account for approximately a quarter of all cases of anaemia globally.[11] Although some studies have examined anaemia among women of reproductive age and children younger than 5 years in India,[12,13] the evidence base on anaemia among men in India is much more sparse. Understanding the prevalence of anaemia in men and how it varies between population groups in this large and heterogeneous country is crucial to inform relevant health policy and health service interventions. If the patterns of variation in anaemia prevalence in India are similar among men and women, then integration of efforts to reduce anaemia in men with ongoing anaemia prevention and treatment programmes that are currently focusing on women could be an effective approach. This logistical integration of services could reduce costs through economies of scale and avoid fragmentation of the public health system into separate vertical programmes that are typically prone to poor inter-programme coordination.

This study aims to address the gap in the literature on anaemia prevalence among men in India and compare the patterns of variation of anaemia prevalence in India between men and women. Specifically, we aimed to determine the prevalence of anaemia among men in India, how the prevalence among men varies by sociodemographic and geographical characteristics, and to what degree the distribution by sociodemographic and geographical characteristics of anaemia among men in India is similar to that among women.

Methods

Study design and population

In this nationally representative cross-sectional study, we analysed data from India's fourth National Family Health Survey (NFHS-4), which was carried out from Jan 20, 2015, to Dec 4, 2016, in all 29 states and seven Union Territories of the country and is available in the public domain.[14] The NFHS-4 was designed to be representative for each of India's over 600 districts for key indicators including anaemia. It was undertaken using a two-stage sampling strategy. In the first stage, 28 586 primary sampling units (census enumeration blocks in urban areas and villages in rural areas) were selected with probability proportional to population size, with population sizes determined using the 2011 census count data. After undertaking a complete mapping of all households located in each selected primary sampling unit, primary sampling units that contained fewer than 40 households were merged with the nearest primary sampling unit and every primary sampling unit that contained more than 300 households was split into two separate units.[14] In the second stage, 22 households were selected in each primary sampling unit using systematic

random sampling. All women aged 15–49 years in the selected households were invited to participate in the survey. Men aged 15–54 years were invited to participate in a random subsample of 15% of these households. The choice to sample more women than men in the NFHS-4 was made because of the survey's primary focus on maternal and child health. The household response rate was 97·6%, and the individual response rate was 91·9% among men and 96·7% among women.[14]

Our analysis of this existing dataset in the public domain received a determination of "not human subjects research" by the institutional review board of the Harvard T. H. Chan School of Public Health on May 9, 2018, and so did not require a full ethical review.

Measurement of anaemia

The NFHS-4 measured haemoglobin concentration in all participating adults using a capillary blood sample from a finger prick, which was then analysed using the portable HemoCue Hb 201+ device (HemoCue AB, Ängelholm, Sweden). More details on how haemoglobin was measured are in the appendix (p 2). Following WHO's recommendations,[15] anaemia in men was categorised as any anaemia if their haemoglobin concentration was lower than 13·0 g/dL, moderate or severe if it was lower than 11·0 g/dL, and severe if it was lower than 8·0 g/dL. Anaemia in non-pregnant women was defined as any anaemia if their haemoglobin concentration was below 12·0 g/dL, moderate or severe if it was below 11·0 g/dL, and severe if it was below 8·0 g/dL. Haemoglobin concentrations of all participants were adjusted for smoking status and altitude before applying these cutoffs using formulae provided by the US Centers for Disease Control and Prevention.[14,16] Smoking status was ascertained through self-report. Altitude was measured separately for each primary sampling unit by the survey team (using global positioning satellite devices) and recorded in m above sea level.[17] Pregnancy status of women was ascertained by self-report.

Independent variables

We included all independent variables from the NFHS-4 we thought could be used for the targeting of anaemia prevention and treatment efforts and that could be ascertained by health-care workers without needing to undertake physical or laboratory measurements. The independent variables we used were household wealth quintile, educational attainment, marriage status, geographical location (ie, state or district, and whether the household was located in a rural or urban area), body-mass index (BMI) group, current smoking, current consumption of smokeless tobacco, and alcohol consumption. BMI was included in our analysis as broad categories (<16·0 kg/m², 16·0–17·9 kg/m², 18·0–22·9 kg/m², 23·0–24·9 kg/m², 25·0–27·4 kg/m², 27·5–29·9 kg/m², and ≥30·0 kg/m²) under the rationale that broad BMI groups can be assessed visually without needing to do an exact measurement. The NFHS-4 team used a SECA 874 U digital floor scale (seca GmbH, Hamburg, Germany) for weighing participants and a SECA 213 stadiometer (seca GmbH, Hamburg, Germany) to measure the height of adults.

The NFHS-4 team created household wealth quintiles on the basis of a continuous household wealth index, which was the first (unrotated) component from a principal components analysis that used respondents' answers to six key housing characteristics and household ownership of 25 durable goods. Both the continuous household wealth index and categorisation into quintiles were calculated separately for rural and urban areas. More information on the creation of the household wealth quintiles is in the appendix [pp 3–4]. The survey asked participants whether they currently smoke cigarettes or bidis, or smoke or use tobacco in any other form.

Statistical analysis

We set haemoglobin values above 20 g/dL or below 4 g/dL as missing under the assumption that these extreme values are likely due to measurement error. Pregnant women and household visitors were also excluded from the analysis. Hence, our sample size is smaller than that of the official NFHS-4 report.[14]

See **Online** for appendix

	Total (n=739 715)	Men (n=106 410)	Women (n=633 305)
Anaemia severity group			
Any anaemia	342 677 (46·3%)	23 981 (22·5%)	318 696 (50·3%)
Moderate or severe anaemia	173 913 (23·5%)	5066 (4·8%)	168 847 (26·7%)
Severe anaemia	14 180 (1·9%)	513 (0·5%)	13 667 (2·2%)
Age, years			
15–19	132 214 (17·9%)	18 029 (16·9%)	114 185 (18·0%)
20–24	116 355 (15·7%)	15 581 (14·6%)	100 774 (15·9%)
25–29	113 574 (15·4%)	15 194 (14·3%)	98 380 (15·5%)
30–34	102 903 (13·9%)	13 868 (13·0%)	89 035 (14·1%)
35–39	99 447 (13·4%)	13 279 (12·5%)	86 168 (13·6%)
40–44	85 637 (11·6%)	11 468 (10·8%)	74 169 (11·7%)
45–49	81 324 (11·0%)	10 730 (10·1%)	70 594 (11·1%)
50–54	8261 (1·1%)	8261 (7·8%)	NA
Household wealth quintile			
Quintile 1 (poorest)	137 623 (18·6%)	17 629 (16·6%)	119 994 (18·9%)
Quintile 2	157 743 (21·4%)	22 190 (20·9%)	135 553 (21·4%)
Quintile 3	157 173 (21·2%)	23 179 (21·8%)	133 994 (21·2%)
Quintile 4	147 916 (20·0%)	22 071 (20·7%)	125 845 (19·9%)
Quintile 5 (richest)	139 260 (18·8%)	21 341 (20·0%)	117 919 (18·6%)
Education			
No formal schooling	195 963 (26·5%)	14 387 (13·5%)	181 576 (28·7%)
Some primary school	44 517 (6·0%)	6985 (6·6%)	37 532 (5·9%)
Completed primary school	49 413 (6·7%)	6771 (6·4%)	42 642 (6·7%)
Some secondary school	297 481 (40·2%)	49 888 (46·9%)	247 593 (39·1%)
Completed secondary school	66 146 (8·9%)	12 027 (11·3%)	54 119 (8·5%)
More than secondary school	86 195 (11·7%)	16 352 (15·4%)	69 843 (11·0%)

(Table 1 continues on next page)

	Total (n=739 715)	Men (n=106 410)	Women (n=633 305)
(Continued from previous page)			
Body-mass index, kg/m²			
<16·0	26 899 (3·6%)	3011 (2·8%)	23 888 (3·8%)
16·0–17·9	97 888 (13·2%)	12 343 (11·6%)	85 545 (13·5%)
18·0–22·9	374 689 (50·7%)	54 362 (51·1%)	320 327 (50·6%)
23·0–24·9	93 170 (12·6%)	15 982 (15·0%)	77 188 (12·2%)
25·0–27·4	68 017 (9·2%)	10 892 (10·2%)	57 125 (9·0%)
27·5–29·9	34 665 (4·7%)	4589 (4·3%)	30 076 (4·7%)
≥30·0	43 316 (5·8%)	5001 (4·7%)	38 315 (6·1%)
Data missing	1071 (0·1%)	230 (0·2%)	841 (0·1%)
Alcohol consumption			
Never	689 980 (93·3%)	72 883 (68·5%)	617 097 (97·5%)
Less than once a week	22 686 (3·1%)	14 928 (14·0%)	7758 (1·2%)
About once a week	20 327 (2·7%)	13 944 (13·1%)	6383 (1·0%)
Almost every day	6722 (0·9%)	4655 (4·4%)	2067 (0·3%)
Current smoking			
Yes	120 853 (16·3%)	52 667 (49·5%)	68 186 (10·8%)
No	618 862 (83·7%)	53 743 (50·5%)	565 119 (89·2%)
Consumption of smokeless tobacco			
Yes	92 652 (12·5%)	34 832 (32·7%)	57 820 (9·1%)
No	647 063 (87·5%)	71 578 (67·3%)	575 485 (90·9%)
Location			
Rural area	512 470 (69·3%)	73 073 (68·7%)	448 406 (70·8%)
Urban area	227 245 (30·7%)	33 337 (31·3%)	184 899 (29·2%)
Marriage status			
Currently married	510 161 (69·0%)	67 025 (63·0%)	443 136 (70·0%)
Not currently married*	229 554 (31·0%)	39 385 (37·0%)	190 169 (30·0%)

Data are n (%). All estimates shown here are unweighted. NA=not applicable. *Not currently married includes the questionnaire response options of never married, separated, divorced, widowed, and deserted.

Table 1: **Demographic characteristics of analysable survey participants**

Separately for men and women, we estimated the prevalence of any anaemia, moderate or severe anaemia, and severe anaemia nationally, and then by age group and by state. We used sampling weights in these prevalence estimates to account for the survey design. Because of the small number of men sampled in Union Territories, we focused on states for our analysis of the geographical variation of prevalence of anaemia.

We calculated age-standardised prevalence estimates (which we used to compare anaemia prevalence between states) using sampling weights that were—separately for men and women—additionally weighted to the age distribution of the Indian population in 2013 (estimated using the population estimates of the Global Burden of Disease project for 2015).[18]

To identify whether states' wealth and expenditure on health explained differences in anaemia prevalence between states, we plotted state-level anaemia prevalence against states' gross domestic product (GDP) per capita and total public health expenditure. States' total health expenditure for 2013–14 was obtained from the Takshashila Institution and GDP data for 2013–14 from the Indian Central Statistics Office.[19,20] Indian Rupee values were converted to 2015 international dollars. Additionally, for each anaemia severity group, we plotted the district-level prevalence of anaemia among men against that among women to ascertain to what degree district-level anaemia prevalence is similar between both sexes.

Finally, separately for men and women, we regressed each anaemia severity group (any anaemia, moderate or severe anaemia, and severe anaemia) onto individuals' sociodemographic characteristics, BMI group, smoking status, current consumption of smokeless tobacco, alcohol consumption, and three district-level variables using mixed-effects Poisson regression with a robust error structure. We used three district-level variables: the proportion of the sampled participants (including both men and women) in a district who completed primary school, the proportion living in an urban area, and the district-level median of the continuous household wealth index (hereafter referred to as median household wealth) that we used to categorise households into wealth quintiles. We calculated the median household wealth jointly for rural and urban areas in a district for these regressions, but we also show the same regressions (run separately for urban and rural areas) when the median was calculated separately in rural and urban areas. We standardised all district-level variables to ease interpretation and comparability by subtracting the mean of the variable and dividing by two SDs. We included these district-level variables to determine to what degree district-level development and urbanisation predict prevalence of anaemia and could thus be used for the geographical targeting of prevention and treatment programmes for anaemia. We chose these three variables because they could be calculated directly from the data, avoiding the need to rely on the quality of other data sources. We chose to fit unadjusted rather than multivariable regressions because we aimed to determine whether the independent variables predict (but not necessarily cause) anaemia. However, given the comparatively strong association between age and anaemia (and between age and other independent variables, such as education), we adjusted all regressions (except when age group was the independent variable) for continuous age, allowing for non-linearities in age with restricted cubic splines with five knots placed at the fifth, 27·5th, 50th, 72·5th, and 95th percentiles. We included a random intercept for each district and additionally adjusted SEs for clustering at the district level. We chose Poisson rather than logistic regression to obtain the more easily interpretable risk ratio.

p values of less than 0·05 were considered significant. We did all analyses using R (version 3.5.2) and Stata (version 15).

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing

	Any anaemia		Moderate or severe anaemia		Severe anaemia	
	Male	Female	Male	Female	Male	Female
Age group prevalence, years						
15–19	29·3% (28·3–30·4)	53·9% (53·4–54·4)	5·7% (5·2–6·2)	27·9% (27·5–28·4)	0·5% (0·4–0·7)	2·2% (2·1–2·3)
20–24	18·4% (17·4–19·3)	53·5% (53·0–54·0)	4·1% (3·6–4·6)	28·6% (28·2–29·1)	0·3% (0·2–0·4)	2·2% (2·1–2·3)
25–29	19·2% (18·2–20·2)	52·7% (52·2–53·3)	4·0% (3·6–4·5)	28·0% (27·5–28·4)	0·4% (0·3–0·5)	2·1% (2·0–2·2)
30–34	19·9% (18·8–20·9)	51·7% (51·2–52·3)	4·4% (3·8–5·0)	27·4% (26·9–27·9)	0·4% (0·3–0·6)	2·4% (2·2–2·6)
35–39	21·7% (20·6–22·9)	52·7% (52·2–53·2)	4·7% (4·1–5·2)	28·4% (27·9–28·9)	0·5% (0·3–0·7)	2·5% (2·4–2·7)
40–44	23·1% (22·0–24·3)	53·2% (52·6–53·7)	5·5% (4·9–6·1)	29·6% (29·0–30·1)	0·6% (0·4–0·7)	2·8% (2·6–3·0)
45–49	26·0% (24·7–27·3)	52·3% (51·7–52·9)	6·0% (5·4–6·6)	28·1% (27·5–28·6)	0·7% (0·5–0·9)	2·6% (2·4–2·8)
50–54	29·8% (28·3–31·3)	NA	7·8% (6·9–8·6)	NA	1·0% (0·7–1·3)	NA
Total population						
Crude prevalence	23·2% (22·7–23·7)	52·9% (52·6–53·2)	5·1% (4·9–5·4)	28·2% (28·0–28·5)	0·5% (0·5–0·6)	2·4% (2·3–2·4)
Age-standardised prevalence	23·0% (22·5–23·5)	53·0% (52·7–53·3)	5·0% (4·8–5·2)	28·2% (28·0–28·4)	0·5% (0·4–0·6)	2·3% (2·3–2·4)

Data are prevalence with 95% CIs in parentheses. Prevalences are weighted to account for survey design. NA=not applicable.

Table 2: **National prevalence of anaemia in India, by sex and age group and for total population**

of the report. The corresponding author had full access to the data in the study and had final responsibility for the decision to submit for publication.

Results

Of 112 122 men aged 15–54 years who completed the survey, 1911 (1·7%) were household visitors and 3801 (3·4%) had a missing haemoglobin measurement (of whom 121 had a haemoglobin measurement above 20 g/dL or below 4 g/dL, which we set to missing), leaving a sample for analysis of 106 410 men. For the comparison of anaemia prevalence between men and women, we had a sample of 667 265 non-pregnant women aged 15–49 years, of whom 19 807 (3·0%) were household visitors and 14 153 (2·1%) had a missing haemoglobin measurement (with 517 being set to missing due to the haemoglobin measurement being above 20 g/dL or below 4 g/dL), leaving a sample of 633 305 women for analysis. Men and women had similar demographic characteristics, except that men were less likely to be married and tended to have a higher educational attainment (table 1). 14 387 (13·5%) men and 181 576 (28·7%) women had no formal schooling. 512 470 (70·5%) participants lived in rural areas. Demographic characteristics for survey participants with a missing haemoglobin measurement are shown in the appendix (pp 5–6).

Among men, the crude prevalence of any anaemia was 23·2% (95% CI 22·7–23·7), moderate or severe anaemia was 5·1% (4·9–5·4), and severe anaemia was 0·5% (0·5–0·6; table 2). Anaemia prevalence, regardless of severity, was lowest among men aged 20–34 years. Anaemia prevalence was substantially higher among women than among men, with 52·9% (95% CI 52·6–53·2) having any anaemia, 28·2% (28·0–28·5) moderate or severe anaemia, and 2·4% (2·3–2·4) severe anaemia. Anaemia prevalence among women was similar across age groups. Thus, while only 21·7% (95% CI 20·9–22·5) of men with any anaemia had moderate or severe anaemia, this proportion was 53·2% (52·9–53·5) among women with any anaemia.

The age-standardised prevalence of anaemia among men varied widely between states (figure 1). Excluding Union Territories, it ranged from 9·2% (95% CI 7·7–10·9) in Manipur to 32·9% in Bihar (31·0–34·7) for any anaemia, from 1·1% (0·6–1·9) in Mizoram to 8·6% (6·7–10·9) in Meghalaya for moderate or severe anaemia, and from 0·1% (<0·1–0·2) in Mizoram to 0·9% (0·5–1·6) in Andhra Pradesh for severe anaemia (state-level prevalence estimates by age group, sex, and location are shown in the appendix [pp 9–30]). Generally, the pattern of variation in anaemia prevalence across states was similar for men and women. However, we noted the following exceptions: Haryana had one of the highest anaemia prevalence estimates among women but not among men; other than a high prevalence in Andhra Pradesh, and Meghalaya, relatively little variation exists between states in the prevalence of moderate or severe anaemia for men whereas considerable variation exists for women; and although women in Telangana and Andhra Pradesh had the highest prevalence of severe anaemia, the prevalence among men in these two states was similar to that in several other states. At the district level, the age-standardised prevalence of anaemia among men was highly correlated with that among women (figure 2).

A state's GDP per capita was not significantly associated with the state-level prevalence of any of the three categories of anaemia among men and women, except for a negative association with any anaemia among men (p=0·051; appendix pp 63–64). A state's public health expenditure per capita, however, was negatively associated with prevalence of anaemia for all three anaemia severity groups among both men and women (appendix pp 61–62).

In the regression analysis, men aged 20–34 years and men living in urban areas had the lowest probability of having any anaemia and moderate or severe anaemia (table 3). All three severity groups were negatively associated with household wealth and education. Likewise, smoking, consumption of smokeless tobacco, and being underweight (ie, BMI <18·0 kg/m²) were all associated with a higher risk of having anaemia for all anaemia severity groups. All three indicators of district-level development (proportion who completed primary education, proportion living in an urban area, and district-level median household wealth [calculated jointly for rural and urban areas]) were generally negatively associated with anaemia. The negative associations between district-level median household wealth and each anaemia severity group were stronger in rural areas than in urban areas (appendix p 68). The regression results among women were generally similar to those among men (appendix pp 65–67); however, among women, we found no substantial differences in the probability of having anaemia between age groups. Crude anaemia prevalence estimates disaggregated by sex, age group, location (rural or urban), and household wealth quintile or education are shown in the appendix (pp 7–8).

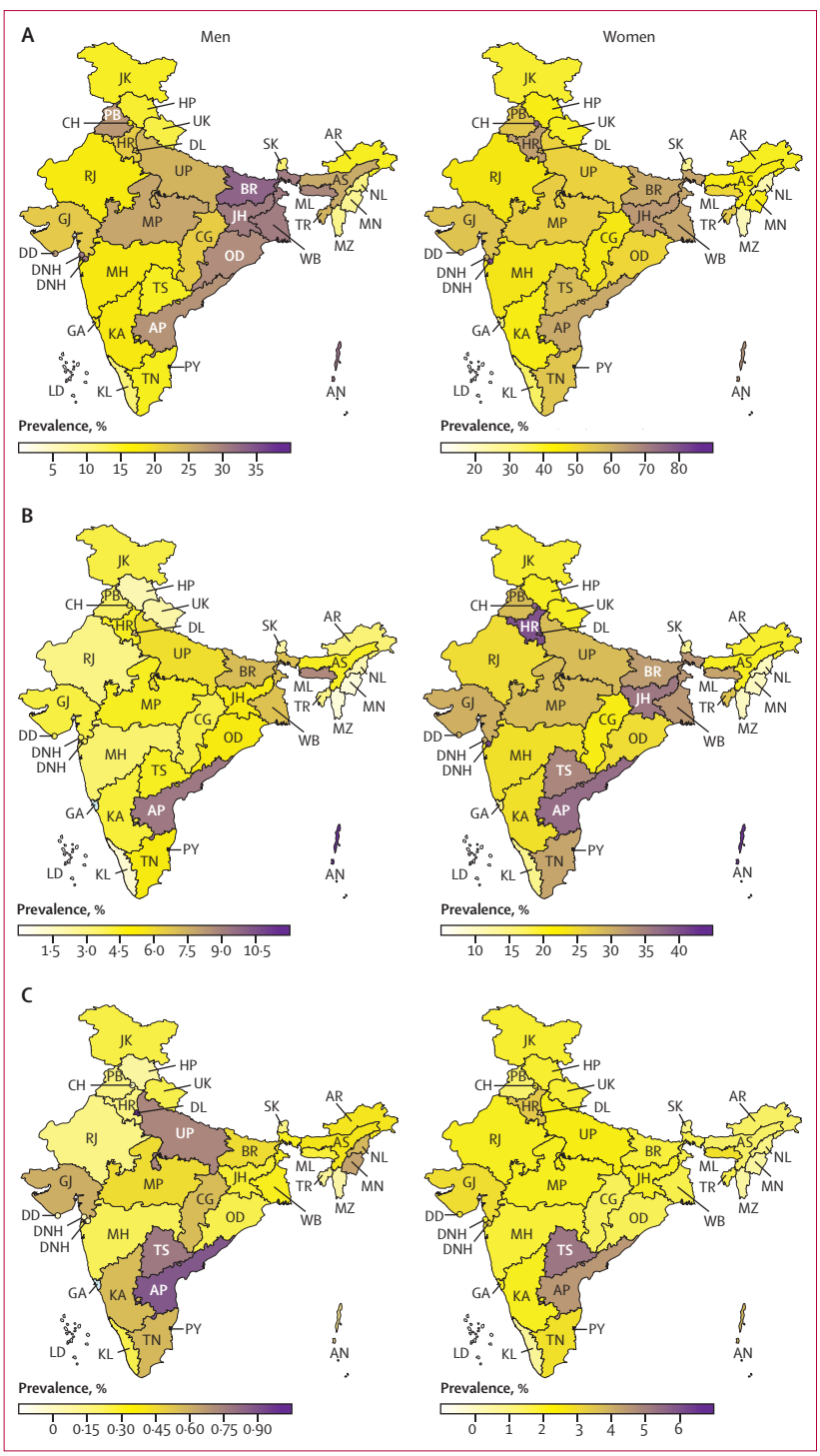

Figure 1: **Age-standardised prevalence of anaemia by state and sex**
Prevalence of any anaemia (A), moderate or severe anaemia (B), and severe anaemia (C). Point estimates and 95% CIs for each state and Union Territory disaggregated by sex, age group, and rural or urban location are in the appendix (pp 9–30). AN=Andaman and Nicobar Islands. AP=Andhra Pradesh. AR=Arunachal Pradesh. AS=Assam. BR=Bihar. CG=Chhattisgarh. CH=Chandigarh. DU=Daman and Diu. DL=Delhi. DNH=Dadra and Nagar Haveli. GA=Goa. GJ=Gujarat. HR=Haryana. HP=Himachal Pradesh. JH=Jharkhand. JK=Jammu and Kashmir. KA=Karnataka. KL=Kerala. LD=Lakshadweep. MP=Madhya Pradesh. MH=Maharashtra. MN=Manipur. ML=Meghalaya. MZ=Mizoram. NL=Nagaland. OD=Odisha (formerly Orissa). PB=Punjab. PY=Puducherry. RJ=Rajasthan. SK=Sikkim. TN=Tamil Nadu. TS=Telangana. TR=Tripura. UP=Uttar Pradesh. UK=Uttarakhand (formally Uttaranchal). WB=West Bengal.

Discussion

We found a substantial anaemia prevalence among men aged 15–54 years in India of 23·2% for any anaemia, 5·1% for moderate or severe anaemia, and 0·5% for severe anaemia. Notably, only 21·7% of men with anaemia had moderate or severe anaemia, which was substantially lower than the 53·2% among women with any anaemia. Anaemia prevalence among men varied widely between states and was more common among those with lower household wealth and education, in rural areas, smokers, consumers of smokeless tobacco, with a BMI of less than 18·0 kg/m², and living in districts with a lower primary school completion rate, level of urbanisation, and median household wealth. Anaemia was least common among men aged 20–34 years. Although prevalence of anaemia among men at the district level was highly correlated with that among women, we observed notable differences in the pattern of state-level variation of anaemia prevalence between the sexes. The variation in prevalence of anaemia by individual-level sociodemographic characteristics and district-level indicators of economic development was similar between men and women.

Our findings have several important policy implications. First, with almost a quarter of surveyed men aged 15–54 years having some degree of anaemia, we have

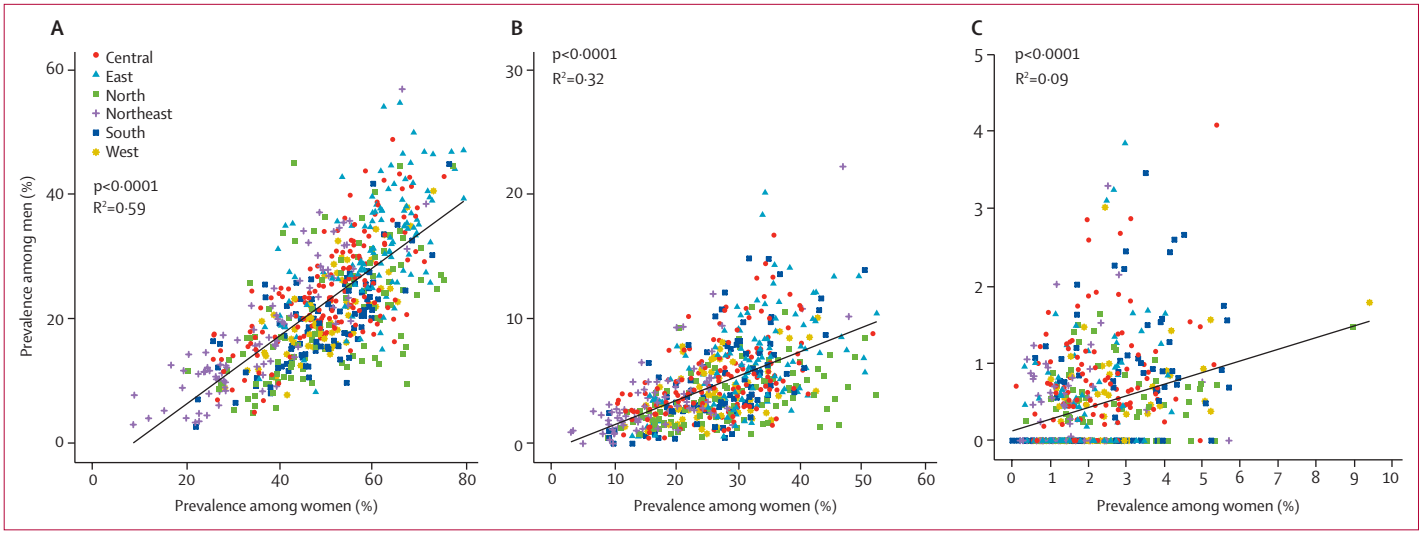

Figure 2: **Association of age-standardised district-level anaemia prevalence among women with that among men in India**
Association between the sexes for any anaemia (A), moderate or severe anaemia (B), and severe anaemia (C). The black line shows the ordinary least squares regression line with each district having the same weight. p and R^2 values refer to this ordinary least squares regression.

	Any anaemia		Moderate or severe anaemia		Severe anaemia	
	Risk ratio	p value	Risk ratio	p value	Risk ratio	p value
Individual-level predictors						
Age group, years						
15–19	1 (ref)	..	1 (ref)	..	1 (ref)	..
20–24	0·67 (0·64–0·69)	<0·0001	0·73 (0·65–0·81)	<0·0001	0·68 (0·48–0·96)	0·027
25–29	0·66 (0·63–0·68)	<0·0001	0·70 (0·63–0·77)	<0·0001	0·78 (0·56–1·09)	0·143
30–34	0·69 (0·66–0·72)	<0·0001	0·75 (0·68–0·83)	<0·0001	0·86 (0·62–1·19)	0·360
35–39	0·73 (0·70–0·76)	<0·0001	0·87 (0·79–0·95)	0·002	0·98 (0·71–1·35)	0·907
40–44	0·79 (0·75–0·83)	<0·0001	0·96 (0·86–1·06)	0·404	1·08 (0·76–1·52)	0·675
45–49	0·90 (0·86–0·94)	<0·0001	1·14 (1·03–1·26)	0·013	1·29 (0·92–1·81)	0·146
50–54	1·00 (0·96–1·05)	0·897	1·41 (1·27–1·55)	<0·0001	1·87 (1·37–2·54)	<0·0001
Household wealth quintile						
Quintile 1 (poorest)	1 (ref)	..	1 (ref)	..	1 (ref)	..
Quintile 2	0·86 (0·83–0·89)	<0·0001	0·74 (0·68–0·81)	<0·0001	0·84 (0·65–1·09)	0·187
Quintile 3	0·77 (0·74–0·80)	<0·0001	0·65 (0·59–0·71)	<0·0001	0·70 (0·53–0·94)	0·018
Quintile 4	0·67 (0·64–0·70)	<0·0001	0·54 (0·49–0·60)	<0·0001	0·65 (0·48–0·87)	0·004
Quintile 5 (richest)	0·61 (0·57–0·64)	<0·0001	0·49 (0·44–0·54)	<0·0001	0·59 (0·44–0·81)	0·001
Education						
No formal schooling	1 (ref)	..	1 (ref)	..	1 (ref)	..
Some primary school	0·92 (0·87–0·96)	0·0003	0·95 (0·85–1·06)	0·322	0·72 (0·50–1·03)	0·075
Completed primary school	0·88 (0·84–0·92)	<0·0001	0·87 (0·78–0·98)	0·017	0·93 (0·66–1·31)	0·669
Some secondary school	0·81 (0·78–0·84)	<0·0001	0·75 (0·69–0·81)	<0·0001	0·67 (0·52–0·85)	0·001
Completed secondary school	0·73 (0·69–0·76)	<0·0001	0·65 (0·58–0·73)	<0·0001	0·57 (0·40–0·81)	0·002
More than secondary school	0·65 (0·62–0·69)	<0·0001	0·55 (0·50–0·62)	<0·0001	0·43 (0·31–0·61)	<0·0001
Location						
Urban	1 (ref)	..	1 (ref)	..	1 (ref)	..
Rural	1·25 (1·20–1·30)	<0·0001	1·32 (1·23–1·43)	<0·0001	1·11 (0·91–1·35)	0·293
Currently married						
Yes	1 (ref)	..	1 (ref)	..	1 (ref)	..
No*	0·97 (0·93–1·01)	0·171	1·07 (0·98–1·18)	0·129	1·27 (0·94–1·71)	0·114

(Table 3 continues on next page)

	Any anaemia		Moderate or severe anaemia		Severe anaemia	
	Risk ratio	p value	Risk ratio	p value	Risk ratio	p value
(Continued from previous page)						
Smoking						
No	1 (ref)	..	1 (ref)	..	1 (ref)	..
Yes	1·06 (1·03–1·08)	0·0001	1·14 (1·07–1·21)	<0·0001	1·17 (0·97–1·42)	0·099
Smokeless tobacco consumption						
No	1 (ref)	..	1 (ref)	..	1 (ref)	..
Yes	1·15 (1·12–1·18)	<0·0001	1·21 (1·14–1·29)	<0·0001	1·17 (0·98–1·41)	0·088
Alcohol consumption						
Never	1 (ref)	..	1 (ref)	..	1 (ref)	..
Less than once a week	0·97 (0·93–1·00)	0·072	0·95 (0·87–1·04)	0·303	0·66 (0·49–0·89)	0·006
About once a week	0·97 (0·93–1·01)	0·103	0·97 (0·89–1·05)	0·448	0·69 (0·51–0·92)	0·012
Almost every day	1·06 (1·00–1·13)	0·042	1·21 (1·05–1·38)	0·007	1·21 (0·83–1·77)	0·327
BMI group, kg/m²						
<16·0	1 (ref)	..	1 (ref)	..	1 (ref)	..
16·0–17·9	0·82 (0·78–0·87)	<0·0001	0·70 (0·62–0·80)	<0·0001	0·50 (0·35–0·73)	<0·0003
18·0–22·9	0·60 (0·57–0·63)	<0·0001	0·43 (0·38–0·50)	<0·0001	0·27 (0·17–0·41)	<0·0001
23·0–24·9	0·54 (0·47–0·61)	<0·0001	0·39 (0·28–0·53)	<0·0001	0·29 (0·11–0·76)	0·011
25·0–27·4	0·52 (0·46–0·59)	<0·0001	0·34 (0·25–0·47)	<0·0001	0·12 (0·03–0·51)	0·004
27·5–29·9	0·53 (0·42–0·68)	<0·0001	0·36 (0·20–0·62)	0·0003	0·41 (0·10–1·65)	0·212
≥30	0·61 (0·58–0·65)	<0·0001	0·41 (0·35–0·46)	<0·0001	0·29 (0·21–0·41)	<0·0001
District-level predictors						
Proportion who completed primary education	0·69 (0·65–0·73)	<0·0001	0·63 (0·57–0·69)	<0·0001	0·71 (0·58–0·88)	0·002
Proportion living in an urban area	0·85 (0·80–0·91)	<0·0001	0·84 (0·76–0·93)	0·0005	1·03 (0·82–1·28)	0·821
Median household wealth†	0·72 (0·68–0·77)	<0·0001	0·68 (0·62–0·75)	<0·0001	0·82 (0·65–1·03)	0·081

Data are risk ratios with 95% CIs in parentheses or p value. Except for the regression for age group (which was not additionally adjusted for continuous age), all regressions included the variable shown in the table, continuous age (with restricted cubic splines with five knots), and a random intercept for district as independent variables. *Not currently married includes the questionnaire response options of never married, separated, divorced, widowed, and deserted. †Median calculated jointly for rural and urban areas in a district.

Table 3: **Individual-level and district-level predictors of anaemia in men in India**

shown that anaemia among men is a substantial public health issue in India that has thus far received little attention from both a research and a policy perspective. Second, we have highlighted a large variation in the prevalence of anaemia among men among states and districts, which can inform the targeting of resources and relevant programmes to those areas that are in greatest need. Notably, we showed that simply targeting less wealthy states might not be an effective strategy because GDP per capita accounts for a relatively small degree of the variation in anaemia prevalence among states. For instance, Andhra Pradesh, one of India's wealthier states, had a higher prevalence of moderate or severe anaemia among men than Bihar, which is India's least wealthy state as measured by GDP per capita.[20] Third, we found that district-level prevalence of anaemia among men is highly correlated with that among women, and that the patterns of variation in prevalence of anaemia by individual-level and district-level characteristics were similar between men and women, suggesting that future efforts to reduce anaemia among men could target the same population groups as those among women.

For the **Anemia Mukt Bharat website** see https://anemiamuktbharat.info/dashboard/#/

India has made several large-scale efforts to prevent and treat anaemia. Most notably, the National Nutritional Anaemia Prevention Programme has been providing free iron and folic acid supplements for children, expectant and nursing mothers, and women who attend family planning services through primary health-care facilities since it was launched in 1970.[21] In 2013, the National Iron Plus Initiative extended the provision of free iron and folic acid supplements to boys aged 10–19 years.[22] The few existing evaluations of the National Nutritional Anaemia Prevention Programme suggest that it has not been successful in reducing anaemia prevalence in any age group.[21] In 2018, India launched a new large-scale initiative to tackle anaemia, called Anemia Mukt Bharat. Aiming to reach children, pregnant women, women of reproductive age (20–49 years), and male and female adolescents aged 10–19 years, this initiative combines several strategies to prevent and treat anaemia, including iron and folic acid supplementation, deworming, food fortification in schools, and malaria screening. Anemia Mukt Bharat is projected to reach 450 million beneficiaries by 2022.[23] Given the inexpensive treatment of many common forms

of anaemia and the condition's effect on economic productivity, policy makers in India might want to consider extending some components of the Anemia Mukt Bharat programme to men, especially in the states and districts in which we found a particularly high prevalence of anaemia in men. For instance, screening for anaemia could be offered to men during household visits by community health workers (eg, the Accredited Social Health Activists cadre) or community meetings. Given our findings, these services should especially focus on poor households in rural areas and adolescent and older men.

Before the NFHS-4, the third NFHS (NFHS-3)—a nationally representative study undertaken between November, 2005, and August, 2006—also measured haemoglobin concentrations among men aged 15–54 years.[24] The official NFHS-3 report indicates a similar anaemia prevalence of 24% among men as identified in this study. Similar to the NFHS-4, state-level variation in prevalence of anaemia among men in the NFHS-3 was high, ranging from 8·0% in Kerala to 39·6% in Assam. Another notable study on anaemia among men in India is the National Nutrition Monitoring Bureau study, which was undertaken between 2004 and 2005 in rural areas of nine states; reporting the prevalence of anaemia to be 55% among a sample of 3397 men.[25]

Our study has several limitations. First, due to data limitations, we were unable to determine the type and cause of anaemia. Second, a clinical diagnosis of anaemia would ideally be based on a laboratory-based measurement of a venous blood sample rather than a point-of-care test of a capillary blood sample. The use of the HemoCue device, as opposed to analysis of venous blood in a laboratory, might have led to a slight underestimation of anaemia prevalence.[26] Third, our results are only representative of men aged 15–54 years, because that was the age range sampled as part of the NFHS-4 survey. However, due to India's relatively young population, this age range accounts for approximately three-quarters of all men aged 15 years and older in India. Finally, the people who did not respond to the survey or with a missing haemoglobin measurement might have had a different anaemia prevalence than those included in the survey, which would bias our estimates. However, the household response rate and individual response rate among men was high (97·6% and 91·9%) and the proportion of men with a missing haemoglobin value was low (3·4%), which restricts the potential degree of bias due to missing observations.

Anaemia among men is an important public health issue in India that has thus far received little research and policy attention. Policy makers should consider extending existing efforts to reduce anaemia among women to include men; not only to reap economies of scale but also because we found that the patterns of variation in the prevalence of anaemia at the district and individual level were similar between men and women. Overall, given the high prevalence of anaemia in the country and the condition's association with adverse health and economic outcomes, further improvements in the country's efforts to reduce the burden of anaemia are urgently needed.

Contributors

OD and PG designed this secondary data analysis and drafted the manuscript. OD, MT, and PG analysed the data. All authors provided critical input to the interpretation of the data and revision of the manuscript.

Declaration of interests

We declare no competing interests.

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