Policy Analysis Measuring What we intend to treat: The Capillary–Venous Discrepancy, the Withdrawal of Anaemia Measurement from NFHS-6, And the Case for a Tiered Surveillance Architecture in South Asia

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Abstract

Background: India's National Family Health Survey (NFHS) has reported an apparently worsening anaemia burden, with childhood prevalence rising from 58.6 % to 67.1 % between 2015–16 and 2019–21 despite two decades of iron supplementation policy. A parallel body of evidence, using venous blood and automated analysers, reports prevalence roughly half as high in comparable populations. Haemoglobin measurement has consequently been withdrawn from NFHS-6, leaving South Asia's largest anaemia surveillance instrument without an anaemia indicator.

Methods: A structured policy analysis was conducted. Published prevalence estimates from the NFHS rounds, the Comprehensive National Nutrition Survey (CNNS), a venous blood-based survey in eight Indian states, a multi-centric hospital-based venous study, and paired capillary–venous methodological studies were extracted and placed on a common basis. The 2024 World Health Organization guideline on haemoglobin cutoffs was reviewed for its implications for low- and middle-income country surveillance. Estimates were compared descriptively; no new primary data were collected and no re-analysis of individual records was undertaken.

Results: Capillary- and venous-based estimates of the same populations differ by 20 to 36 percentage points. Childhood anaemia is reported at 67.1 % by NFHS-5 and at 40.5 % and 30.7 % by CNNS analyses using venous blood; among women in eight states, capillary-based prevalence of 61 % compares with 41 % on venous sampling. A pooled venous-minus-capillary haemoglobin difference of approximately 0.29 g/dL is smaller than these gaps imply, but because prevalence is defined by a fixed threshold, modest shifts relocate large numbers of people across it. The severity composition of the NFHS increase is informative: between NFHS-4 and NFHS-5 the moderate category rose by 7.6 percentage points while the mild category was essentially unchanged. State-level changes are implausibly large in places, including a 32.7 percentage-point rise in Assam over roughly four years.

Conclusions: The discrepancy is real, but withdrawal of measurement is the wrong response to it: it removes the indicator rather than the error, and forecloses evaluation of programmes that continue to operate. A tiered architecture is proposed — venous-based population surveillance, an aetiological panel on a sub-sample, retained point-of-care testing reported honestly as a screen-positive rate, and a paired calibration sub-study in every round — together with reporting of district priorities as probabilities rather than ranks. The argument generalises to other South Asian surveillance systems facing the same measurement decision.

Keywords: Anaemia, Haemoglobin Measurement, Health Surveillance, Nutrition Policy, National Family Health Survey, South Asia.

1. INTRODUCTION

Anaemia is among the most extensively measured conditions in South Asian public health and among the least well understood. It is measured because it is cheap to measure: a finger-prick, a portable photometer, a single number compared against a threshold. It is poorly understood because that number has been asked

to carry more inferential weight than its measurement properties can support, and because a condition with many causes has been managed as though it had one.

The Indian evidence brings the problem to a point. Successive rounds of the National Family Health Survey (NFHS), the largest population health survey in the region, record an anaemia burden that is not merely high but worsening. Among children aged 6–59 months, prevalence rose from 58.6 % in NFHS-4 (2015–16) to 67.1 % in NFHS-5 (2019–21). Among women aged 15–49 years it rose from 53.1 % to 57.0 %, among adolescent girls from 54.1 % to 59.1 %, and among pregnant women from 50.4 % to 52.2 %. These increases occurred during a period in which the Anaemia Mukt Bharat programme was launched and scaled, iron and folic acid supplementation coverage for pregnant women improved substantially, antenatal contact and institutional delivery rose, and mandatory fortification of rice with iron was introduced in public distribution channels. Read at face value, the surveys describe a national programme that intensified its central intervention and watched the target indicator deteriorate.

A second body of evidence describes a different country. The Comprehensive National Nutrition Survey (CNNS) 2016–18, conducted over an overlapping period with venous blood and laboratory analysers, reported childhood anaemia at 40.5 % in one published analysis of children aged 12–59 months and at 30.7 % in another assessment of the same survey, less than half the NFHS figure. A community-based venous survey across eight Indian states published in 2025 reported 41 % anaemia among adult women, against a capillary-based NFHS-5 figure of 61 % for the same states, and found that mild anaemia accounted for roughly half of all cases and that iron deficiency was a less dominant aetiology than policy has assumed. A multi-centric hospital-based study using venous samples and automated analysers found 49.4 % prevalence among apparently healthy children under the WHO threshold, and 19.6 % under the alternative CNNS threshold.

The Government of India resolved this tension by removing it. Haemoglobin measurement has been dropped from NFHS-6 on the reasoning that capillary-based estimation is unreliable, with the intention that venous-based instruments such as the Diet and Biomarker Survey in India (DABS-I) will supply the estimate instead. The decision has been contested in the Indian literature on the ground that a known and directionally consistent bias is a calibration problem rather than grounds for abandoning measurement, and that a break in a three-decade series will obstruct evaluation of the very programmes that continue to operate.

This paper takes that controversy as its subject. It does not attempt to adjudicate the true prevalence of anaemia in India, which no currently available evidence base can settle. It asks a narrower and more tractable set of questions. How large is the discrepancy between measurement protocols, and is it consistent enough to be treated as a calibration offset? What does the internal structure of the reported increase — its severity composition and its geographical distribution — suggest about how much of it is measurement and how much is epidemiology? What does the 2024 WHO guideline require of surveillance systems in low- and middle-income settings, and what does it cost to comply? And given that a surveillance system must serve three distinct functions — estimating burden, targeting districts, and screening individuals for referral — which of those functions actually requires venous measurement, and which does not?

The questions are framed for India because that is where the data are richest, but they are not confined to it. Bangladesh, Pakistan, Nepal and Sri Lanka all operate haemoglobin measurement within demographic and health survey platforms using the same point-of-care technology, and all face the same choice as the WHO guidance on venous sampling diffuses into national practice. A decision taken in Delhi on measurement protocol is, in effect, a proposal for the region.

2. METHODS

This is a policy analysis based on published sources. No primary data were collected, no individual-level records were obtained, and no re-analysis of survey microdata was undertaken; all quantitative values reported here are as published by the original investigators and are cited to them.

2.1 Source identification

Three categories of source were sought. The first comprised national survey reports providing prevalence estimates for India: the NFHS rounds and the CNNS 2016–18. The second comprised peer-reviewed studies reporting anaemia prevalence from venous blood in Indian populations, or reporting paired capillary and venous haemoglobin measurements in the same individuals. The third comprised normative and commentary literature on measurement protocol, including the 2024 WHO guideline on haemoglobin cutoffs, the underlying threshold-derivation work, and published commentary on the NFHS-6 decision.

Sources were identified through PubMed and through the reference lists of the retrieved articles, supplemented by the survey reports themselves. Because the object of the analysis is a policy controversy rather than a treatment effect, no formal systematic-review protocol was applied and no quality-weighted pooling was performed; the analysis is a structured narrative synthesis, and its inferences are correspondingly qualitative except where a single source supplies a directly quoted quantity.

2.2 Comparison basis

Prevalence estimates were placed side by side only where the compared figures refer to populations that are plausibly comparable in age band, sex and period. Where age bands differ between surveys — for instance, NFHS reports children aged 6–59 months while one CNNS analysis reports 12–59 months — the difference is stated explicitly in the accompanying text and the comparison is treated as indicative rather than exact. No attempt was made to standardise estimates statistically across surveys, since the published reports do not supply the information such standardisation would require.

2.3 What This Design Can and Cannot Establish

The design can establish the magnitude and direction of the discrepancy between measurement protocols as reported in the literature, and can test whether the internal structure of the reported trend is consistent with a pure measurement explanation. It cannot establish the true prevalence of anaemia in India, cannot attribute the discrepancy to any single mechanism among the several that plausibly contribute, and cannot quantify the programme consequences of misclassification beyond what published modelling studies report. These limits are revisited in Section 5.

2.4 Ethics

Ethical approval was not required. The analysis uses only aggregate data already in the public domain and involves no human participants, no identifiable individual data and no intervention.

3. THE REPORTED BURDEN AND ITS INTERNAL STRUCTURE

3.1 The headline trend

Figure 1 and Table 1 set out the national picture as measured. Every group deteriorated between the two rounds, and every group sits far above the 40 % threshold at which WHO classifies anaemia as a severe public health problem. The increase is largest in the youngest group and smallest among pregnant women, who are also the group receiving the most intensive supplementation contact.

Table 1. National anaemia prevalence by group, NFHS-4 and NFHS-5

Population group	NFHS-4 (%)	NFHS-5 (%)	Change (pp)	WHO category, NFHS-5
Children 6–59 months	58.6	67.1	+8.5	Severe public health problem
Adolescent girls 15–19 years	54.1	59.1	+5.0	Severe public health problem
Women 15–49 years	53.1	57.0	+3.9	Severe public health problem
Pregnant women 15–49 years	50.4	52.2	+1.8	Severe public health problem
Adolescent boys 15–19 years	—	31.1	—	Moderate public health problem
Men 15–49 years	—	25.0	—	Moderate public health problem

Note. pp = percentage points. All values are capillary-based estimates using portable haemoglobinometers and the WHO thresholds current at the time of survey. Dashes indicate figures not compiled for this analysis from the earlier round.

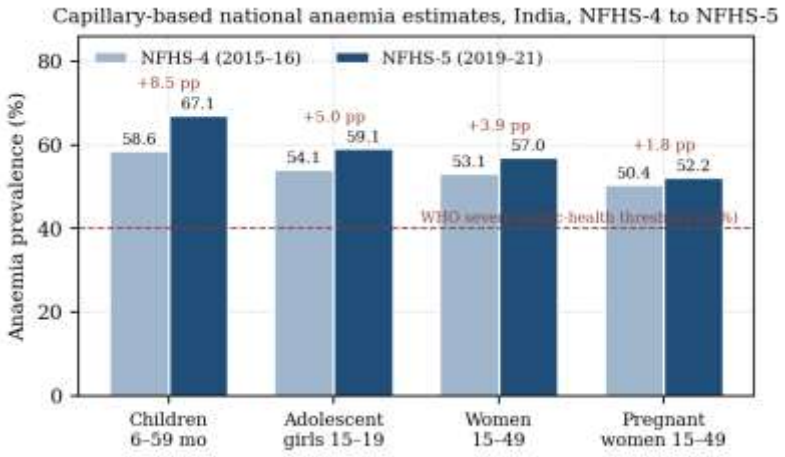

Figure 1. Capillary-based national anaemia prevalence in India by population group, NFHS-4 (2015–16) and NFHS-5 (2019–21). Data from the published NFHS reports.

Two features of Table 1 deserve comment before any measurement question is raised. The first is the sex gradient: male prevalence is roughly half female prevalence in the same households, surveyed by the same teams with the same devices. That gradient is biologically expected and is reassuring about the instrument, since a purely technical artefact would not be expected to respect it. The second is that the pregnant-women figure is the lowest of the four female groups and rose least, which is difficult to reconcile with a straightforward story of programme failure, since pregnancy is the point of maximum supplementation intensity.

3.2 Severity composition

If a survey round detects more anaemia because its measurement has shifted downward relative to the previous round, the additional cases should accumulate disproportionately just below the threshold — that is, in the mild category. Figure 2 shows that this is not what happened between NFHS-4 and NFHS-5 among children.

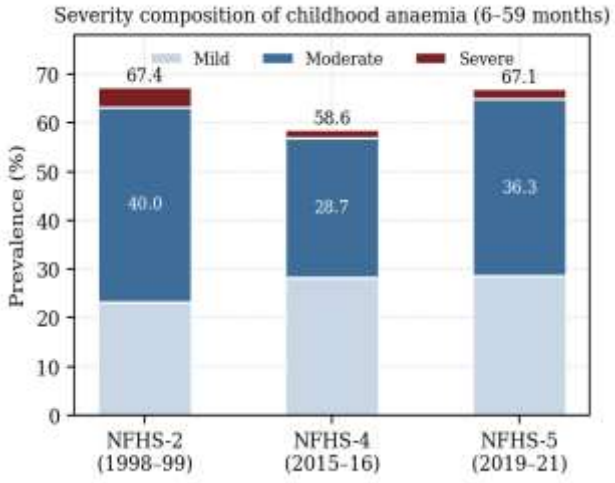

Figure 2. Severity composition of anaemia among children aged 6–59 months across NFHS rounds. Moderate anaemia accounts for the great majority of the NFHS-4 to NFHS-5 increase.

The mild category was essentially flat, moving from 28.3 % to 28.6 %. The moderate category rose by 7.6 percentage points, from 28.7 % to 36.3 %, and the severe category rose from 1.6 % to 2.2 %. Nearly nine-tenths of the total increase therefore occurred in categories that sit well below the diagnostic threshold rather than adjacent to it. A downward shift in measured haemoglobin of the magnitude reported in the methodological literature — of the order of 0.3 g/dL — cannot by itself move a child from non-anaemic to moderately anaemic. This is the strongest single piece of internal evidence that the NFHS increase is not wholly a measurement artefact, and it constrains any explanation that attributes the entire discrepancy to protocol.

The same longer view complicates the picture in the other direction. Comparison with NFHS-2 shows that moderate anaemia at 36.3 % in NFHS-5 remains below the 40.0 % recorded in 1998–99, and severe anaemia at 2.2 % remains well below the 4.1 % of that round. The two-decade trajectory is therefore one of substantial improvement in the clinically consequential categories, interrupted by a recent reversal, rather than of continuous deterioration. Presenting the total prevalence figure alone obscures this and has contributed to a public discourse of unrelieved failure that the severity data do not support.

3.3 Geographical Distribution of the Change

Figure 3 shows the states at the documented extremes of change in childhood anaemia. The distribution is difficult to reconcile with epidemiology alone.

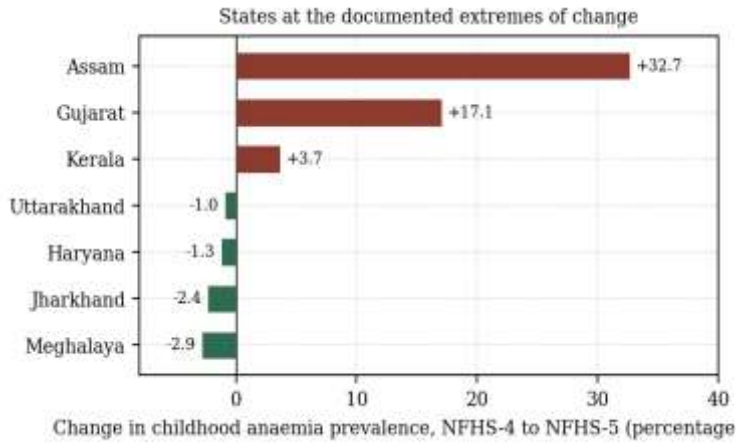

Figure 3. States at the documented extremes of change in childhood anaemia prevalence between NFHS-4 and NFHS-5.

Assam recorded a rise of 32.7 percentage points, from 35.7 % to 68.4 %, over roughly four years. Gujarat rose 17.1 points to reach nearly 80 % of children. Against these, four states recorded small declines. A 32.7-point rise in a population-level nutritional indicator over four years has no plausible aetiological mechanism in the absence of famine, epidemic malaria or mass displacement, none of which occurred. Changes of this magnitude in a small number of states, with near-stability in others, point to something that varies at the level of survey implementation — field team, device batch, cuvette storage and age, ambient conditions, or the training and technique of finger-prick sampling — rather than at the level of the population being measured.

This is the reading that matters most for programme design, and it is more damaging than a uniform bias would be. A constant offset, however large, preserves the ranking of districts and therefore preserves the validity of targeting decisions even if it distorts the headline number. Bias that varies geographically corrupts the ranking itself, which is precisely the use to which district-level anaemia data are put when programme resources are allocated. The distinction is developed in Section 4.3.

4. THE MEASUREMENT DISCREPANCY

4.1 Magnitude across Paired Sources

Figure 4 and Table 2 place the capillary- and venous-based estimates side by side. The gaps are large, consistent in direction, and not confined to a single survey or age group.

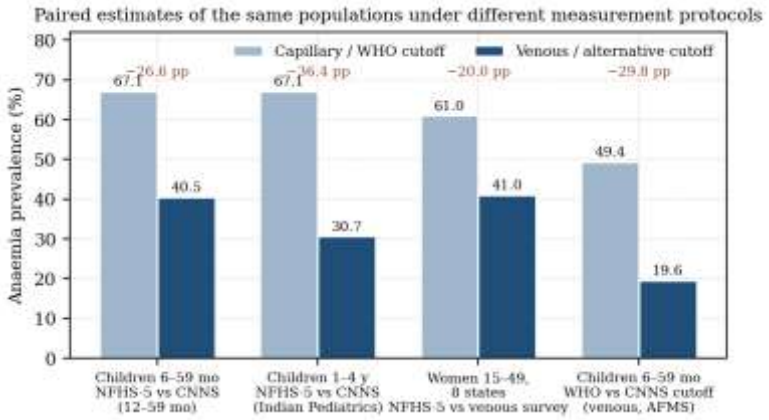

Figure 4. Anaemia prevalence in comparable Indian populations estimated under different measurement protocols. Age bands differ slightly between sources; comparisons are indicative.

Table 2. Published anaemia estimates under capillary and venous protocols

Source and population	Protocol	Prevalence (%)	Comparator (%)	Gap (pp)
NFHS-5, children 6–59 months	Capillary, portable device	67.1	—	—
CNNS 2016–18, children 12–59 months	Venous, autoanalyser	40.5	67.1 (NFHS-5)	26.6
CNNS 2016–18, children (published assessment)	Venous, autoanalyser	30.7	67.1 (NFHS-5)	36.4
Eight-state venous survey, adult women	Venous, autoanalyser	41	61 (NFHS-5, same states)	20
Multi-centric study, children 6–59 months	Venous, WHO cutoff	49.4	67.1 (NFHS-5)	17.7
Multi-centric study, children 6–59 months	Venous, CNNS cutoff	19.6	49.4 (same sample, WHO cutoff)	29.8

Note. pp = percentage points. The final row compares two thresholds applied to one sample and therefore isolates the contribution of the cutoff, as distinct from the contribution of the sampling route.

The last row of Table 2 is the analytically important one, because it separates two effects that the debate routinely conflates. Applying two different thresholds to a single set of venous measurements from one sample of children moves prevalence from 49.4 % to 19.6 %, a gap of nearly thirty percentage points with no change whatever in the blood sample, the device, the operator or the population. Whatever else is true, a substantial share of the disagreement in the literature is about where the line is drawn rather than about how the blood is obtained. Discussion that treats the whole discrepancy as a capillary-sampling problem misattributes it, and a policy that fixes only the sampling route will not close the gap.

4.2 Why a Small Haemoglobin Shift Produces a Large Prevalence Shift

The paired methodological studies that measure both routes in the same individuals report a difference far smaller than Figure 4 might suggest. A published synthesis of Indian paired-sample studies puts the pooled venous-minus-capillary difference at approximately 0.294 g/dL, with substantial heterogeneity between

studies. The apparent contradiction dissolves once the shape of the haemoglobin distribution is considered. Population haemoglobin is approximately normally distributed with a large mass concentrated in the region where the diagnostic threshold falls; a small horizontal displacement of that distribution therefore relocates a disproportionate number of individuals across a fixed vertical line. Prevalence is not a measurement but a count of threshold crossings, and counts of threshold crossings are maximally sensitive to bias precisely where the population is densest.

Figure 5 shows what follows when the pooled shift is propagated through the national childhood estimate in a published bias analysis. The point estimate moves from 68.1 % as measured to 63.1 %, but the uncertainty interval spans 52.7 % to 70.4 %.

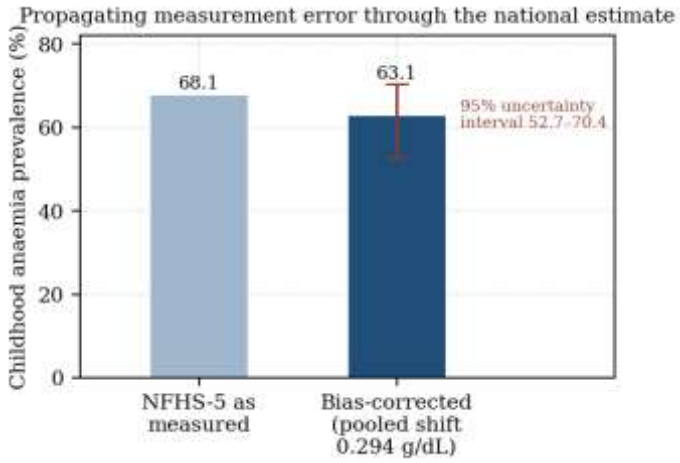

Figure 5. Effect of propagating the pooled venous-minus-capillary haemoglobin difference through the national childhood anaemia estimate, with the resulting uncertainty interval.

Two readings of Figure 5 are both correct and are usually presented as though they were alternatives. The first is that correcting for the measurement difference does not rescue the optimistic account: even after correction, the central estimate remains above 60 % and the interval does not approach the CNNS figures. Something other than capillary sampling is generating the gap, and the threshold evidence of Section 4.1 is the obvious candidate. The second is that the interval is very wide — nearly eighteen percentage points — which means the national estimate is not known to within anything like the precision with which it is conventionally reported and used. A figure quoted to one decimal place is being carried into policy with an implied precision it does not possess.

4.3 Burden, Targeting and Screening are three Different Problems

Public discussion of the NFHS-6 decision has proceeded as though a surveillance system has one job. It has three, and they have different measurement requirements.

Burden Estimation asks what the national or state prevalence is, for the purposes of resource envelopes, international reporting and programme evaluation over time. It is the function most damaged by a systematic offset, and the only one for which the absolute level of the estimate matters. It is also the function for which a modest, well-characterised sample measured to laboratory standard is entirely sufficient: precision of the national mean does not require measuring 1.6 million people.

Targeting asks which districts should receive intensified programme effort. It depends not on the absolute level but on the ordering of districts, and a uniform bias leaves ordering untouched. What corrupts it is bias that varies geographically — which, as Section 3.3 argued, is what the state-level pattern suggests is present. Published work propagating measurement error through district estimates finds that only about half of districts in the measured highest-prevalence quintile remain in that quintile with at least 80 % probability once sampling error alone is accounted for, and that this proportion falls further once

measurement bias is allowed to vary between districts. District rankings are therefore being used with a confidence the data do not support, and this is true independently of which protocol is adopted.

Screening asks whether a particular individual in front of a health worker should be referred, supplemented or investigated. It is a clinical decision at the point of care, it must be made with equipment that works in a village, and a point-of-care device that errs slightly toward over-detection is not obviously the wrong instrument for it: the cost of a false positive is an unnecessary referral, and the cost of a false negative is a missed case. Capillary point-of-care testing is appropriate technology for this function and should be retained for it.

Once the three functions are separated, the NFHS-6 decision reads differently. Its error is not that it doubts capillary measurement, which is well founded, but that it responds to a problem in function one by deleting the indicator that serves all three. Table 3 sets out the policy options against the three functions.

Table 3. Policy options for anaemia measurement in national surveillance

Option	Burden estimation	District targeting	Individual screening	Principal cost
Retain capillary as before	Biased, direction known	Corrupted if bias varies	Adequate	Continued misestimation of level
Drop measurement (NFHS-6)	No estimate; series broken	No data	Unaffected (separate system)	Programmes cannot be evaluated
Venous in full sample	Accurate	Accurate	Not feasible at point of care	Cost, refusal, cold chain, logistics
Venous core sample + capillary elsewhere	Accurate on core	Usable with calibration	Retained	Requires a calibration sub-study
Tiered architecture (proposed)	Accurate with stated uncertainty	Reported as probabilities	Retained and honestly labelled	Design and analytic complexity

Note. The comparison assumes the aetiological panel described in Section 5.2 is attached to whichever option is chosen; none of the options addresses aetiology on its own.

5. DISCUSSION

5.1 From Measurement to Policy: How the Error Propagates

The consequences of the measurement question are not confined to the accuracy of a published percentage. Figure 6 traces the pathway by which a protocol decision becomes a programme decision.

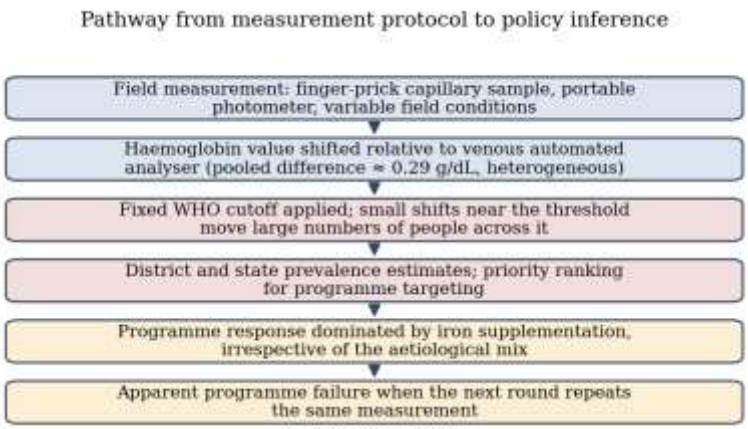

Figure 6. Pathway by which the measurement protocol propagates into programme inference and response.

The pathway matters because of what sits at its end. For two decades Indian anaemia policy has rested on an assumption that anaemia is predominantly iron-deficiency anaemia and that iron supplementation is therefore the appropriate central response. The venous evidence disturbs that assumption directly: the eight-state survey found iron deficiency to be a less dominant aetiology than anticipated, and the CNNS-based work found that only about a third of childhood anaemia was attributable to iron deficiency. Anaemia in South Asian populations is also produced by vitamin B12 and folate deficiency, by inflammation and chronic infection, by haemoglobinopathies including sickle cell disease and the thalassaemia traits that are common in several Indian subpopulations, and by parasitic infestation. None of these responds to iron, and in some of them — particularly where inflammation is present — additional iron is not therapeutically inert.

An overestimated prevalence, combined with an assumed aetiology, therefore produces a specific policy failure mode: universal iron supplementation scaled to a burden that is partly artefactual, delivered to populations in which a substantial fraction of true cases will not respond to it, and evaluated against an indicator that will not move. The observed pattern — intensified supplementation, static or rising measured prevalence — is what this failure mode looks like from the outside, and it is consistent with both the measurement explanation and the aetiological explanation. That the same observation is consistent with two very different diagnoses is the clearest possible argument for measuring aetiology rather than inferring it.

5.2 The 2024 WHO Guidance And What Compliance Costs

The 2024 WHO guideline on haemoglobin cutoffs recommends that venous blood, automated haematology analysers and high-quality control measures be used to measure haemoglobin in individuals and populations. It also revises the cutoff for children aged 6–23 months, retains existing cutoffs for several other groups, updates adjustments for elevation and smoking, declines to adjust for genetic ancestry on evidence grounds, and retains the existing classification of public health significance. Published assessment of the revised paediatric cutoff applied to Indian survey data finds it reduces measured prevalence in the 6–23-month group by approximately ten percentage points in both NFHS-5 and CNNS.

The guidance is, on its face, a vindication of the critics of capillary sampling. Its implications for low- and middle-income surveillance are less comfortable than that framing suggests, and are worth stating plainly, since the same choice faces every survey programme in the region.

- Venous sampling requires phlebotomy-trained staff, vacutainers, a cold chain in many settings, and a laboratory relationship that survey field logistics in remote districts do not currently support. Cost per sample rises by a multiple, not a margin.
- Consent and refusal behave differently. Venous draws in young children attract higher refusal than finger-pricks, and refusal that correlates with household characteristics introduces selection bias that can offset the measurement gain.
- Sample size must fall for a given budget. Since the value of NFHS lies substantially in its district-level granularity, a shift to venous sampling across the full sample would trade measurement validity against geographical resolution — which is a real trade, not an obvious improvement.
- A cutoff revision is itself a break in series. Applying new thresholds to old data and new data alike is necessary for comparability and is not automatic; where it is not done, an apparent improvement will be recorded that is purely definitional.

These constraints do not argue against compliance. They argue that compliance has to be designed rather than declared, and that a design which protects district resolution while achieving laboratory-standard estimation at the national and state level is preferable to either horn of the dilemma as currently posed.

5.3 A Tiered Surveillance Architecture

Figure 7 sets out the architecture this analysis supports. Its logic is that the three functions identified in Section 4.3 should be served by the instruments appropriate to each, rather than by one instrument asked to do all three badly.

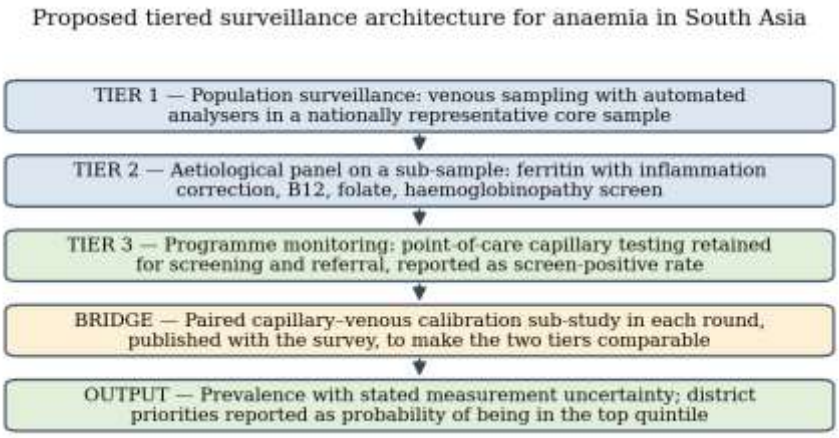

Figure 7. Proposed tiered architecture separating population estimation, aetiological characterisation, programme screening and inter-tier calibration.

The first tier measures burden to laboratory standard in a nationally and state-representative core sample using venous blood and automated analysers, sized for precision at that level rather than at district level. The second attaches an aetiological panel to a sub-sample of the first — ferritin with inflammation correction, vitamin B12, folate, and haemoglobinopathy screening — so that the composition of the burden is measured rather than assumed, which is the single most consequential gap in current practice. The third retains point-of-care capillary testing throughout the programme system for individual screening and referral, but reports its output as a screen-positive rate rather than as prevalence, a labelling change that costs nothing and would have prevented much of the present confusion.

The bridge between the tiers is a paired capillary–venous calibration sub-study embedded in every survey round and published with it. This is the element most often omitted and the one that makes the rest coherent: it converts an unknown bias into a measured offset with a known distribution, allows retrospective adjustment of the historical series, and permits screen-positive rates from the third tier to be translated into prevalence with stated uncertainty. It is inexpensive relative to the surveys it serves, requiring only that a subset of participants be measured twice.

Finally, output reporting should change. District priorities should be published as the probability that a district falls in the highest-burden quintile, not as a rank, and national estimates should carry the uncertainty interval that measurement error implies. Both are presentational changes that follow from analyses already published, and both would improve the quality of decisions taken from the data without requiring a single additional blood sample.

Table 4. Research and implementation priorities

Priority	Question to be answered	Feasibility
Calibration sub-study	What is the capillary–venous offset, and how much does it vary by state, device and field condition?	High — embeds in existing rounds
Aetiological panel	What fraction of anaemia is iron-responsive in each region and age group?	Moderate — needs laboratory capacity
Haemoglobinopathy mapping	Where do sickle cell and thalassaemia traits materially alter the interpretation of prevalence?	Moderate — partly under way
Threshold validation	Are WHO cutoffs appropriate for South Asian populations, and what are the functional correlates?	Low — requires outcome cohorts
Series bridging	How should the historical NFHS series be adjusted so that pre- and post-transition data remain comparable?	High — analytic work on existing data

Regional harmonisation	Can Bangladesh, Nepal, Pakistan and Sri Lanka adopt a common protocol and calibration standard?	Moderate — institutional, not technical

5.4 Limitations

This analysis is a narrative synthesis of published aggregate estimates, not a systematic review and not a re-analysis of microdata. Three limitations follow. First, the comparisons in Table 2 are between surveys that differ in age band, sampling frame and field period as well as in measurement protocol, so the gaps reported cannot be attributed entirely to protocol; the direction is consistent across every pairing, which supports the qualitative conclusion, but the magnitudes should not be read as measurements of bias. Second, no quality appraisal or weighting was applied to the included studies, and the venous-based literature is smaller, more recent and more heterogeneous in setting than the survey literature it is being compared against; the multi-centric study, in particular, is hospital-based and its sample of apparently healthy children is not population-representative. Third, the argument in Section 3.3 that the state-level pattern indicates implementation variation is an inference from implausibility rather than a demonstration, since no published study has decomposed state-level change into measurement and epidemiological components. That decomposition is feasible with existing data and is listed in Table 4.

A further limitation is scope. The analysis is framed around India because the Indian evidence base is unusually rich, and the extension to other South Asian countries in Section 6 is argued from similarity of survey platform and measurement technology rather than from country-specific evidence, which was not systematically retrieved.

6. REGIONAL IMPLICATIONS

The choice India has made is one that every demographic and health survey programme in South Asia will face, because all of them measure haemoglobin with the same class of point-of-care device and all of them will encounter the 2024 WHO guidance. Three implications follow for the region.

The first is that cross-country comparison of anaemia prevalence in South Asia is currently comparing measurement protocols as much as populations, and will become more so as countries transition at different times and in different ways. Any regional target — including the global nutrition targets to which these countries are signatories — is being assessed against a moving instrument. A regional calibration standard would be worth more than any individual country's protocol upgrade, and is an institutional problem rather than a technical one.

The second is that the aetiological question is regional in a way the measurement question is not. Haemoglobinopathy distributions, dietary patterns, infection burden and altitude vary sharply across South Asia, and the assumption that anaemia is predominantly iron-deficient is unlikely to be equally wrong in Kerala, in the tribal districts of central India, in the Terai and in coastal Sri Lanka. A regional aetiological mapping exercise would tell each country something its own surveys currently do not.

The third is a warning drawn from the Indian sequence of events. A measurement problem that is left unresolved long enough eventually gets resolved by deletion, because the alternative — publishing figures that are widely known to be contested — becomes institutionally uncomfortable. The moment to build calibration into a survey programme is before the credibility of its indicator is exhausted, not after.

7. CONCLUSION

India's anaemia statistics are contested for good reason. Capillary- and venous-based estimates of comparable populations differ by twenty to thirty-six percentage points, and a substantial part of that gap is attributable not to the sampling route at all but to the threshold applied, as a single study measuring one set of venous samples against two cutoffs demonstrates. At the same time, the internal structure of the reported increase resists a purely technical explanation: the additional cases between NFHS-4 and NFHS-5 accumulated overwhelmingly in the moderate category rather than just below the diagnostic threshold,

which is not the signature a measurement shift would leave. Both the sceptics and the defenders of the NFHS estimates are partly right, and the data as currently collected cannot settle the remainder.

Withdrawing haemoglobin measurement from NFHS-6 removes the indicator rather than the error. It breaks a three-decade series at the moment that series is most needed, leaves programmes that continue to consume public resources without an evaluation instrument, and does nothing about the threshold question or the aetiological question, which are where much of the real uncertainty lies.

The alternative proposed here is to separate the three functions a surveillance system performs and to serve each with the appropriate instrument: venous measurement in a core sample sized for national and state estimation, an aetiological panel on a sub-sample so that the composition of the burden is measured rather than assumed, retained point-of-care testing for individual screening reported honestly as a screen-positive rate, and a paired calibration sub-study in every round to hold the tiers together. District priorities should be reported as probabilities and national estimates with their measurement uncertainty. None of these elements is novel in isolation; what is missing is the decision to assemble them. For a region in which anaemia remains, on any estimate, a severe public health problem, measuring it well is not a statistical nicety but the precondition for treating it.

Declarations

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Data availability: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author contributions:

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Bashar Sabah Sahib	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

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