HEALTHCARE INFRASTRUCTURE AND OUTCOMES

GAP ANALYSIS FOR EQUITABLE PUBLIC HEALTH INVESTMENT: A DISTRICT-LEVEL STUDY IN INDIA

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ABSTRACT

Public healthcare infrastructure may not match population health need, and state averages can hide this. This study examines how health need, public facility supply and public health financing align across 338 districts in 20 phase-I Indian states and Union Territories. Need is measured by a Nutrition Burden Index (NBI) built from four NFHS-5 (2019–21) indicators. Supply is public facilities per 100,000 population (National Health Profile 2023; Census 2011). A Healthcare Gap score (NBI percentile minus facility-density percentile) and a Priority Investment Quadrant identify districts with above-median burden and below-median density. Financing is examined through National Health Mission (NHM) budget, expenditure and unspent-balance data for 2018–19 to 2024–25.

Stunting ranges from 15.5% to 59.0%, and state membership explains 70% of the variance in the NBI. Facility density is negatively associated with burden (Spearman's $\rho = -0.53$). The Priority Investment Quadrant holds 115 districts (34%), led by Bihar (36), Gujarat (29) and Maharashtra (24); 95 lie outside the Aspirational Districts list. The Pradhan Mantri Ayushman Bharat Health Infrastructure Mission (PM-ABHIM) balance held with states was equivalent to 103% of FY2024–25 releases, although it included funds carried forward from earlier years; the comparable balances were 12.6% for the NHM flexible pool and 0.5% for infrastructure maintenance.

Findings need caution. Infrastructure data are available only by state, so district rankings largely reflect state differences. Facility counts are rural-area counts divided by total population, which may understate density in more urbanised states (Appendix A). The sample is not nationally representative, and causal inference is not supported. District allocation data are unavailable, so whether funding follows need remains untested. The study offers a transparent baseline for needs-based prioritisation.

Keywords: healthcare infrastructure, district-level analysis, equity, Nutrition Burden Index, Healthcare Gap score, National Health Mission, public health financing, India

1. INTRODUCTION

1.1 Background, Research Problem and Rationale

Healthcare infrastructure is an essential component of public health systems because it determines the physical availability of healthcare services and the capacity of governments to respond to the medical needs of their populations. The availability of primary health centres, community health centres, sub-centres, hospitals and other public facilities influences the accessibility of preventive, promotive and curative healthcare. However, the presence of healthcare infrastructure alone does not guarantee favourable health outcomes. The effectiveness of the healthcare system also depends on the adequacy of clinical personnel, the quality of services, the availability of essential equipment, operational efficiency and the extent to which facilities are accessible to the populations they serve.

In India, these concerns are particularly important because healthcare needs, population density and public healthcare infrastructure differ considerably across geographical areas. States with large populations may operate extensive networks of public facilities in absolute numbers while still providing relatively low facility availability per person. Similarly, an apparently well-performing state may contain districts with substantial nutritional deprivation, inadequate access to services or other unmet health needs. Aggregate expenditure figures and state-level averages may therefore not identify the areas where additional public health investment would generate the greatest equity benefits. Districts provide an important analytical level for investigating these differences: they are relevant to the planning and implementation of public health programmes, the delivery of healthcare services and the identification of local development priorities.

The central problem addressed by this study is that the distribution of public healthcare infrastructure may not correspond to the geographical distribution of health needs. A district with a relatively high burden of malnutrition and anaemia may require greater healthcare capacity, but the availability of facilities may not increase proportionately with that burden. This possibility is consistent with the inverse care law, which suggests that the availability of healthcare can vary inversely with the need for it (Tudor Hart, 1971). The distinction between the number of facilities and their availability relative to population is particularly important in the Indian context. Absolute numbers indicate the size of a healthcare network, whereas facility density provides a more relevant indication of the scale of public provision relative to the population served.

The problem also extends beyond infrastructure. Public health investment involves not only allocating financial resources but also converting those resources into functioning

infrastructure and effective services. Approved budgets, actual expenditure and unspent balances provide different information about this process: an allocation may be approved without being fully spent, while expenditure on infrastructure does not automatically establish that facilities are adequately staffed or producing better health outcomes. This raises an important question for public policy: whether the resources committed to healthcare are sufficient, appropriately directed and effectively implemented in areas where health needs are substantial.

Three connected considerations motivate the study. First, health needs vary substantially across districts, and national and state averages can conceal considerable differences in child nutrition, anaemia and other indicators of population health; a district-level assessment makes these differences visible and helps identify geographical concentrations of deprivation. Second, healthcare infrastructure must be assessed relative to need rather than through absolute numbers alone, so the study examines facility density per 100,000 population and compares its distribution with nutritional deprivation. Third, infrastructure and financing must be interpreted together, because public investment involves both resource allocation and implementation, and expenditure trends and unspent balances show how difficult it can be to turn approved budgets into functioning public infrastructure.

The study therefore connects three dimensions of India's public health system: population health needs, public healthcare facility supply and public health financing. It uses district- level nutritional indicators from the National Family Health Survey-5 (NFHS-5, 2019–21), public healthcare facility counts reported in the National Health Profile 2023 for facilities functioning as of 31 March 2022, and government health expenditure and National Health Mission (NHM) financing records covering 2018–19 to 2024–25. An essential distinction is that the available data do not permit a direct comparison between each district's health needs and its actual public health expenditure. The study therefore assesses the need–supply gap directly but examines financing through the national and state-level information that is available. Its objective is not merely to rank districts or states, but to identify areas where the relationship between health needs and public provision raises concerns for equitable investment.

1.2 Conceptual Framework

The study draws on two complementary ideas.

The first is Donabedian's (1988) structure–process–outcome framework, which distinguishes between the structure of a healthcare system, the processes through which care is delivered and the outcomes achieved. In this study, public healthcare facilities represent a measure of

structure, while nutritional indicators represent a dimension of population health outcomes. Although adequate infrastructure is necessary for effective service delivery, its existence does not establish that healthcare is being delivered effectively. Staffing, quality, utilisation and other service-delivery conditions may influence the relationship between infrastructure and outcomes.

The second is Tudor Hart's (1971) inverse care law, which provides a useful perspective for examining whether the availability of healthcare corresponds to the distribution of health needs. Applied to the present study, this perspective raises the possibility that districts with greater nutritional deprivation may not necessarily have proportionately greater public facility availability.

These ideas inform the study's central analytical sequence:

Health need → Facility supply → Healthcare gap → Financing context → Equitable investment priorities

The first step measures nutritional deprivation using district-level health indicators. The second examines public facility density relative to population. The third compares the relative positions of health need and facility supply to identify potentially underserved districts. The fourth examines public health expenditure patterns and fund absorption. Finally, the combined evidence is interpreted to identify implications for needs-based investment.

The framework deliberately keeps nutritional burden and infrastructure supply as separate measures before calculating the healthcare gap. This avoids treating a district as adequately served simply because one composite index combines a favourable result in one dimension with an unfavourable result in another.

1.3 Research Gap

Previous research has examined different aspects of healthcare inequality in India, including the distribution of health infrastructure, geographical variation in health outcomes and the allocation of public resources. Hati and Majumder (2013), for example, provide an important district-level precedent by examining healthcare infrastructure, health outcomes and economic wellbeing through composite indices. However, the continued relevance of the issue calls for analysis using more recent nutritional data and a more explicit framework for identifying the mismatch between need and public facility supply.

A further analytical challenge is that identifying geographical disparities is not the same as determining whether funding responds to them. Infrastructure and outcome measures can be

compared at district level in the available dataset, whereas the available public financing records do not provide corresponding district-level allocation and expenditure figures. Consequently, the relationship between district-level health needs and actual district-level spending remains difficult to establish empirically.

The present study addresses these issues by integrating recent nutritional indicators, public facility density, geographical comparisons and financing evidence within a single framework. It develops a Nutrition Burden Index (NBI), constructs a percentile-based Healthcare Gap score and identifies districts falling into a Priority Investment Quadrant. It also examines variations across sampled regions and Aspirational Districts, alongside national NHM spending patterns and scheme-level unspent balances.

The study's contribution is therefore both analytical and policy-oriented. It offers a method for identifying districts where health need is high relative to measured public facility supply and establishes the information required to move towards a more comprehensive assessment of need-responsive public investment. Its results should nevertheless be interpreted in light of the geographical sample and the different administrative levels at which the infrastructure and financing data are reported.

1.4 Research Question and Objectives

The central research question is:

To what extent is public healthcare facility supply aligned with district-level nutritional need in the sampled Indian states and Union Territories, and what do available public financing data reveal about the challenges of equitable public health investment?

The study addresses this question through the following objectives:

1. To measure the variation in district-level nutritional deprivation using indicators of childhood stunting, childhood underweight, child anaemia and women's anaemia.

2. To examine the relationship between nutritional need and the availability of public healthcare facilities relative to population.

3. To identify districts with high nutritional burden and relatively low facility supply, and to examine how these districts are distributed geographically.

4. To compare nutritional burden and facility supply across sampled regions and between Aspirational Districts and other districts.

5. To analyse NHM budget and expenditure trends and the absorption of funds across selected health programmes.

6. To identify the implications of the observed need–supply mismatch for more equitable public health investment and future district-level financing research.

The corresponding analytical expectations are that nutritional burden will vary considerably across districts, that facility supply will not necessarily increase in proportion to health need, and that aggregate expenditure figures alone will be insufficient to establish whether funding is distributed equitably. These are propositions to be examined through the study's evidence rather than assumptions that must hold in advance.

1.5 Scope and Contribution of the Study

The empirical analysis covers 338 districts drawn from 20 phase-I states and Union Territories for which the relevant NFHS-5 district estimates are available. The sample is a coverage-based selection of available districts rather than a random sample of all Indian districts. It is therefore suitable for identifying disparities within the observed sample but should not be treated as nationally representative.

The principal outcome data relate to NFHS-5, 2019–21. Infrastructure information comes from public facility counts for March 2022, while the population denominator is based on Census 2011. Financing data cover national NHM budget and expenditure series from 2018– 19 to 2024–25, with government health expenditure also examined at state level. Because the reference periods and administrative levels differ, the study interprets associations cautiously and does not claim to establish causal relationships.

The principal contribution is a structured way of connecting health need, public facility supply and financing implementation in a setting where each dimension is often examined separately. In particular, it distinguishes between the number of facilities, their density relative to population, the relative mismatch between need and supply, and the ability to convert financial releases into infrastructure. This distinction provides a more useful starting point for equitable investment planning than relying exclusively on aggregate budgets or facility totals.

The remainder of the paper presents the literature review (Section 2), methodology (Section 3), data analysis and interpretation (Section 4), ethical considerations (Section 5), limitations (Section 6), main findings and discussion (Section 7), conclusion (Section 8) and recommendations (Section 9). Appendix A tests how sensitive the facility densities are to the population denominator.

2. LITERATURE REVIEW

Healthcare investment needs to account for differences in local resources, service capacity and population needs. This review focuses on three themes that correspond to the study's analytical sequence: infrastructure and workforce disparities (facility supply); infrastructure, service continuity and health outcomes (the link between supply and need); and public financing and equitable resource allocation (the financing context). Together, they establish why nutritional need, public facility supply and public expenditure are examined alongside one another at district level.

2.1 Healthcare Infrastructure, Workforce and District-Level Disparities

Healthcare capacity depends on the availability of facilities, beds and personnel, as well as the services they can provide. The literature identifies two related concerns: resources are unevenly distributed, and their presence does not necessarily indicate operational capacity.

Karan et al. (2021) documented substantial differences in the distribution and composition of India's health workforce. Their distinction between registered professionals and the active workforce shows why registration figures alone can overstate available personnel. Their national and state-level findings nevertheless require district evidence before they can identify particular staffing priorities.

Operational capacity also depends on provider competence and the organisation of services. Das et al. (2022), using an earlier survey of rural healthcare markets, found considerable variation in providers' medical knowledge. Such knowledge affects the care providers are capable of delivering, although it does not measure their actual clinical practice. Mukherji et al. (2024) extended the geographical assessment through a universal health coverage index covering 687 districts. Their framework brings service capacity, coverage and financial protection into a common assessment, but does not establish the effect of individual investments over time.

The pandemic further complicated the relationship between resources and performance. Pandey et al. (2021) found no robust relationship between their state-level infrastructure index and their measure of COVID-19 management. Their cross-sectional results suggest that infrastructure must be interpreted alongside local social conditions and epidemic circumstances, rather than treated as a sufficient explanation of outcomes.

These studies support examining district resources and staffing separately, while leaving open whether district-level supply is aligned with local health need.

2.2 Healthcare Infrastructure, Service Continuity and Health Outcomes

Healthcare resources including functioning facilities, beds and trained staff can improve outcomes by supporting timely and effective treatment. The evidence distinguishes access to services from the quality and continuity of the care received.

Gupta et al. (2016) found that districts with a greater proportion of round-the-clock primary health centres had lower infant mortality in India's high-focus states. This establishes an association between service availability and survival, rather than the effect of a particular investment. Lee et al. (2022) examined a different dimension: institutional delivery was associated with better neonatal survival in districts with higher measured maternity-care quality, but not in those with the poorest quality. Their quality measure used women's reports of antenatal and immediate postnatal care, averaged at district level; it was not a direct assessment of every facility.

Intervention evidence reinforces the distinction between care processes and outcomes. In a randomised trial in Uttar Pradesh, Semrau et al. (2017) found that a coaching-based childbirth checklist programme improved adherence to essential practices without significantly improving the primary composite maternal and perinatal outcome. Unlike the observational studies, the trial evaluated a specific intervention, but its findings cannot be generalised to all improvements in healthcare quality.

During COVID-19, continuity of treatment became an additional concern. Jain and Dupas (2022) documented widespread disruption among dialysis patients covered by a public insurance programme in Rajasthan, with disruptions associated with adverse health outcomes. Their findings show how pandemic restrictions could affect patients requiring non-COVID care. Jha et al. (2022), using survey and administrative mortality evidence, estimated a substantially greater mortality burden than official COVID death totals indicated. Their study highlights the need to distinguish reported COVID deaths from broader mortality changes.

The evidence therefore supports assessing access, quality and continuity separately; it does not show which infrastructure component best explains outcome differences across districts. This study therefore measures need and supply separately before comparing them.

2.3 Public Healthcare Financing and Equitable Resource Allocation

Public financing affects both the resources available to healthcare providers and the costs faced by patients. Two questions are central: whether allocations reflect local needs, and whether public spending results in accessible services for disadvantaged populations.

Chatterjee and Smith (2021), examining district and facility financing in Odisha, identified a weak relationship between district expenditure and measures of need, including poverty and lagging health outcomes. Bagepally et al. (2022) compared state health budgets with disease burden during 2015–2019 and found substantial differences in allocations relative to that burden. Although the studies operate at different geographical levels, both show why expenditure totals need to be assessed against population needs. Their findings do not, however, establish a causal relationship between larger budgets and improved outcomes.

Allocation rules also influence who benefits. Fan et al. (2018) compared input-based equalisation transfers with outcome-based incentive transfers. They found limited equalisation under the former and rewards concentrated in already better-performing states under the latter. Bowser et al. (2019), using benefit-incidence analysis, found substantial interstate differences in the distribution of benefits from public healthcare spending. Together, these studies distinguish rewarding measured performance from directing resources towards disadvantaged populations.

Financial protection is a related but separate issue. Prinja et al. (2017) found stronger evidence that publicly financed insurance schemes increased healthcare utilisation than that they improved financial protection. Their review concerns earlier schemes and should not be treated as an evaluation of every subsequent programme. It nevertheless shows why insurance coverage cannot substitute for evidence on affordable service availability.

For the present study, household financial protection serves only as context, because comparable district-level information is not available. The financing analysis therefore compares national NHM budgets, expenditure and unspent balances with the distribution of need and facility supply (Sections 4.1 and 7.6), which addresses the distinction between the size of a budget, its allocation and the capacity to absorb it.

2.4 Literature Summary and Research Gap

The reviewed studies show that infrastructure, staffing, service delivery and financing are closely related, but they examine different parts of that relationship. Gupta et al. associate functioning primary care with lower mortality, while Lee et al. and Semrau et al. show why access and improved care processes cannot automatically be equated with better outcomes. Pandemic evidence adds concerns about treatment disruption and incomplete mortality reporting. The financing studies similarly distinguish expenditure levels from allocation according to need and the distribution of benefits. These findings support a comparison that

considers resources, spending and outcomes together without assuming that any single measure explains health-system performance.

The gap is therefore not an absence of district research. Existing work includes district coverage assessments, local financing studies and analyses of pandemic outcomes. What remains insufficiently addressed by the studies reviewed here is whether public facility supply is aligned with district-level health need, and whether available financing data show that investment follows that need. The present study addresses this gap by (i) measuring district nutritional need through the Nutrition Burden Index (Objective 1), (ii) comparing it with public facility density through the Healthcare Gap score and the Priority Investment Quadrant (Objectives 2–4), and (iii) examining national NHM budgets, expenditure and unspent balances as the financing context (Objective 5). On this basis it draws implications for needs- based investment (Objective 6). The analysis is observational and ecological: it identifies districts where need is high relative to measured supply, but it does not establish that particular spending decisions caused differences in outcomes.

3. RESEARCH METHODOLOGY

3.1 Research design and conceptual framework

The study is a quantitative, cross-sectional, ecological design with a national budget time series. The district is the unit of analysis because it is the main unit of health planning under the National Health Mission (NHM) and the level at which the Aspirational Districts Programme (ADP) sets and monitors targets (Kapoor & Green, 2020). The design has three layers. (i) A needs layer, the Nutrition Burden Index, built from district outcomes in NFHS-5 (2019–21). (ii) A supply layer, public facilities per 100,000 population. (iii) A financing layer, national NHM budget and expenditure for 2018–19 to 2024–25 and state government health expenditure. The "healthcare gap" is where need is high and supply is low; the "equity" question is whether money follows the gap.

The framework follows Donabedian's (1988) structure–process–outcome logic: facilities and services (structure) are necessary but not sufficient for outcomes. It also draws on the inverse care law (Tudor Hart, 1971), under which provision tends to vary inversely with need. Comparative designs are used within the same data: North versus South districts, region versus region, and Aspirational versus other districts. Figure M1 shows how the pieces connect and which equations belong to each step.

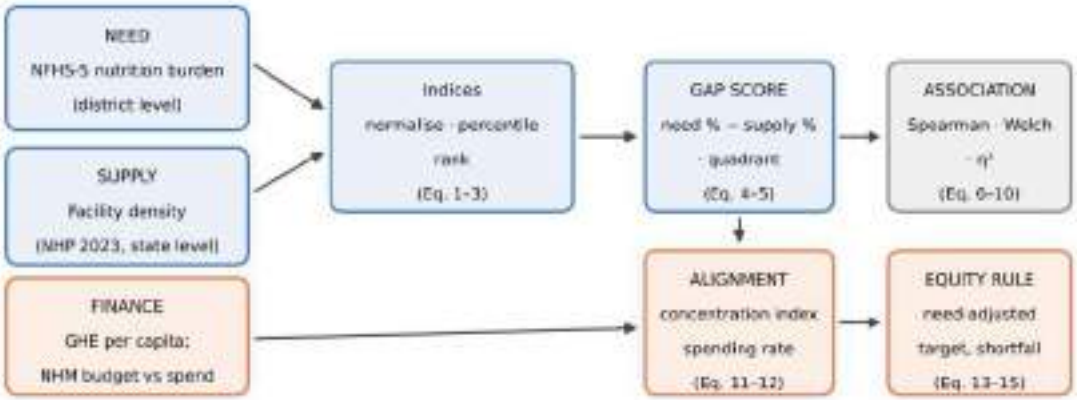

Figure M1. Analytical framework. Blue boxes are the need–supply–gap steps; orange boxes are the financing and equity steps.

The analysis runs in five linked steps, and each step has its equations in Sections 3.6 and 3.7:

1. Need, supply and finance inputs. Need is the NFHS-5 nutrition burden. Supply is public facility density. Finance is government health expenditure per capita and NHM budget against spending.

2. Indices. Indicators are normalised, averaged into the Nutrition Burden Index and converted to percentile ranks (Equations 1–3).

3. Gap score. Need percentile minus supply percentile, and the priority quadrant (Equations 4–5).

4. Association. Spearman correlation, Welch and Mann–Whitney tests, and the between-state share of variance (Equations 6–10).

5. Alignment and equity rule. Whether money follows need, how fast it is spent, and what need-adjusted target and shortfall would make extra investment more equitable (Equations 11–15).

How the framework translates into the research objectives

Each layer and step of the framework answers one operational question, and Table M1 links these to the six research objectives in Section 1.4, the equations used and where the results are reported. Objectives 1 and 2 (variation in nutritional need and its relationship with facility supply) correspond to questions 1 and 3, which measure the needs and supply layers and test whether infrastructure is associated with outcomes. Objectives 3 and 4 (identifying and comparing high-gap districts, regions, northern and southern districts, and Aspirational and other districts) correspond to question 2. Objective 5 (NHM budgets, expenditure and

absorption of funds) corresponds to question 4, and Objective 6 (implications for equitable investment) corresponds to question 5, the need-adjusted allocation rule. Because infrastructure and finance are not available at district level, questions 4 and 5 can be answered only in part at present (Section 6).

Table M1. Research objectives, framework steps and where each is addressed

Operational question	Obj.	Framework step	Methods (equations)	Reported in
1. Measure the district gap between need and supply	1	Steps 1–3 (need, supply, indices, gap score)	Index construction and percentile gap (Eq. 1–4)	Tables 2, 6; Figure 2
2. Locate where the gap is concentrated (states, regions, North vs South, Aspirational vs other)	3, 4	Step 3 and comparison designs	Priority quadrant, ranking, Welch and Mann–Whitney tests, variance decomposition (Eq. 5, 7–10)	Tables 2A–5; Figures 3–4
3. Test whether infrastructure is associated with outcomes	2	Step 4 (association)	Spearman correlation (Eq. 6) reported	Figures 4–5
4. Assess whether financing follows need and how fast money is spent	5	Step 5, financing layer	Spending rate and unspent balance (Eq. 11) reported nationally; concentration index (Eq. 12) planned	Tables 1, 1A, 1B; Figure 1
5. Set out a need-adjusted allocation rule	6	Step 5, equity rule	Target, shortfall and fixed- envelope allocation (Eq. 13–15)	Illustrative only; not run

3.2 Data sources

All data are secondary and public. Table A1 lists each variable, its source and reference year. Outcome data come from the NFHS-5 district fact sheets and NFHS-4 (IIPS & ICF, 2017) as compiled in the Mission Poshan district geovisualisation (Exhibit 6, 342 districts; IIPS & ICF, 2021). NFHS-5 surveyed 636,699 households nationally. Infrastructure counts (sub-centres, primary health centres, community health centres, sub-divisional and district hospitals functioning on 31 March 2022) come from the National Health Profile 2023 (CBHI, 2023), based on Rural Health Statistics 2021–22 (MoHFW, 2022), and are divided by Census 2011 populations. Public spending comes from NHP Tables 4.1.6–4.1.7 (state government health expenditure, 2019–20, National Health Estimates), NHP Tables 4.2.1–4.2.2 and 4.2.4 (national NHM approved outlay and actual expenditure) and the Ministry of Finance Expenditure Profile 2025–26 (actual 2023–24, budget and revised estimates 2024–25, and Statement 4AA on fund balances held by states). Aspirational District status follows the 112- district list in Kapoor and Green (2020, Appendix).

Rural counts and total-population denominators. The Rural Health Statistics enumerate facilities in rural areas, while the density denominator is the total Census 2011 population of the state. The densities reported in Table 2A are consistent with that construction (for example, Maharashtra's 13,726 facilities divided by its 112.4 million residents gives 12.2 per 100,000). Density is therefore likely to be understated in more urbanised states, which would push them towards the priority quadrant. Appendix A repeats the density calculation for the nine largest states that can be checked, using rural population as the denominator; it shows that the ranking of states changes materially, and Section 6.12 states what this means for the findings.

Every table and figure in this paper uses real published data and names its source in the caption or note.

Table A1. Variable dictionary and data sources

Variable	Role	Source	Year	Level	Statu s
A. Recent data used in the district analysis (NFHS-5, NHP 2023)					
Stunting, underweight, child and women anaemia (%)	Outco me	NFHS-5 / NFHS-4 via Mission Poshan Exh. 6	2019–21; 2015–16	District	Real
Nutrition Burden Index (0– 100)	Need	Constructed from NFHS-5 (Sec. 3.6; Eq. 1–2)	2019–21	District	Real
Facilities per 100,000 (SC+ PHC+CHC+SDH +DH)	Supply	NHP 2023 Tab. 6.2.1; Census 2011	2022 / 2011	State, attached to district	Real
Healthcare Gap score	Gap	Constructed from NFHS-5 and NHP 2023 (Sec. 3.6; Eq. 3–4)	—	District	Real
Aspirational District flag	Group	Kapoor & Green (2020), Appendix	2018 list	District	Real
Region (North, South, East, West, North-East)	Group	Authors' classification (Sec. 4.3)	—	State	Real
B. Financing data (national and state)					
Government health expenditure (Rs crore)	Anchor	NHP 2023 Tab. 4.1.6–4.1.7	2019–20	State	Real
NHM budget and actual expenditure (Rs crore)	Anchor	NHP 2023 Tab. 4.2.1–4.2.2, 4.2.4; MoF Expenditure Profile 2025–26	2018–19 to 2024–25	National	Real
Unspent balances with states (SNA accounts)	Contex t	MoF Expenditure Profile 2025– 26, Statement 4AA	31 Dec 2024	National, by scheme	Real

3.3 Population and sample

The target population is all districts of India (about 707 in NFHS-5). The analytical sample is the 338 districts of 20 states and Union Territories for which NFHS-5 phase-I district estimates are available in the data file used (four Dadra & Nagar Haveli and Daman & Diu rows with

corrupted records in the source were excluded). Of these, 44 are Aspirational Districts. The sample is therefore the full set of districts in phase-I states, not a random draw, and it is not representative: Uttar Pradesh, Rajasthan, Madhya Pradesh, Tamil Nadu, Punjab, Haryana, Delhi, Odisha, Jharkhand and Chhattisgarh are absent.

Regions are defined as follows. North: Himachal Pradesh, Jammu & Kashmir, Ladakh. South: Andhra Pradesh, Telangana, Karnataka, Kerala. East: Bihar, West Bengal. West: Gujarat, Maharashtra, Goa. North-East: Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura. The Andaman & Nicobar Islands (3 districts) are kept in descriptive tables but left out of regional comparisons. Because the "North" group has only 34 districts in three states,

North–South results should be read as a comparison of these states, not of the whole northern region. The same applies to every region: each regional result describes only the sample states listed above (Table 3).

Why this sample is suitable. The study aims to describe and compare the need–supply gap, not to estimate a national figure, and the sample serves that aim for four reasons. All 338 districts come from one survey round (NFHS-5 phase I) with common definitions, so outcomes are comparable across districts. The sample spans the range of conditions the questions need: stunting from 15.5% to 59.0%, facility density from 12 to 120 per 100,000, and all five regions, with high-burden, low-supply states (Bihar) and low-burden, high-supply states (Mizoram) both present. It contains 44 of the 112 Aspirational Districts, enough to compare them with other districts. And the groups are large enough for the tests used (34 northern and 88 southern districts). The cost is coverage: the absent states are large and populous, so the findings describe these 20 states and UTs and should not be extended to India as a whole.

3.4 Sampling technique

No further sampling is applied: the analysis uses complete enumeration (census) of the districts available, which removes sampling error from the district selection. Sampling error remains inside each NFHS district estimate, which comes from a stratified, two-stage probability sample of households (IIPS & ICF, 2021); estimates are treated as given and robustness is checked by dropping small districts. The 10 largest infrastructure states are a purposive subset chosen by the ranking rule stated for the exhibit, and the top and bottom five gap districts are rank-based extremes.

3.5 Time period of the study

The financing series cover seven financial years, 2018–19 to 2024–25, read in three periods for the COVID-19 discussion: pre-COVID (2018–19, 2019–20), COVID (2020–21, 2021–22) and

post-COVID (2022–23 to 2024–25). Outcomes are a single cross-section (NFHS-5, 2019–21; NFHS-4, 2015–16 for change), infrastructure is as on 31 March 2022, and population is Census 2011. These dates differ, which is a limitation (Section 6). National NHM figures run to 2024–25 (2024–25 is a revised estimate, not a final actual); they are national figures with no district split (Section 6).

How the time differences affect interpretation

Outcomes precede infrastructure. Outcomes are measured in 2019–21 and facilities are counted in March 2022. The facility count describes supply that existed after, and partly before, the outcomes were measured, so the association between them (Section 4.8) shows co-variation across districts, not that supply caused the outcome. Chronic indicators such as stunting also reflect conditions over many earlier years.

Old population denominators. Census 2011 populations are older than both measures. Where a state has grown faster than average, true density is lower than reported. Percentile ranks soften this for levels, but rankings can still change if growth differs across states.

Need is largely pre-pandemic; finance is not. NFHS-5 fieldwork in the sample states was largely completed before March 2020, while the financing series run through the COVID- 19 years to 2024–25. Need is therefore a largely pre-pandemic baseline, and the later spending series cannot be read as a response to the need measured here.

Different units. Finance is national and annual; need and supply are district-level and measured once. The two are compared in narrative only, not district by district. The statements in Sections 4 and 7 are worded to respect these differences.

3.6 Variables and index construction

Outcome variables are district prevalence (%) of stunting, underweight and anaemia among children, and anaemia among women, all from NFHS-5. The Infrastructure Index is the district's percentile rank (0–100) of state facility density. Percentile ranks are used because min–max scaling lets one outlier (Ladakh, 120 facilities per 100,000 on a very small population) compress every other district. Financing variables are the national NHM budget and actual expenditure (Rs crore), the spending rate (expenditure / budget × 100), unspent balances held by states, and state government health expenditure per capita (Rs). The index and gap formulas follow.

Why these indicators. The four nutrition indicators are used as the need measure for three reasons. They are the only outcome measures available in a recent, comparable form for every district in the sample (district mortality is not in the data used). They respond to services the

public system provides, such as antenatal care, iron and folic acid supplementation, immunisation, growth monitoring and referral, as well as to food, sanitation and income, so they are relevant to a health-investment question. And together they cover chronic undernutrition (stunting), combined under-nutrition (underweight) and micronutrient deficiency in both children and women (anaemia). The four are averaged with equal weights because there is no firm evidence for unequal weights and an unweighted mean is transparent (OECD/JRC, 2008). Supply is measured by public facility counts because they are the only facility data available on a uniform basis for all states (NHP 2023), they are the "structure" element in Donabedian's logic, and public facilities are what a public investment decision can change. The financing indicators show how much is budgeted, how fast it is spent and how much is left unspent. The limits of each choice are in Section 6.

3.6.1 Index construction

Indicators are first placed on a common 0–100 scale using min–max normalisation. All four indicators used in the Nutrition Burden Index are adverse outcomes: higher prevalence indicates greater nutritional deprivation. Accordingly, the direct transformation in Equation (1a) is used for these indicators, so higher transformed values represent greater burden. Equation (1b) is the reverse transformation and is used only where an indicator's raw direction must be inverted to maintain the intended direction of an index.

$$x'_{ij} = [(x_{ij} - \min_i x_{ij}) / (\max_i x_{ij} - \min_i x_{ij})] \times 100 \quad (1a)$$

$$x'_{ij} = [(\max_i x_{ij} - x_{ij}) / (\max_i x_{ij} - \min_i x_{ij})] \times 100 \quad (1b)$$

The Nutrition Burden Index (NBI) is the unweighted mean of the four directly rescaled prevalence indicators (following OECD/JRC, 2008). Because higher prevalence represents worse outcomes, a higher NBI indicates a heavier nutritional burden:

$$NBI_i = (1/4) \sum_{k=1}^{4} x'_{ik}, \quad k \in \{\text{stunting, underweight, child anaemia, women anaemia}\} \quad (2)$$

Ranks, not raw scores, are used to compare need and supply, because one outlier (Ladakh) would otherwise compress all other districts. The percentile rank, with average ranks for ties, is:

$$P(x_i) = 100 \times (r_i - 0.5) / N; \quad r_i = \text{rank of } x_i \text{ (average rank for ties)} \quad (3)$$

3.6.2 Gap score and priority quadrant

The Healthcare Gap score is need percentile minus supply percentile. It lies between −100 and +100; positive means under-served relative to need, so +100 is highest need with least infrastructure and −100 the reverse. The mean is zero by construction. Need is the nutrition burden and supply is state facility density.

$$G_i = P(NBI_i) - P(INF_i) \quad (4)$$

A district is in the priority quadrant if its state facility density is below the sample median and its burden is above the sample median.

$$Q_i = 1 \text{ if } INF_i < median(INF) \text{ and } NBI_i > median(NBI); \quad Q_i = 0 \text{ otherwise} \quad (5)$$

3.6.3 How to read the composite indices

All indices in this study are relative measures, and they should be read as follows.

Nutrition Burden Index (0–100). It places a district between the lowest and the highest values observed in the sample on the four indicators. A value of 0 means the lowest burden observed, not zero malnutrition; 100 means the highest observed. It is not a prevalence, and 50 is not a threshold.

Infrastructure Index (percentile). It is the rank of the state's facility density. A value of 50 is the sample median. Every district in a state has the same value, and the index says nothing about staffing, beds or quality.

Healthcare Gap score (−100 to +100). It is a difference of ranks. A positive score means the district ranks higher on need than on supply; a negative score means the reverse. Because the mean is zero by construction, a negative score means better supplied than needy relative to this sample, not oversupplied in an absolute sense. Scores cannot be compared with studies that use other samples.

Indices are therefore used to rank and to prioritise, and each is read together with the underlying indicators (Tables 2 and 6).

3.7 Data analytics techniques

Table M2 lists every technique in the design, the equations behind it, and whether it is applied and reported in Section 4 or is planned and not yet reported. Techniques marked planned are part of the design but no results from them appear in this paper, and no result in Section 4 depends on them. Sections 3.7.1 to 3.7.3 give the formulas behind the tests, the financing-alignment measures and the allocation rule.

Table M2. Analytical techniques, equations and reporting status

Technique	Eq.	Status	Where reported or what is needed
Applied and reported in Section 4			
Descriptive statistics: mean, SD, median, range, CV (outcomes, infrastructure, financing)	9	Applied	Tables 2, 4
Trend analysis of the national NHM budget, expenditure and spending rate (Series A and B)	11	Applied	Tables 1, 1A; Figure 1

Technique	Eq.	Status	Where reported or what is needed
Absorption: spending rate and unspent balances (national, by scheme)	11	Applied	Tables 1, 1B
Ranking and cross-tabulation: ten largest infrastructure states; top and bottom five gap districts	—	Applied	Tables 2A, 6; Figure 2
Percentile-rank gap score and priority quadrant	3–5	Applied	Table 2; Section 4.8, Figure 4
Group comparison, North versus South: Welch t- test, Cohen's d, Mann–Whitney U	7–8	Applied	Tables 4, 5
Series comparison of COVID-period national spending rates, year by year	11	Applied	Table 1A; Section 4.7
Spearman correlation among burden, stunting, anaemia, facility density and gap	6	Applied	Figures 4, 5
Variance decomposition: between-state share of burden variance (η^2)	10	Applied	Section 4.2 (70%)
Visualisation: bar charts, heat map, box plots, scatter plot with fitted line	—	Applied	Figures 1–5
Planned, not yet reported			
Pearson correlation among the same variables	—	Planned	Not reported; only Spearman is shown
Concentration index and rank correlation of spending with gap (does money follow need)	12	Planned	Needs state or district spending by gap rank
Equity-weighted allocation rule: target, shortfall, fixed envelope	13–15	Planned	Illustrative; needs district allocation data

3.7.1 Tests of association and difference

Status: Spearman correlation, Welch t-test, Cohen's d, Mann–Whitney U, CV and η^2 are applied and reported (Sections 4.2, 4.5, 4.8).

Monotonic association between continuous measures uses Spearman's ρ, and group differences use Welch's unequal-variance t-test (Welch, 1947) with Cohen's d as the effect size (Cohen, 1988) and the Mann–Whitney U test as a rank-based check (Mann & Whitney, 1947). Dispersion is summarised by the coefficient of variation and the between-state share of variance (η^2).

$$\rho_S = corr(rank(X), rank(Y)) = \Sigma(R_i - \bar{R})(S_i - \bar{S}) / \sqrt{[\Sigma(R_i - \bar{R})^2 \Sigma(S_i - \bar{S})^2]}, \text{ using average ranks for ties} \quad (6)$$

$$t = (\bar{x}_1 - \bar{x}_2) / \sqrt{(s_1^2/n_1 + s_2^2/n_2)}; \quad df = (s_1^2/n_1 + s_2^2/n_2)^2 / [(s_1^2/n_1)^2/(n_1-1) + (s_2^2/n_2)^2/(n_2-1)] \quad (7)$$

$$d = (\bar{x}_1 - \bar{x}_2) / s_p; \quad s_p = \sqrt{[((n_1-1)s_1^2 + (n_2-1)s_2^2)/(n_1+n_2-2)]} \quad (8)$$

$$CV = (SD / mean) \times 100 \quad (9)$$

$$\eta^2 = \Sigma_s\, n_s(\bar{y}_s - \bar{y})^2 / \Sigma_i(y_i - \bar{y})^2 \quad (10)$$

3.7.2 Financing alignment and absorption

Status: absorption (Equation 11) is applied to national data and reported in Section 4.1; the concentration index (Equation 12) is planned.

Absorption. The spending rate SR is expenditure E as a percentage of allocation A, and unspent funds U is their difference. Rates above 100 mean spending beyond allocation, for example through supplementary allocations or revised budgets.

$$SR_{it} = (E_{it} / A_{it}) \times 100; \quad U_{it} = A_{it} - E_{it} \quad (11)$$

Does money follow need? The concentration index (Wagstaff et al., 1991) of per capita spending h , with states ordered from lowest to highest gap and weighted by population share w , runs from −1 to +1. C > 0 means spending is concentrated among high-gap states (pro-need); C < 0 means it leans toward low-gap states. A rank correlation between spending and gap is reported alongside.

$$C = (2/\mu)\, \Sigma_i\, w_i h_i R_i - 1; \quad R_i = \Sigma_{k<i}\, w_k + w_i/2; \quad \mu = \Sigma_i\, w_i h_i \quad (12)$$

3.7.3 Equity-weighted allocation rule

Status: illustrative; not run on real allocations (Section 4 reports no allocation results).

The allocation rule scales a population-based benchmark μ (the population-weighted mean of current per capita spending) up for under-served areas and down for well-served ones. The parameter λ controls how strongly need counts: λ = 0 is pure per capita equality; λ = 1 lets a +100 gap double the benchmark and a −100 gap reduce it to zero. Because cutting existing budgets is rarely feasible, the main output is the shortfall: additional money needed to lift each area to its target, with no clawback. A budget-neutral version redistributes a fixed envelope B.

$$T_i = \mu(1 + \lambda G_i/100), \quad 0 \le \lambda \le 1 \quad (13)$$

$$S_i = Pop_i \times max(0, T_i - h_i) \quad (14)$$

$$A_i = B \times [Pop_i(1 + \lambda G_i/100)] / \Sigma_j\, Pop_j(1 + \lambda G_j/100) \quad (15)$$

Equations 13–15 apply unchanged at district level once district populations, gap scores and allocations are loaded. Where the spending rate is low (an illustrative threshold is 90%) and the gap is positive, the first remedy is implementation support rather than a larger allocation. At present the rule can be run only at state level, because district allocation and expenditure are not available from public sources.

3.8 Methodological limitations

The main limits are set out in Section 6 and are summarised here in five points: (i) there are no public district budget or expenditure data, so the financing evidence is national and state- level; (ii) infrastructure varies only by state, so district gap rankings are largely state rankings; (iii) the

design is ecological and descriptive, and cannot support causal claims (Robinson, 1950); (iv) outcomes are nutrition indicators and the sample is phase-I states only (338 of

about 707 districts); and (v) the reference years differ, and the percentile-based gap score carries further limits. A sixth limit, the use of rural-area facility counts over total population, is examined in Appendix A and Section 6.12.

3.9 Data analysis and interpretation

The analysis proceeds from description to comparison to association, using the techniques defined in Section 3.7. For each exhibit in Section 4 the text states (a) what is measured, (b) the statistic, and (c) how to read it for investment. Four reading rules apply throughout.

A positive gap, or membership of the priority quadrant, means that on current supply the district is under-served relative to need.

A spending rate below 100% means unspent funds; above 100% means spending beyond the allocation.

A t-test is read together with Cohen's d (0.2 small, 0.5 medium, 0.8 large), because with several hundred districts even trivial differences are significant.

Infrastructure is attached at state level, so district observations in the same state are not independent and p-values on state-level variables are optimistic.

The allocation rule (Equations 13–15) is illustrative until district allocation data are available. Two official national series are chain-linked: Series A (NHP Tables 4.2.1–4.2.2) for 2018–19 and 2019–20, and Series B (flexible pool plus infrastructure maintenance; NHP Table 4.2.4 and the Expenditure Profile 2025–26) from 2020–21, because only Series B reaches 2024–25 (Table 1A compares them). The 2024–25 rate is 100% because the revised estimate equals the budget estimate.

4. DATA ANALYSIS AND INTERPRETATION

4.1 National NHM trend, 2018–19 to 2024–25

Table 1 sets out the real national NHM trend. Two official national series are used because neither covers the whole period (Table 1A). Series A (NHP Tables 4.2.1–4.2.2) shows actual NHM expenditure at 86% of outlay in 2018–19 and 92% in 2019–20. Series B (flexible pool for RCH and health system strengthening plus infrastructure maintenance; NHP Table 4.2.4 and the Expenditure Profile 2025–26) shows 112% in 2020–21, 91% in 2021–22, 108% in 2022–23 and 113% in 2023–24, and a revised estimate equal to the budget (Rs 35,783 crore) in 2024–25. Over 2020–21 to 2023–24, Series B expenditure was 105.6% of budget (Rs 123,621 crore

against Rs 117,034 crore). No district-level budget or expenditure series is published in the public sources used here (Section 6), so the trend is national.

Table 1. National NHM budget and spending, FY2018–19 to 2024–25, with sources

FY	National NHM budget (Rs cr)	Actual expenditure / RE (Rs crore)	National rate (%)	Series and source
2018–19	32,130	27,764	86.4	A: NHP T4.2.1–2
2019–20	39,551	36,367	91.9	A: NHP T4.2.1–2
2020–21	27,989	31,296	111.8	B: NHP T4.2.4
2021–22	31,100	28,300	91.0	B: NHP T4.2.4
2022–23	28,860	31,196	108.1	B: NHP T4.2.4
2023–24	29,085	32,828	112.9	B: NHP T4.2.4 (BE); MoF EP 2025–26 (actual)
2024–25	35,783	35,783	100.0	B: MoF EP 2025–26 (BE = RE)

2024–25 35,783 35,783 100.0 B: MoF EP 2025–26 (BE = RE)

Note: National series, real data. Series A is the broader NHM head (NHP 2023, Tables 4.2.1–4.2.2); Series B is the flexible pool plus infrastructure maintenance (NHP Table 4.2.4; Ministry of Finance Expenditure Profile 2025–26, Statement 3). The two are not comparable in level, so national totals are not given. The FY2024–25 figure is the revised estimate (RE), not a final actual-expenditure figure. Sources: NHP 2023 Tables 4.2.1–4.2.4; MoF Expenditure Profile 2025–26.

Table 1A. Two official NHM series for the same years (Rs crore)

FY	Series A budget	Series A actual	Series A rate (%)	Series B budget	Series B actual	Series B rate (%)
2020–21	39,839	39,569	99.3	27,989	31,296	111.8
2021–22	42,978	49,278	114.7	31,100	28,300	91.0
2022–23	47,634	40,662	85.4	28,860	31,196	108.1

Note: Series A: NHP 2023, Tables 4.2.1–4.2.2. Series B: NHP 2023, Table 4.2.4 (flexible pool + infrastructure maintenance + programme management). The series differ in coverage, so rates differ, and the COVID-year reading depends on which is used (Section 4.7).

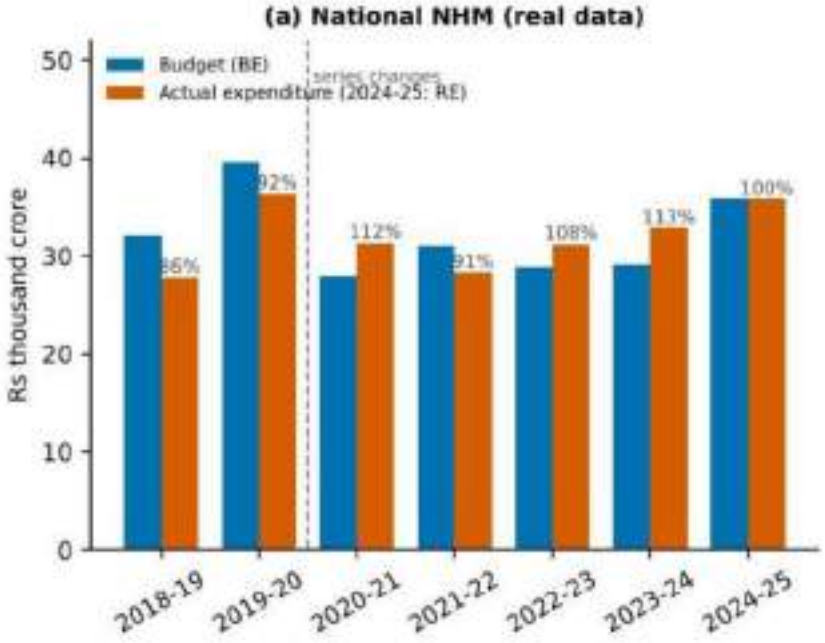

Figure 1. National NHM budget allocation versus actual expenditure, FY2018–19 to 2024–25 (bar chart). Series change after 2019–20; 2024–25 actual is a revised estimate. Source: NHP 2023 Tables 4.2.1–4.2.4; MoF Expenditure Profile 2025–26.

Reading Figure 1: national spending is below budget in 2018–19 and 2019–20, above it in 2020–21, below it in 2021–22 and above it again in 2022–23 and 2023–24. An unspent balance is therefore not a stable property of the programme; it moves with funding shocks and with how the budget is revised.

Table 1B. Unspent balances held by states for NHM and health-infrastructure schemes, as on 31 December 2024 (Rs crore)

Scheme	RE 2024–25	Released by Centre to 31.12.2024	Balance with states (SNA + treasury)	Balance as % of 2024– 25 releases
Flexible Pool for RCH & Health System Strengthening, NHP and NUHM	28,783	23,792	2,988	12.6
Infrastructure Maintenance	7,000	5,788	29	0.5
PM Ayushman Bharat Health Infrastructure Mission (PM-ABHIM)	3,000	1,112	1,145	103

Note: Source: Ministry of Finance, Expenditure Profile 2025–26, Statement 4AA. Balances include carry-over from earlier years and normal just-in-time float, so they are not annual underspending. PM-ABHIM balance exceeds 2024–25 releases because of earlier-year funds. National, scheme-level data: no state or district split.

Table 1B is the only evidence in the sources used on scheme-level fund balances. Approximately 12.6% of releases for the NHM flexible pool and 0.5% for infrastructure

maintenance were held in state accounts at the end of December 2024. The PM-ABHIM balance (Rs 1,145 crore) was equivalent to 103% of FY2024–25 releases (Rs 1,112 crore), but includes funds carried forward from earlier years and is not a direct measure of annual underspending or a comparable annual absorption rate. These figures are national and do not provide a state or district split.

4.2 Descriptive statistics and coefficient of variation

Table 2. Descriptive statistics and coefficient of variation (CV, %) of outcomes, healthcare gap and infrastructure

Variable	N	Mean	SD	Min	Median	Max	CV (%)
Stunting, children (%) 2019–21	338	34.14	8.19	15.50	33.70	59.00	24.0
Underweight, children (%)	338	31.02	10.11	7.20	31.20	57.20	32.6
Anaemia, children (%)	338	65.16	13.64	28.00	67.80	95.50	20.9
Anaemia, women (%)	338	57.02	13.50	14.90	58.65	93.50	23.7
Nutrition Burden Index (0–100)	338	49.78	15.12	10.45	51.43	86.85	30.4
Facilities per 100,000 (state)	338	21.03	11.15	12.05	18.94	120.44	53.0
Infrastructure Index (percentile, 0–100)	338	50.15	28.81	5.77	50.15	99.85	57.5
Healthcare Gap score (burden pct − infra pct)	338	−0.00	50.50	−96.01	7.62	91.57	n/a

Note: All rows are real (NFHS-5, NHP 2023). CV is not reported where the mean is zero by construction (Gap). Sources: NFHS-5 district fact sheets; NHP 2023 Tab. 6.2.1; authors' calculations.

Dispersion is widest in infrastructure (CV 53%, inflated by Ladakh at 120 per 100,000) and in the Nutrition Burden Index (CV 30%), and lowest for anaemia in children (CV 21%), which is high everywhere (mean 65%). Stunting ranges from 15.5% to 59.0% (mean 34.1%), a 3.8- fold spread between districts. A one-way decomposition shows that the state a district belongs to accounts for 70% of the variance in the burden index, so most inequality lies between states, but 30% lies within states and cannot be reached by state averages alone.

4.3 State-wise analysis: the ten largest health-infrastructure states

States are ranked by total public facilities (sub-centres, PHCs, CHCs, sub-divisional and district hospitals) among the 20 states and UTs in the analytical sample. Table 2A gives the ten largest.

Why total facilities and facilities per 100,000 lead to different conclusions. The two measures answer different questions. A total count measures the size of a state's network; facilities per 100,000 divide that count by the Census 2011 population and so measure how thinly the

network is spread. Maharashtra (13,726 facilities) and Andhra Pradesh (13,418) lead on totals and are within 2.5% of each other, yet their densities are 12.2 and 27.2 per 100,000, a difference of more than twofold. Dividing each total by its density implies roughly 112

million people in Maharashtra against roughly 50 million in Andhra Pradesh, which accounts for the whole difference. In the same way, Bihar (12,541; 12.0) has almost the same total as Karnataka (12,168; 19.9) but a density about 40% lower, and Kerala has about half of Maharashtra's total but a density about 65% higher (20.1 against 12.2). Jammu & Kashmir has the smallest network of the ten (3,538) and the highest density (28.8).

Totals therefore show where facilities are physically concentrated and what the network costs to maintain, but they say little about access, because they ignore the population served. Density is the better basis for equity, which is why the gap score uses it, and investment that followed totals would favour the largest states, whereas investment that follows density points to places where each facility serves the most people. Neither measure captures size, staffing, beds or quality, and both depend on Census 2011 populations, which understate present populations (Section 3.5). Because the facility counts are rural-area counts divided by total population, density is also likely to be understated in more urbanised states (Section 3.2; Appendix A). By density, Bihar is lowest in the sample (12.0 per 100,000), followed by Maharashtra (12.2), and it also has one of the highest burdens (64.3, with Gujarat at 64.9); Andhra Pradesh and Jammu & Kashmir have the highest density of the ten (27.2 and 28.8).

Table 2A. The ten largest health-infrastructure states in the sample

State	Total facilities	Per 100,000	Govt health exp. per capita 2019–20 (Rs)	Districts	ADP districts	Mean burden	Mean gap
Maharashtra	13,726	12.2	1,675	36	4	54.2	41.0
Andhra Pradesh	13,418	27.2	1,699	13	3	46.5	−39.5
Bihar	12,541	12.0	701	38	13	64.3	75.6
Karnataka	12,168	19.9	1,655	30	2	47.1	−21.3
West Bengal	12,154	13.3	1,346	20	0	56.5	38.2
Gujarat	11,371	18.8	1,861	33	2	64.9	32.6
Kerala	6,721	20.1	2,590	14	1	21.0	−64.9
Assam	5,951	19.1	1,657	33	7	55.5	5.9
Telangana	5,872	16.7	2,263	31	3	52.4	20.3
Jammu & Kashmir	3,538	28.8	1,554	20	2	46.3	−44.1

Note: Facilities: NHP 2023, Table 6.2.1 (31 March 2022). Per capita GHE: NHP 2023, Tables 4.1.5–4.1.7. Burden and gap: authors' calculation from NFHS-5. Sources: NHP 2023 Tab. 6.2.1 and 4.1.5–4.1.7; NFHS-5; authors' calculations.

4.4 Region-wise analysis

Table 3. Region-wise healthcare infrastructure and outcome gap, sample states only

Region (sample states only)	States	Districts	Facilities per 100,000	Mean burden	Mean gap
East (Bihar, West Bengal)	2	58	12.5	61.6	62.7
North (Himachal Pradesh, J&K, Ladakh)	3	34	38.8	45.9	−50.0
North-East (7 states)	7	84	24.9	41.8	−33.0
South (Andhra Pradesh, Telangana, Karnataka, Kerala)	4	88	19.9	44.8	−16.3
West (Gujarat, Maharashtra, Goa)	3	71	15.4	58.5	35.2

Note: Facilities, burden and gap are real (NFHS-5, NHP 2023). Each region comprises only the states named or counted; other states of the region are not in the file. Island UT (3 districts) excluded. Sources: NFHS-5; NHP 2023; Census 2011.

The regional results describe the sample states only and are not estimates for whole regions. In this sample the two eastern states (Bihar and West Bengal) and the three western states (Gujarat, Maharashtra and Goa) have the largest positive gaps (+62.7 and +35.2): high burden with low facility density (12.5 and 15.4 per 100,000). The three northern states (Himachal Pradesh, Jammu & Kashmir and Ladakh) and the seven north-eastern states have negative gaps because they combine moderate burden with the highest facility density, which may partly reflect a hill-state effect of many small facilities serving small populations. These results should not be read as findings for northern, eastern or any other region as a whole. Uttar Pradesh, Punjab, Haryana and Delhi are absent from the northern group, Odisha and Jharkhand are absent from the eastern group, and Tamil Nadu is absent from the southern group, so the regional means could differ if those states were added. Allocation by region cannot be shown because public sources give no district allocation (Section 6); the equity- relevant quantity, allocation per unit of gap, is the first thing to compute once such data exist.

4.5 North versus South: core comparative analysis

District allocation and spending cannot be compared between North and South because no public district-level budget data are available (Section 6). The comparison below therefore uses the real outcome and supply data, and it compares the three northern sample states (34 districts) with the four southern sample states (88 districts), not the two regions as a whole.

Table 4. Descriptive statistics for northern (n = 34) and southern (n = 88) sample districts

Variable	North mean	North SD	North median	North CV (%)	South mean	South SD	South median	South CV (%)
Nutrition Burden Index	45.9	8.3	44.5	18.1	44.8	14.2	46.5	31.8
Stunting (%)	28.3	5.7	27.4	20.1	31.7	8.2	31.1	25.8

Variable	North mean	North SD	North median	North CV (%)	South mean	South SD	South median	South CV (%)
Facilities per 100,000 (state)	38.8	21.6	28.8	55.7	19.9	3.3	19.9	16.8
Healthcare Gap score	−50.0	20.0	−54.1	n/a	−16.3	36.9	−13.5	n/a

Note: Facilities are state-level, so within-region SD reflects between-state differences only. CV for the gap score is not interpretable (mean near zero). Sources: NFHS-5; NHP 2023; authors' calculations.

Table 5. Welch two-sample t-test comparing northern and southern sample districts: infrastructure and outcome gap (NFHS-5 2019–21; NHP 2023)

Variable	North mean	South mean	Diff. (N–S)	t	df (Welch)	p	Cohen's d	p (Mann–Whit ney)
Nutrition Burden Index	45.9	44.8	1.2	0.56	100.9	0.576	0.09	0.929
Stunting (%)	28.3	31.7	−3.4	−2.57	85.9	0.012	−0.44	0.024
Facilities per 100,000 (state)	38.8	19.9	18.9	5.09	33.6	<0.001	1.62	<0.001
Healthcare Gap score	−50.0	−16.3	−33.7	−6.46	107.0	<0.001	−1.02	<0.001

Note: Real variables use NFHS-5 / NHP 2023. Facilities and gap depend on state-level infrastructure, so effective sample size is closer to 7 states than to 122 districts; treat p-values as descriptive. Sources: NFHS-5; NHP 2023; authors' calculations.

Northern and southern sample districts do not differ in overall nutrition burden (45.9 against 44.8; t = 0.56, p = 0.58), although stunting is lower in the northern states (28.3% against 31.7%; p = 0.012, d = −0.44). The three northern states have almost twice the facility density of the four southern states (38.8 against 19.9 per 100,000; d = 1.6), so their mean gap is far lower (−50.0 against −16.3; d = −1.0). Similar overall need but unequal supply means that, within this sample, the southern districts are relatively under-provided with public facilities compared with the northern ones, although facility counts do not capture facility size, staffing or catchment population, which may differ between the two groups. The result does not extend to the North and South as regions.

4.6 Districts with the Highest and Lowest Healthcare Gap Scores

Figure 2 ranks districts by the Healthcare Gap score. The five largest gaps are all in Bihar (Araria, Sheikhpura, Nalanda, Banka, Lakhisarai), where burden is among the highest in the sample and facility density is the lowest; three of the five (Araria, Sheikhpura, Banka) are Aspirational Districts. The five smallest gaps are all in Mizoram (Champhai, Aizawl, Lunglei, Mamit, Serchhip), which has very low burden and the second-highest facility density after Ladakh. Because infrastructure is state-level, the extremes are state-driven; with district facility counts the ranking would reorder within states. Since NFHS-5 is a 2019–21 snapshot, this ranking describes the baseline, not a trend over 2018–2025.

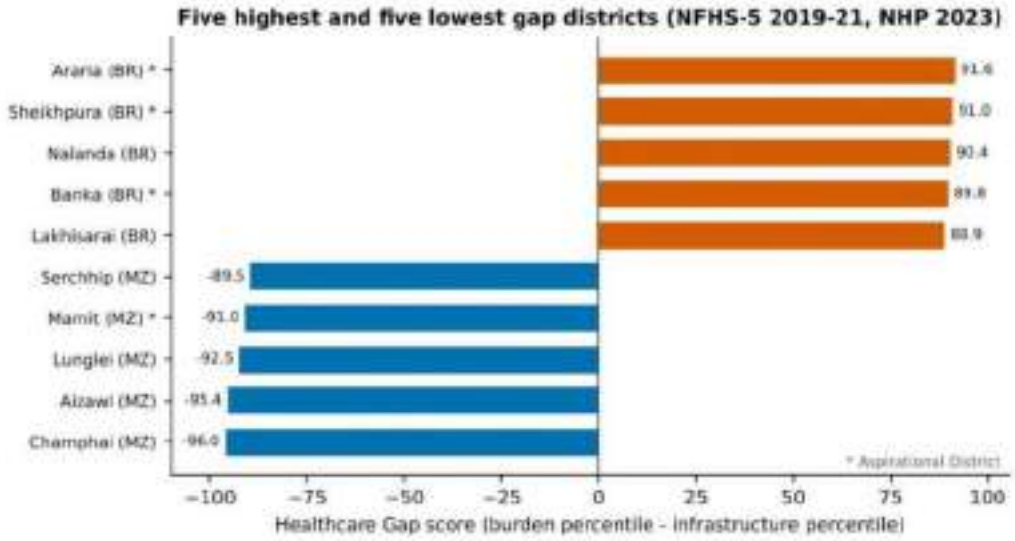

Figure 2. The five districts with the highest and the five with the lowest healthcare infrastructure and outcomes gap (NFHS-5 2019–21, NHP 2023). Source: NFHS-5; NHP 2023; authors' calculations.

Table 6. Data behind Figure 2

District	State	Stunting (%)	Burden index	Facilities per 100,000	Gap score
Araria *	Bihar	49.9	74.6	12.0	91.6
Sheikhpura *	Bihar	53.6	73.8	12.0	91.0
Nalanda	Bihar	42.6	72.5	12.0	90.4
Banka *	Bihar	46.7	71.9	12.0	89.8
Lakhisarai	Bihar	42.7	71.2	12.0	88.9
Serchhip	Mizoram	31.8	24.1	42.0	−89.5
Mamit *	Mizoram	26.4	22.5	42.0	−91.0
Lunglei	Mizoram	26.5	21.2	42.0	−92.5
Aizawl	Mizoram	25.3	18.1	42.0	−95.4
Champhai	Mizoram	27.2	16.9	42.0	−96.0

Note: Aspirational District. Upper five: highest gap; lower five: lowest gap. Sources: NFHS-5; NHP 2023; Kapoor & Green (2020) for the Aspirational flag.*

4.7 COVID-19 period: what the data can and cannot show

The two official national series disagree on the pattern of NHM spending in the COVID-19 years: Series A shows 99% of outlay in 2020–21, 115% in 2021–22 and 85% in 2022–23, and Series B shows 112%, 91% and 108% (Table 1A), so neither shows a spending collapse in 2020–21. These rates describe what was spent and not an effect of the pandemic: the series move in opposite directions, budgets were revised during the period, the data are national and annual with no comparison group, and NFHS-5 fieldwork in the sample states was largely completed before March 2020, so the survey outcomes cannot show pandemic effects. Evidence on service disruption comes from other sources (WHO, 2022; Sharma et al., 2024) and is context, not a result of this study; testing whether districts with weaker infrastructure absorbed less when funds rose would need a district-year panel built on real district budget data (Section 6).

4.8 Additional diagnostics

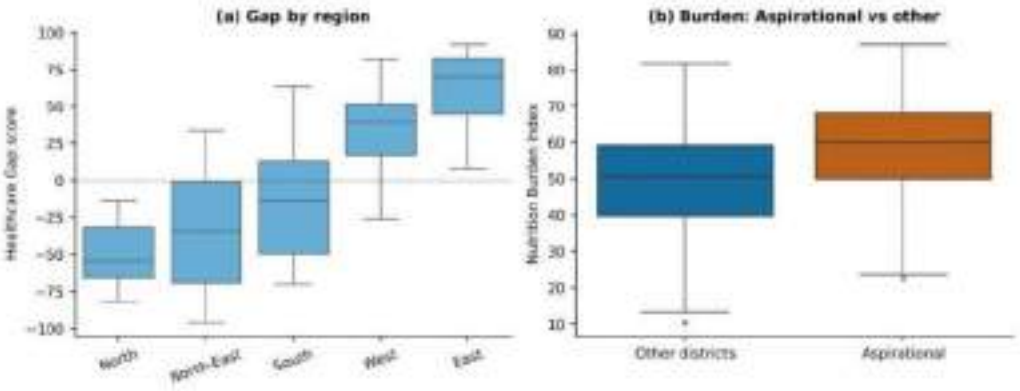

Figure 3. Box plots: (a) Healthcare Gap score by region (sample states); (b) Nutrition Burden Index in Aspirational and other districts. Source: NFHS-5; NHP 2023; Kapoor & Green (2020).

Figure 3(a) orders the sample regions from North (lowest gap) to East (highest). Figure 3(b) shows that Aspirational Districts carry a higher burden (median 59.9 against 50.5; Mann–Whitney $p < 0.001$), so ADP targeting is directionally consistent with need, although 12 of the 44 matched Aspirational Districts (27%) still fall below the median burden.

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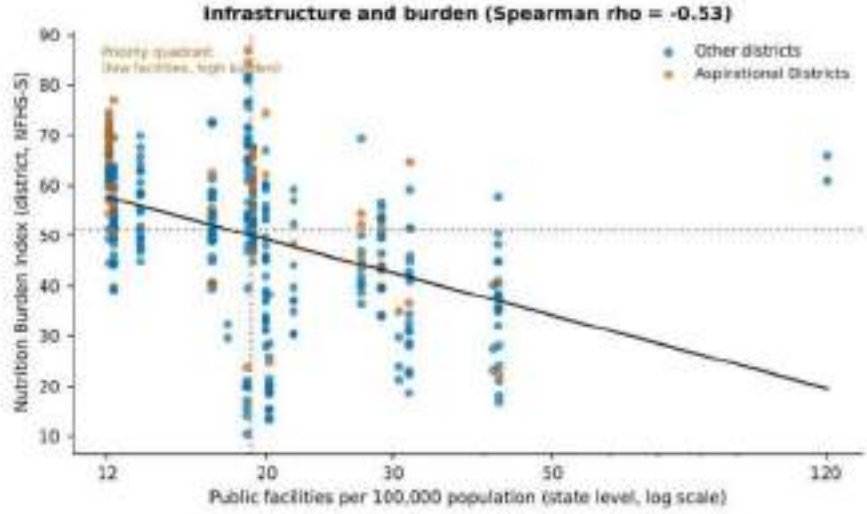

Figure 4. Scatter plot of state facility density (log scale) against district Nutrition Burden Index, with fitted line; Aspirational Districts highlighted. Source: NFHS-5; NHP 2023; Kapoor & Green (2020).

Facility density and burden are negatively associated (Spearman rho = −0.53, n = 338, state-level exposure, so interpret with caution). 115 districts fall in the priority quadrant (below-

median density, above-median burden), of which 20 are Aspirational. Ladakh has very high density and moderate burden (right edge of Figure 4). The priority quadrant is concentrated in Bihar (36 districts), Gujarat (29), Maharashtra (24), Telangana (13) and West Bengal (13).

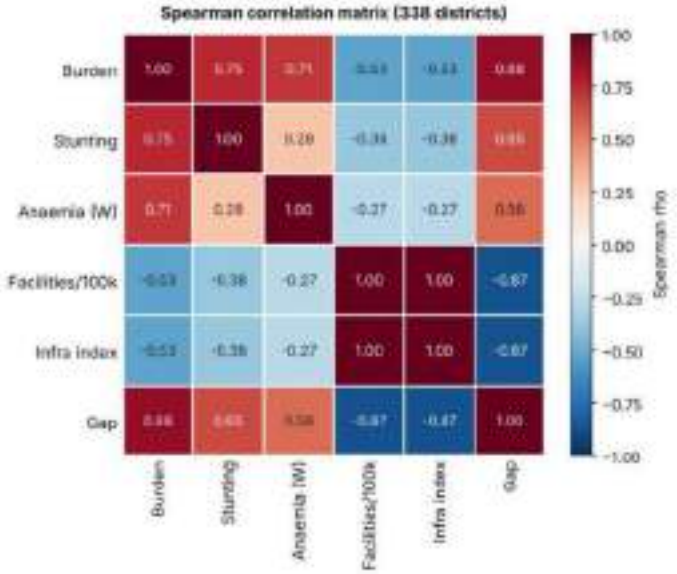

Figure 5. Heat map of Spearman correlations among outcome, infrastructure and gap variables. Source: NFHS-5; NHP 2023; authors' calculations.

The nutrition indicators move together (burden with stunting 0.75 and with women's anaemia 0.71), while facility density is negatively correlated with burden (−0.53) and with the gap score (−0.87). The latter is partly by construction, since the gap is the burden percentile minus the infrastructure percentile.

5. ETHICAL CONSIDERATIONS

This study uses only secondary, publicly available, aggregated data (NFHS-5 and NFHS-4 district estimates, the National Health Profile 2023, Census 2011, the Ministry of Finance Expenditure Profile 2025–26 and the Aspirational Districts list), with no direct contact with participants, no identifiable information and no intervention, so formal review by an institutional ethics committee was not required and the risk of re-identification is negligible. The most important data issue is that public sources do not report budget allocation or expenditure by district: the financing evidence used here is national (NHM) and state-level, so no result is attributed to the spending behaviour of any district. Rankings can stigmatise the places at the bottom, so the Bihar and Mizoram extremes, which are largely driven by state-level facility counts, are described as a baseline of supply relative to need and not a judgement on local administration; a high nutrition burden is not read as a failure of the health system alone, and Aspirational District status is reported as a programme designation, not a label of underperformance. The design is ecological and the sample covers phase-I states only, so

associations should not be applied to individuals or facilities (Robinson, 1950) and p-values on state-level variables are treated as descriptive. Findings should be used to direct resources and implementation support toward districts with high need and low supply, not to penalise districts that spend slowly, since a district that cannot absorb its allocation may need technical

support rather than a smaller budget, and they should be combined with local evidence on staffing, quality, access and the private sector before guiding allocation. Data, definitions, formulas and code are described in enough detail for the analysis to be reproduced, all sources are acknowledged, and the work is the authors' own analysis and writing.

6. LIMITATIONS

6.1 No district budget data.

Public sources report NHM allocation, release and expenditure nationally and by state, not by district, so whether money follows need, and how fast districts absorb it, cannot be tested at district level. The financing evidence is national (Tables 1, 1A, 1B) and state-level (government health expenditure per capita).

6.2 Infrastructure is measured at state level and attached to districts, so gaps inside states are not observed and district gap rankings are largely state rankings.

District facility, workforce and bed counts (National Health Resource Repository, HMIS) should replace it.

6.3 Facility counts ignore staffing, beds, equipment, quality and the private sector.

They are a coarse proxy for capacity (Kruk et al., 2018). Census 2011 populations understate present populations and inflate density; small-population Ladakh is an outlier.

6.4 Outcomes are nutrition indicators, not mortality or service use; district mortality is not in the data used.

Nutrition outcomes respond to many non-health determinants (food, sanitation, income), so a high burden is not purely a health-system failure.

6.5 The sample is 338 of about 707 districts, from phase-I states only, with no UP, Rajasthan, MP, Tamil Nadu or Punjab.

The "North" group has only three states, and every regional result describes only the sample states in that region. Results are not nationally representative.

6.6 The ecological design supports description and association, not causal inference, and aggregate relationships need not hold for individuals or facilities (Robinson, 1950).

District observations within a state are correlated, so district-level p-values for state- level variables are optimistic.

6.7 Reference years differ: outcomes 2019–21, infrastructure March 2022, population 2011, national NHM budget 2018–25 (Section 4.5).

NFHS-4 values for 79 districts with boundary changes are approximated from parent districts, so change estimates for those are approximate. Name matching may have missed some Aspirational Districts (44 of 112 were found, because the remaining 68 lie in states outside the file).

6.8 The percentile-rank gap score has zero mean by construction and depends on the sample.

scores are not comparable across studies with different samples.

6.9 Some planned techniques are not yet reported.

The concentration index and the equity- weighted allocation rule are planned (Table M2), so the findings in Section 8 rest only on the applied techniques.

6.10 The national NHM series are central-sector figures and exclude state own-source spending, which is the larger share of public health spending (state governments accounted for about 64% of government health expenditure in 2019–20, NHP Table 4.1.4).

The two series used (A and B) differ in coverage and give different COVID-year readings; 2024–25 is a revised estimate. Unspent-balance data (Table 1B) are national, by scheme, and include carry-over and float.

6.11 Claims about COVID-19 service disruption rest on external evidence (Section 5.7)

because no district-level service-use or budget data are used here, so spending patterns are not attributed to the pandemic.

6.12 Rural-area facility counts are divided by total population.

The Rural Health Statistics enumerate rural facilities, whereas the density denominator is the total Census 2011 population (Section 4.2). This understates density, and so overstates the gap, in more urbanised states such as Maharashtra, Gujarat and Telangana, which together account for 66 of the 115 Priority Quadrant districts. Appendix A shows that the densities and the ranking of states change materially when rural population is used instead. The district- level Healthcare Gap scores and Priority Quadrant counts reported in this paper have not been recomputed on that basis, because that requires the district-level burden file and facility counts for all 20 sample states; until that is done, the quadrant counts for Gujarat, Maharashtra and Telangana in particular are the most likely to change and should be read with caution.

7. MAIN FINDINGS AND DISCUSSION

7.1 Variation in Nutritional Need Across Districts

The first major finding is the substantial variation in nutritional deprivation across the 338 districts included in the study. The analysis uses four indicators from NFHS-5: childhood stunting, childhood underweight, anaemia among children and anaemia among women. These indicators capture different but interconnected dimensions of nutritional disadvantage and are combined to construct the Nutrition Burden Index (NBI), with higher values indicating greater nutritional burden relative to the observed sample.

The descriptive results reveal considerable differences between districts. Childhood stunting ranges from 15.5% to 59.0%, with a mean of 34.14%. Childhood underweight ranges from 7.2% to 57.2%, while anaemia affects an average of 65.16% of children and 57.02% of women in the sample. The NBI ranges from 10.45 to 86.85, with a mean of 49.78 and a coefficient of variation of 30.4%.

These differences indicate that nutritional deprivation is not distributed uniformly across the study sample. Some districts experience substantially greater nutritional disadvantage than others, implying that a uniform approach to public health planning may overlook differences in the intensity of need. The high average prevalence of childhood and women's anaemia also indicates that nutritional challenges are not restricted to a small number of exceptionally disadvantaged districts.

The study further examines whether these differences primarily reflect disparities between states or variation among districts within the same state. The variance decomposition indicates that state membership accounts for approximately 70% of the variation in the Nutrition Burden Index, while the remaining 30% occurs within states. This distinction is important because it demonstrates that state-level differences are a major component of nutritional inequality, but state averages cannot fully represent the distribution of need within individual states.

The implication is that equitable public health planning requires two levels of prioritisation. First, state-level policy must recognise persistent geographical differences in nutritional deprivation. Second, district-level planning must identify local concentrations of need that may not be apparent from overall state performance.

It is also important to interpret the NBI correctly. It is a composite, sample-relative index constructed from normalised nutritional indicators, not a direct measure of malnutrition prevalence. A score of 80, for instance, does not mean that 80% of a district's population is

malnourished. Its purpose is to compare relative nutritional burden across the districts included in the analysis.

7.2 Mismatch Between Nutritional Need and Public Healthcare Facility Supply

The second major finding is that public healthcare facility availability does not align uniformly with nutritional need. To assess this relationship, the study measures functioning public facilities per 100,000 population and compares the resulting supply indicator with district nutritional burden.

The average facility density in the sample is approximately 21.03 facilities per 100,000 population, although the observed distribution is highly dispersed. Facility density ranges from approximately 12.05 to 120.44 per 100,000, with a coefficient of variation of 53%. The upper extreme is associated with Ladakh, where the small population denominator substantially affects the calculated density.

The distinction between absolute facility counts and population-adjusted facility density is particularly revealing. Maharashtra has 13,726 public facilities, Bihar has 12,541 and West Bengal has 12,154, placing all three among the states with the largest public facility networks in the study. Nevertheless, their facility densities are only 12.2, 12.0 and 13.3 per 100,000 population, respectively. Bihar, in particular, combines a large absolute number of facilities with the lowest facility density among the sampled states reported in the comparison. These results demonstrate why infrastructure should not be assessed through facility totals alone. The number of facilities indicates the scale of the public healthcare network, but it does not reveal how widely that network must serve the population. Population-adjusted density offers a more relevant, although still incomplete, measure of relative availability.

The association analysis provides further evidence of a mismatch. The Spearman rank correlation between the Nutrition Burden Index and facility density is −0.53, indicating a moderate negative association: districts with higher nutritional burden tend, within the study's measurement framework, to be associated with lower public facility availability.

This finding is consistent with the concern motivating the research. Where nutritional need is relatively high, public facility supply does not necessarily reach correspondingly high levels.

However, the interpretation requires an important qualification. The infrastructure figures in this analysis are available at state level and are assigned to districts within each state. Consequently, districts in the same state receive the same facility-density measure. The negative association therefore primarily reflects differences between states, rather than

independently measured differences in infrastructure between districts within a state. It cannot establish that one district has fewer facilities than another district in the same state.

Moreover, facility density is a measure of quantity relative to population, not of the quality or effective capacity of healthcare provision. It does not account fully for the differences in facility size, beds, staffing, equipment, accessibility or service quality. The counts are also rural-area counts divided by total population, so density is likely to be understated in more urbanised states (Appendix A).

The evidence should therefore be understood as identifying a relative need–supply mismatch, rather than proving that facility availability alone determines nutritional outcomes.

7.3 Identification of Priority Investment Districts

Building on the observed relationship between nutritional burden and facility availability, the study constructs a Healthcare Gap score to identify districts where measured supply is relatively weak compared with nutritional need.

The score is calculated as Gi = P(NBIi) − P(INFi), where P(NBIi) represents the district's percentile rank for nutritional burden and P(INFi) represents the percentile rank of the facility-supply measure assigned to that district.

A positive gap indicates that a district ranks relatively worse in nutritional need than in facility supply, suggesting that its measured supply position is insufficient relative to its need. A negative gap indicates that its facility-supply rank is more favourable than its need rank. These scores are relative to the study sample, rather than absolute assessments of adequacy.

The analysis identifies 115 districts, or 34% of the sample, in the Priority Investment Quadrant. These districts have above-median nutritional burden and below-median facility density. They are concentrated in Bihar, Gujarat, Maharashtra, Telangana and West Bengal. Bihar accounts for 36 priority districts, followed by Gujarat with 29, Maharashtra with 24, Telangana with 13 and West Bengal with 13. The concentration of priority districts in these states demonstrates that the need–supply mismatch is geographically uneven.

The five districts with the largest positive Healthcare Gap scores are all located in Bihar: Araria (+91.6), Sheikhpura (+91.0), Nalanda (+90.4), Banka (+89.8) and Lakhisarai (+88.9). Their burden index, stunting and facility density are shown in Table 6 (Section 4.6).

In contrast, the five districts with the lowest gap scores are located in Mizoram, led by Champhai (−96.0) and Aizawl (−95.4). These districts combine relatively low nutritional burden with a more favourable facility-density position. The contrast identifies two very

different profiles: districts where nutritional need is high relative to measured supply and districts where measured supply is more favourable relative to need.

Nevertheless, the extreme rankings are largely driven by state-level infrastructure measures. They should not be interpreted as precise assessments of facility adequacy within each district. With actual district-level facility, workforce and bed-strength data, the rankings could change substantially.

The main analytical contribution of this exercise is therefore the creation of a transparent baseline for prioritisation. It shows where further investigation and targeted investment may be most warranted, while highlighting the need for better district-level infrastructure data before final funding decisions are made.

7.4 Alignment of Priority Programmes with Nutritional Need

The study also examines whether districts included in the Aspirational Districts Programme (ADP) display greater nutritional deprivation than other districts in the analytical sample.

The results indicate that the median Nutrition Burden Index for matched Aspirational Districts is 59.9, compared with 50.5 for other districts. The difference is statistically significant according to the Mann–Whitney test ($p < 0.001$). This suggests that the programme's geographical targeting is directionally consistent with the distribution of nutritional need: districts included in the programme tend to have higher nutritional burdens.

However, the relationship is not complete. Of the 44 matched Aspirational Districts in the sample, 12, or approximately 27.3%, fall below the sample median nutritional burden. Conversely, 95 of the 115 districts identified in the Priority Investment Quadrant are outside the matched Aspirational District sample.

This finding reveals an important distinction between programme targeting and the distribution of relative need. The evidence suggests that the ADP reaches districts with comparatively high nutritional deprivation, but programme designation alone does not capture every district where nutritional burden and low facility availability coincide.

Districts such as Nalanda and Lakhisarai in Bihar illustrate why a broader need-based screening exercise may be useful. Their high positive gap scores indicate that a district's relative supply–need position can warrant attention regardless of whether it appears on the sampled ADP list.

The findings consequently support supplementing existing programme-based targeting with a transparent assessment of nutritional need and relative facility availability. Rather than treating programme membership as the sole criterion for investment, policymakers could use the

Priority Investment Quadrant as an additional diagnostic tool. This conclusion should not be interpreted as evidence that ADP funding is insufficient, misallocated or ineffective. The study does not directly compare district-level programme expenditure with subsequent health improvements. It establishes that programme targeting broadly corresponds to nutritional need, while identifying additional districts that merit closer examination.

7.5 Regional Differences in Health Need and Facility Availability

The regional analysis further demonstrates that nutritional burden and public facility availability do not follow identical geographical patterns. The comparison covers only the states represented in the sample, and the results therefore should not be generalised to entire Indian regions.

Among the sampled regions, Bihar and West Bengal together have a mean Nutrition Burden Index of 61.6 and an average facility density of 12.5 per 100,000 population. Their mean Healthcare Gap score is +62.7, indicating a substantial mismatch between nutritional burden and measured facility supply.

The sampled western states of Gujarat, Maharashtra and Goa have a mean nutritional burden of 58.5, facility density of 15.4 per 100,000 and mean gap score of +35.2. These results likewise indicate a relatively unfavourable need–supply position.

In contrast, the sampled northern states and Union Territories—Himachal Pradesh, Jammu and Kashmir, and Ladakh—have a mean nutritional burden of 45.9 and facility density of 38.8 per 100,000, resulting in a mean gap score of −50.0. The sampled north-eastern states also have a negative mean gap, reflecting comparatively favourable facility density relative to their measured nutritional burden.

The distinction between need and supply becomes particularly clear when comparing the sampled northern and southern groups. The mean Nutrition Burden Index is 45.9 in the northern sample and 44.8 in the southern sample. The difference is not statistically significant ($p = 0.576$). However, mean stunting is lower in the northern sample, at 28.3%, compared with 31.7% in the southern sample, a statistically significant difference in this analysis ($p = 0.012$). The facility-density difference is considerably larger: the northern sample has 38.8 facilities per 100,000 population compared with 19.9 in the southern sample. The resulting difference in mean Healthcare Gap score is −50.0 in the northern group against −16.3 in the southern group. The southern group is therefore comparatively less favourably supplied relative to need within this particular sample.

These comparisons demonstrate why similar levels of nutritional burden do not necessarily imply similar levels of infrastructure provision. They also indicate that an allocation approach based exclusively on regional averages could overlook differences in population size, facility characteristics and local requirements.

However, this is a comparison of selected states, not of northern and southern India in their entirety. The northern group consists of three predominantly mountain jurisdictions, while the southern sample includes four states. Furthermore, district observations share state-level facility measures. The reported significance tests must therefore be treated as descriptive rather than definitive evidence about regional healthcare provision.

7.6 Public Health Financing and Fund Absorption

The financing analysis adds a second dimension to the need–supply problem: even where public funds are approved, spending patterns and implementation can differ between years and programmes.

National NHM expenditure data show considerable year-to-year variation in expenditure relative to approved budgets. In one official series, expenditure was approximately 86.4% of budget in 2018–19 and 91.9% in 2019–20. A second series, covering a different component of NHM spending over later years, records expenditure at approximately 111.8% of budget in 2020–21, 91.0% in 2021–22, 108.1% in 2022–23 and 112.9% in 2023–24.

Under the second series, aggregate expenditure from 2020–21 to 2023–24 amounted to 105.6% of the approved budget. The 2024–25 figure is 100% because the budget estimate and revised estimate are equal; it should not be interpreted as a final actual expenditure figure.

These patterns indicate that annual spending rates can fluctuate above and below approved budgets. They should not, however, be interpreted as evidence that one year of higher spending necessarily reflects better access to healthcare or improved health outcomes. The two series cover different expenditure categories and are not directly interchangeable. Nor can the changes be attributed to the COVID-19 pandemic from these data alone.

The scheme-level fund-balance evidence provides a further insight. As of 31 December 2024, states held approximately Rs 1,145 crore in balances under the Pradhan Mantri Ayushman Bharat Health Infrastructure Mission (PM-ABHIM), compared with Rs 1,112 crore released during FY2024–25. The balance was equivalent to 103% of FY2024–25 releases, but includes funds carried forward from earlier years and is not a direct measure of annual underspending or a comparable annual absorption rate. By comparison, balances amounted to approximately

12.6% of releases for the NHM flexible pool and 0.5% for recurring infrastructure maintenance.

The contrast suggests that funds for new capital infrastructure may require longer implementation and absorption periods than recurring programme expenditure. It raises questions about procurement processes, project preparation, engineering capacity and administrative support. Nevertheless, unspent balances do not automatically establish poor performance. Infrastructure projects often operate over multiple years, and balances can reflect the timing of releases, implementation schedules and funds carried forward. The more appropriate policy response is to investigate implementation constraints and provide the necessary technical and administrative support where required.

Most importantly, the available financing data do not establish whether individual districts with high healthcare gaps actually receive less funding than districts with lower needs. Because district-level allocations and expenditure are unavailable in the public sources used, the study cannot directly estimate the district-level relationship between need and actual spending.

7.7 Integrating the Findings: Implications for Equitable Public Health Investment

Taken together, the results establish three connected points.

First, nutritional need is distributed unevenly across the study sample. The NBI and its underlying indicators reveal substantial differences between districts, while variance decomposition shows that disparities arise both between states and within states. Therefore, broad state-level planning is important, but it is insufficient for identifying every location facing relatively high need.

Second, facility supply does not align uniformly with nutritional burden. The negative association between facility density and nutritional burden, together with the identification of 115 districts in the Priority Investment Quadrant, indicates that many districts occupy an unfavourable relative position. The concentration of high gap scores in Bihar and the sizeable number of priority districts in Gujarat, Maharashtra, Telangana and West Bengal show that the pattern is not confined to a single state.

Third, the financing analysis demonstrates that the scale of approved public expenditure must be considered alongside implementation and absorption. National NHM spending rates fluctuate across years, and unspent balances differ considerably between recurring programmes and capital infrastructure initiatives. However, these fiscal indicators cannot establish whether funding reaches the individual districts with the greatest health needs.

These findings suggest that equitable public health investment requires more than increasing aggregate expenditure or expanding facility numbers. A more useful approach would combine a measure of health need, a measure of healthcare supply, information on population size and evidence about implementation capacity.

The Healthcare Gap score provides a starting point for identifying districts where need exceeds their relative supply position. A needs-adjusted allocation framework could then estimate how much additional investment would be required to improve provision in high-gap areas, without automatically reducing existing allocations elsewhere. However, the proposed allocation rule remains illustrative in this study because reliable district-level expenditure data are not available.

For implementation, priority identification should also be accompanied by district-specific assessments of staffing, hospital beds, equipment, facility functionality, quality and access.

Where capital funds remain unspent, technical support may be more effective than simply increasing the allocation. Similarly, programmes such as the ADP could be complemented by a broader screening mechanism that identifies high-need districts outside existing priority lists.

The central policy implication is therefore that public health investment should be informed by the relationship between population need, effective healthcare capacity and implementation constraints, rather than by aggregate budgets or absolute facility counts alone.

7.8 Interpretation and Limitations of the Findings

The results should be interpreted within the limitations of the available data.

First, the analysis includes 338 districts from 20 phase-I states and Union Territories rather than all districts in India. The estimates therefore describe the observed sample and should not be presented as nationally representative.

Second, facility density is measured at state level and assigned to the districts within each state. The Healthcare Gap scores are consequently driven substantially by differences between states and cannot reveal the full extent of infrastructure inequality between districts within the same state.

Third, the analysis uses facility counts rather than detailed measures of staffed capacity, beds, equipment or service quality. A facility count treats different types of institutions as equivalent units, although their ability to provide care can differ considerably. The use of Census 2011 population denominators for facilities counted in 2022 also creates a mismatch in reference

years. In addition, the counts are rural-area counts divided by total population, which may overstate the gap in more urbanised states (Section 6.12; Appendix A).

Fourth, nutritional indicators are influenced by several determinants beyond healthcare provision, including food security, household income, sanitation and maternal education. The negative association between facility density and nutritional burden should therefore not be interpreted as a causal effect of infrastructure on nutrition.

Fifth, actual district-level public health allocations and expenditure are unavailable in the sources used. Consequently, whether public spending follows district-level need remains untested directly. The financing results should be described as evidence about national expenditure trends and scheme-level absorption, supplemented by state-level expenditure comparisons—not as proof of equitable or inequitable district funding.

Finally, several analyses proposed in the methodology, including the district-level financing concentration analysis and the full needs-weighted allocation exercise, are explicitly classified as planned or illustrative rather than completed. The findings presented here rely on the analyses actually reported in this paper.

7.9 Overall Finding

The study finds that substantial nutritional inequality exists across the sampled Indian districts and that measured public facility availability is not uniformly aligned with nutritional need. The identification of 115 districts in the Priority Investment Quadrant provides a practical baseline for further investigation and targeted planning, while the Aspirational District comparison shows that existing priority programmes capture important areas of need but do not encompass every district with an unfavourable need–supply profile.

At the same time, the financing analysis indicates that expenditure and implementation must be examined separately: higher budget utilisation does not by itself establish that resources reach the districts where they are most needed. Because district-level expenditure data are unavailable, the study cannot definitively conclude whether actual funding allocations are equitable.

The principal contribution is therefore a framework for identifying relative healthcare gaps, prioritising locations for further investment assessment and clarifying the additional district-level financing data needed to design a genuinely needs-responsive allocation system.

8. CONCLUSION

This study examined how population health needs, public healthcare facility supply, and public health financing align across 338 districts in 20 phase-I Indian states and Union Territories. It combined district-level nutritional outcomes from NFHS-5 (2019–21), state- level functioning public facility counts from the National Health Profile 2023 (as on 31 March 2022), and national and state public health expenditure records from FY2018–19 to FY2024–

25. Despite sustained spending under the National Health Mission and targeted initiatives

such as the Aspirational Districts Programme (ADP), sharp sub-national inequalities in maternal and child undernutrition persist alongside uneven facility distribution and variable absorption of capital funds. Earlier research has typically examined infrastructure, outcomes, or budgets in isolation, rather than linking them within a single district-level framework to guide equitable investment.

Four main findings emerge. First, nutritional need varies widely: childhood stunting ranges from 15.5% to 59.0% (mean 34.14%), and the composite Nutrition Burden Index ranges from 2 10.45 to 86.85 (mean 49.78). State membership explains 70% of the variance in the index ($\eta = 0.70$), but the remaining 30% lies within states and cannot be addressed through state averages alone. Second, facility supply is inversely aligned with need: facility density is negatively correlated with the Nutrition Burden Index (Spearman's $\rho = -0.53$), and exactly 115 districts (34.0%) fall into the Priority Investment Quadrant, with below-median facility density and above-median burden. These are concentrated in Bihar (36 districts), Gujarat (29), Maharashtra (24), Telangana (13), and West Bengal (13). Bihar holds all five of the largest positive Healthcare Gap scores (Araria +91.6, Sheikhpura +91.0, Nalanda +90.4, Banka +89.8, Lakhisarai +88.9), while Mizoram holds the five lowest, led by Champhai (−96.0) and Aizawl (−95.4).

Third, priority programmes are directionally well targeted but imperfect. Matched Aspirational Districts carry a significantly higher median burden index than other districts (59.9 against 50.5; Mann–Whitney $p < 0.001$). Even so, 12 of the 44 matched Aspirational Districts (27.3%) fall below the sample median burden, and 95 Priority Quadrant districts, including Nalanda and Lakhisarai in Bihar, lie outside the ADP list. Regional contrasts are

also notable: sampled northern districts ($n = 34$) and southern districts ($n = 88$) have nearly identical nutrition burdens (mean 45.9 against 44.8; Welch's $t = 0.56$, $p = 0.576$), yet the northern hill states have nearly twice the facility density (38.8 against 19.9 per 100,000;

Cohen's d = +1.62), leaving the southern states with a less favourable mean gap score (−16.3 against −50.0).

Fourth, annual spending rates are volatile, while fund balances must be interpreted in light of carry-over and timing. National NHM expenditure moved between roughly 85% and 115% of approved budget across 2018– 19 to 2024–25, averaging 105.6% under Series B over 2020–21 to 2023–24. However, Single Nodal Agency data show a PM-ABHIM balance of Rs 1,145 crore against FY2024–25 releases of Rs 1,112 crore. This balance is equivalent to 103% of current-year releases but includes carry-over from earlier years, so it cannot establish an annual absorption rate. Comparable balances were 12.6% of releases for the NHM flexible pool and 0.5% for recurring infrastructure maintenance.

Taken together, the evidence shows that fair public health investment cannot be guided by aggregate national budgets or raw state facility counts alone. Populous states such as Maharashtra (13,726 facilities), Bihar (12,541), and West Bengal (12,154) rank among the largest in total facility numbers yet have the lowest per-capita densities (12.0 to 13.3 per 100,000). Planners must therefore separate population scale from per-capita availability, account for within-state disparities, and pair capital allocations with implementation support where absorption is slow.

The study contributes a transparent screening framework that brings together the Nutrition Burden Index, state-level facility-density percentiles and the Healthcare Gap score. It keeps measured need and supply distinct before identifying districts with high burden and relatively low facility density. The accompanying no-clawback allocation rule is proposed as an illustrative planning approach, not as a tested allocation outcome: district-level allocation and expenditure data are unavailable to estimate actual district funding shortfalls or determine whether money follows need. The framework can therefore guide further investigation and data collection, but should not be used as a stand-alone funding formula.

The findings must be read within six data and methodological limits. Public sources report NHM allocations, expenditures, and unspent balances only at the national and state levels, so whether money follows need at the district level remains untested. Facility counts are reported by state and attached to districts, so within-state supply differences are unobserved and the gap extremes in Bihar and Mizoram are largely state-driven. Facility headcounts treat a Sub- Centre and a District Hospital as equal units and omit beds, staffing, equipment, quality, and the private sector (Kruk et al., 2018), while dividing 2022 facilities by Census 2011 populations understates current populations and inflates density, with sparse-population Ladakh (120.44

per 100,000) acting as an outlier; the counts are also rural-area counts divided by total population, which may understate density in more urbanised states (Appendix A). District outcomes are limited to four NFHS-5 nutrition and anaemia indicators rather than mortality or service use, and because nutrition also depends on food security, sanitation, maternal education, and household income, a high burden is not solely a health-system failure. The sample covers 338 of roughly 707 districts, omits Uttar Pradesh, Rajasthan, Madhya Pradesh, Tamil Nadu, and Punjab, and represents the North with only three mountain jurisdictions, so results are not nationally representative and the cross-sectional ecological design cannot establish causal effects (Robinson, 1950). Lastly, the reference dates for outcomes (2019–21), facilities (March 2022), population (2011), state health expenditure (2019–20), and national NHM budgets (2018–25) differ, and percentile-based gap scores have a zero mean by construction, so they cannot be compared directly across different district samples.

Future work can build on this baseline in three ways. Integrating NFHS-5 phase-II records and subsequent NFHS-6 district estimates across all roughly 707 districts, together with district neonatal and under-five mortality estimates (Dandona et al., 2020), would test whether the inverse need–supply relationship holds across the northern and central plains. Replacing

state facility densities with district-specific facility, bed, and workforce inventories from the Health Management Information System and the National Health Resource Repository, alongside private-sector and maternity-care quality indicators, would uncover intra-state supply gaps. Finally, compiling district-level NHM Record of Proceedings approvals and Single Nodal Agency expenditure logs would permit direct estimation of the district Concentration Index and spending rates, enabling state planners to run the equity-weighted allocation rule within annual district health action plans.

9. RECOMMENDATIONS

Drawing on the findings and limitations of this study, the following recommendations are grouped by policy and programme design, financing and implementation, data and monitoring, and further research.

9.1 Policy and Programme Recommendations

9.1.1 Extend targeted support to high-gap districts outside existing programme lists

In the original classification, 95 of the 115 Priority Quadrant districts lie outside the Aspirational Districts Programme (ADP). Programme-based targeting may therefore be supplemented by a transparent screening of nutritional need and relative facility supply. The results support further assessment of high-gap districts in Bihar and West Bengal, while

selected districts in Gujarat, Maharashtra and Telangana also warrant validation. However, the classification of the latter states is sensitive to the population denominator used for facility density (Appendix A). Specific funding decisions should therefore follow validation using district-level rural and urban facility counts, corresponding population denominators, staffing and operational-capacity information.

9.1.2 Adopt a needs-based allocation rule that does not claw back existing budgets

A no-clawback, needs-adjusted allocation rule could be considered as a planning tool once comparable state- or district-level spending and population data are assembled. In the current study, the rule is illustrative; actual district-level funding shortfalls cannot be estimated because district allocation and expenditure data are unavailable. Bihar's high mean gap (+75.6) and low per-capita state government health expenditure (Rs 701) provide a reason for further assessment, but do not by themselves establish a calculated funding entitlement.

9.1.3 Plan at two levels, state and district

State membership explains about 70% of the variation in the Nutrition Burden Index, while the remaining 30% lies within states. State-level policy should therefore address persistent inter-state differences, and district health action plans should identify local concentrations of need that state averages conceal.

9.2 Financing and Implementation Recommendations

9.2.1 Pair capital allocations with implementation support

Where programme data indicate delays in converting capital releases into completed infrastructure, the first response should be to diagnose procurement, project preparation, engineering and administrative constraints. The PM-ABHIM balance reported as of 31 December 2024 was equivalent to 103% of FY2024–25 releases, but includes carry-over from earlier years and should not be interpreted as annual underspending. It signals the need for scheme-level, multi-year monitoring rather than, by itself, proving slow absorption. Further allocations should be assessed alongside implementation capacity; reducing allocations should not be the default response.

9.2.2 Monitor absorption separately from budget utilisation

National NHM spending moved between roughly 85% and 115% of approved budgets, and a high spending rate does not show that funds reach the districts that need them. Approved, released, spent and unspent amounts should be reported separately for each scheme, so that carry-over balances are distinguished from genuine underspending.

9.2.3 Publish district-level allocation and expenditure data

Public sources report NHM allocations and expenditure only at national and state level. Publishing district-wise allocations and expenditure would allow governments and researchers to test whether funding follows need and to estimate the spending shortfall in high-gap districts.

9.3 Data and Monitoring Recommendations

9.3.1 Replace state-level supply measures with district-level data

District-specific facility, bed and workforce inventories from the Health Management Information System and the National Health Resource Repository should replace state facility densities. This would reveal supply gaps within states, where the present district rankings largely reflect state differences. Such inventories should cover urban as well as rural facilities and be divided by the population they serve, so that density is not distorted by a mismatch between the facility count and the denominator (Appendix A).

9.3.2 Measure capacity as well as facility counts

A facility count treats a sub-centre and a district hospital as equal units. Future assessments should add staffing, beds, equipment, service quality, accessibility and the private sector, and should combine district screening with local assessments of facility functionality before funds are finally allocated.

9.3.3 Update the baseline and widen coverage

The analysis should be repeated with NFHS-6 district estimates and updated population denominators, and extended to all roughly 707 districts, including the states missing from the present sample. Adding district neonatal and under-five mortality would test whether the need–supply relationship holds beyond nutrition indicators.

9.4 Research Recommendations

9.4.1 Complete the planned analyses

The district concentration index and the equity-weighted allocation exercise should be run once district allocation and expenditure records are available.

9.4.2 Interpret findings with caution

The Healthcare Gap score and the Priority Quadrant are screening tools, not final judgements. The design is ecological and cannot establish causal effects, so results should be used to direct investigation, resources and implementation support, and not to rank or penalise districts or administrations.

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APPENDIX A. SENSITIVITY OF FACILITY DENSITY TO THE POPULATION DENOMINATOR

Purpose. The facility counts used in this study come from the Rural Health Statistics and the National Health Profile 2023 (Section 3.2), and are divided by total Census 2011 population. This appendix checks how much the density, and the ranking of states, changes when the denominator is rural population instead. It is a sensitivity check on the supply measure for the states for which the inputs could be verified. It is not a recomputation of the Healthcare Gap score or of the Priority Investment Quadrant.

Method. For each state, density is recalculated as total facilities (Table 2A) divided by Census 2011 rural population, per 100,000. The total-population densities in the table reproduce those in Table 2A (to rounding), which confirms that Table 2A uses total population as the denominator. Jammu & Kashmir is omitted because its published 2011 rural population includes Ladakh, which is a separate Union Territory in the sample, and a separate rural figure for the two was not available to the authors of this appendix. The ten largest states other than Jammu & Kashmir are therefore represented by nine. Rank 1 is the lowest density.

Table A2. Facility density per 100,000 with total and rural population as denominators (nine of the ten largest states)

State	Total facilities	Per 100,000 total pop.	Rural share of pop. (%)	Per 100,000 rural pop.	Change	Rank (total)	Rank (rural)
Maharashtra	13,726	12.2	54.8	22.3	+83%	2	4
Andhra Pradesh	13,418	27.2	70.4	38.6	+42%	9	9
Bihar	12,541	12.0	88.7	13.6	+13%	1	1
Karnataka	12,168	19.9	61.3	32.5	+63%	7	6
West Bengal	12,154	13.3	68.1	19.5	+47%	3	2
Gujarat	11,371	18.8	57.4	32.8	+74%	5	7
Kerala	6,721	20.1	52.3	38.5	+91%	8	8
Assam	5,951	19.1	85.9	22.2	+16%	6	3
Telangana	5,872	16.7	61.3	27.2	+63%	4	5

Note: Facilities: NHP 2023 Table 6.2.1 (31 March 2022), as in Table 2A. Population: Census 2011, total and rural, for Andhra Pradesh and Telangana as separate states. Rank 1 = lowest density among the nine states. Source: authors' calculations; Census of India 2011 (state-wise total and rural population).

Findings. Three results follow from Table A2.

- Densities rise most where the population is more urban. The increase is 13% in Bihar (89% rural) and 16% in Assam (86% rural), but 74% in Gujarat (57% rural), 83% in Maharashtra (55% rural) and 91% in Kerala (52% rural).
- The ranking changes. Bihar remains the lowest-density state under either denominator, and West Bengal stays among the three lowest (third-lowest by total population and second-lowest by rural population). Gujarat moves from fifth-lowest to third-highest of the nine

states, while Maharashtra moves from second-lowest to fourth-lowest and Telangana from fourth-lowest to fifth.

- The denominator sensitivity is material. Using rural population, Gujarat's density is 32.8 per 100,000, above Karnataka (32.5) and close to Andhra Pradesh and Kerala (38.6 and 38.5). Its 29 districts in the original Priority Quadrant therefore cannot be assumed to remain in that quadrant. The qualitative finding that measured facility supply is relatively low in Bihar and West Bengal is more robust within the states examined, whereas the counts for Gujarat, Maharashtra and Telangana are sensitive to the denominator.

The counts also exclude urban facilities, so rural population is a more consistent denominator for the rural enumeration but is not a complete measure of overall healthcare availability. A full re-estimation of the 338 district gap scores and Priority Quadrant counts requires the district-level Nutrition Burden Index file, facility counts for all 20 sampled states and corresponding Census 2011 rural populations. The revised densities and classifications should be recalculated using Equations 3–5 before the quadrant is used for investment decisions.