Reducing resource disparity in healthcare resource allocation of laboratories in countries with limited resources by empowering policy-making and implementation

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In resource constraint settings of developing countries like India, inadequate importance and consideration to resource (re)allocation approach causes resource disparity issues. The Indian public health care system has focused on developing rural primary health centres (PHCs) to reduce rural–urban resource disparity and pressure on urban health care facilities. However, all the resources as recommended in national standards for PHCs' functioning are not completely available in PHCs. Local-level decision-makers are not provided with a policy framework to (re)allocate resources. This study states that empowering local-level decision makers with the ability to (re)allocate resources to reduce resource disparity is critical. The study proposes a new framework for minimizing resource disparity with resource allocation optimization. The study suggests a strategy to improve implementation of policies like the National Rural Health Mission and the National Health Policy. The 42 PHCs in rural areas of Osmanabad District (India) with 23 laboratory technicians (LTs) as resources are considered as a case study to assess the proposed method. The study optimization model showed that reallocating 6 of 23 LTs to different PHCs would reduce disparity in LT workload (from 57.62% to 30.54%) and LT access (from 116.4% to 49.3%). The disparity reduction highlights the impact of resource reallocation according to the proposed framework.

Keywords: Developing nations, healthcare, optimization, policy, resource disparity, resource allocation.

IN resource-constrained settings of countries like India, allocation of health care resources is not given due importance. Regionally, this creates resource disparity[1] and consequently, it creates population health status disparity[2]. Further, increasing population creates pressure on limited healthcare resources, if additional resources are not provided or allocation of existing resources is not optimized. Current policies focus on resource allocation. This helps decision-makers, but allocation strategy is based on single criterion like population[3,4] rather than on recommended multiple criteria-based approach[5,6]. Single criterion-based approach is difficult to integrate, gives conflicting results[7] and may not always be helpful, like in a medical emergency scenario.

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Literature shows that multi-criteria-based allocation models to reduce resource disparity in developing nations have limited implementability. These models are more mathematical in nature and local governing bodies, the main implementing agencies, are not involved in its development[5]. Further, in a country like India, the geospatial heterogeneity, such as resources, socio-cultural behaviour, governance and economy require that health system functioning should adapt to local constraints[8]. Furthermore, the current approaches[5,9] are based assuming that a nation could achieve its health care resource targets under a given national policy and guidelines constraints. However, developing nations like India may not have financial capability to meet the resource targets given in the national guidelines[10]. Hence, it is important to have a new resource allocation framework for nations that struggle to meet their own national resource targets.

This study aims to address the resource reallocation issue to reduce resource disparity and improve health care services. We propose a new framework for incorporation in national policies to reduce resource disparity, for improving the existing health system functioning. The methodology is demonstrated through a case study of laboratory technician (LT) allocation to rural primary health centres (PHCs) in Osmanabad district of Maharashtra (India). The choice was because of data availability for this district.

Laboratory functioning in an Indian primary health centre

The Indian public health care system for rural areas, in accordance with the Alma Ata Declaration, focuses on preventive and basic curative health care services for major health issues[11]. Accordingly, the National Rural Health Mission (NRHM) is the main Indian national policy that focuses on addressing the health care needs of rural areas. It aims to develop PHCs and sub-centres (SC) in rural areas to provide health care services and disseminate the Government's vertical health programme. In order to standardize services and allocation facilities, NRHM created the Indian Public Health Standards (IPHS)[4].

In rural areas, PHC is the first point of contact to access a physician and basic laboratory. IPHS 2012 recommends one PHC for every 30,000 people (or, every 20,000 people in hilly areas) with at least one MBBS qualified medical officer (MO) and one laboratory technician (LT) along with other staff. IPHS has also provided a list of basic tests that PHCs should be capable of performing[12].

Laboratory is the critical component for any health care system as it plays a major role in medical decision-making[13]. The people can access the PHC laboratory for a test, only after they have been referred to it by the PHC MO. However, in reality, not all PHCs have functional laboratories. Even, when they have laboratories and LT, they may not be able to conduct all the tests mentioned in IPHS[14]. In such a scenario, the complete case of a patient is referred to another public health care facility where the test facility is available[12]. Interestingly, during the field visits to PHCs of Osmanabad district, two additional approaches were found. In the first approach, the patient, who could afford private laboratory facility and did not have time to go to any other public health care facility, was recommended to a nearby private laboratory facility for the test. In the second approach, PHC took the initiative to perform the additional task of collecting the patient's sample at the PHC and sending it to another nearby public health care facility for testing. PHC's health assistant or multipurpose worker performed the task of carrying the sample to the other public health care facility and bringing back the test report during the next trip. The public health care facility performing the test, informed the sample results to the PHC over telephone. This approach was used only for test samples related to malaria and tuberculosis.

In the absence of any spatial mathematical model or any other similar framework in national policies, the decision of posting an LT to a PHC was taken based on pragmatic, political and/or history considerations. It is an approach recognized in literature and criticized for its inability to give optimal solutions[5,7]. In the case of Osmanabad district, the PHC staff had to perform the extra task of carrying samples to other PHC facilities and perform the testing of samples received from other PHC facilities. Sending the samples to other PHCs creates a delay in receiving test results and affects patient treatment. Additionally, the variability of the delay in sample testing across PHCs affects the national agenda of having more standardized PHC services across the nation. Further, many PHCs are sending their samples to urban health care facilities, which increases the burden on existing urban health care facilities.

Therefore, it is desirable to find an optimal solution for allocating LT among the existing PHCs and linking other PHCs with them to reduce: (i) workload variability, (ii) delay in sample testing, and (iii) burden on urban health care facility, as well as, improve the standardization of PHC services across the district. Accordingly, the present study proposes a methodology to improve the spatial distribution of the health care resource – the LT. Using Osmanabad district case study, two outputs were created, namely, (i) PHCs for LT posting, and (ii) which PHCs should send sample to which PHC with an LT posted in it to reduce geospatial resource disparity and improve health care service standardization.

Conceptual framework

The following new approach is proposed to model the problem. Figure 1 outlines the proposed method in brief. The framework initiates with identifying a study area. The identification of resource for allocation in the study area is the second step, which is followed by the number of direct beneficiaries (like health care facilities, population) among whom it had to be distributed. The constraints defined by the national policy guidelines are identified followed by the identification of local constraints. The weightage or importance given to each constraint in optimization (referred to in this paper as 'importance value (IV)') is defined. Finally, the objective function is created using constraints and their IV, which is mathematically optimized for the whole study area.

Resource allocation problem

The Osmanabad district has eight blocks (Figure 2) with rural population accounting for 84% of the total population (1.7 million)[15]. The public medical laboratories in the

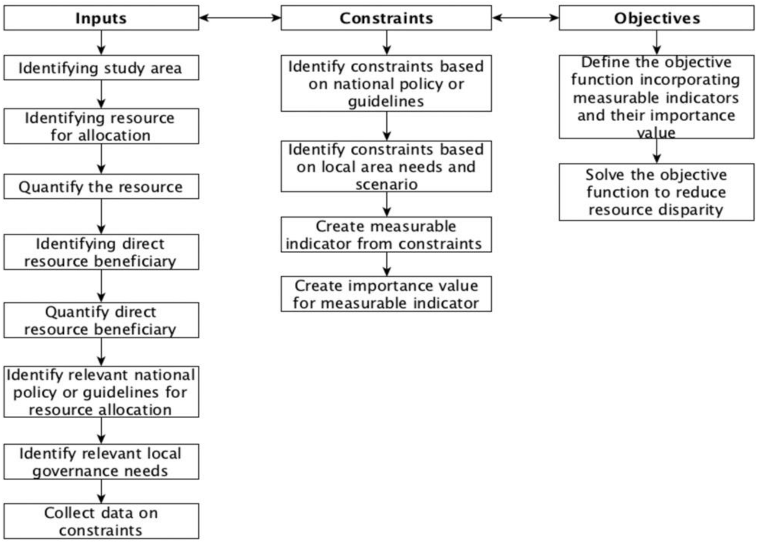

Figure 1. Methodology for allocation of health care resources in local constraint settings.

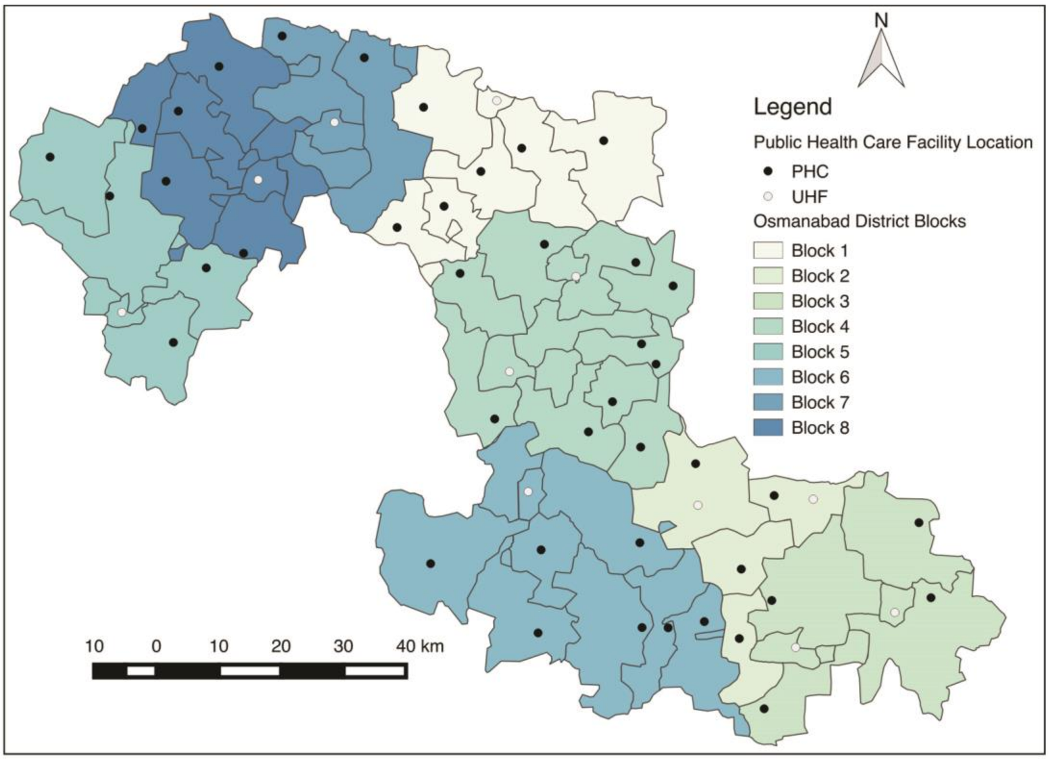

Figure 2. Map of Osmanabad district along with its eight blocks and public health care facility. The boundaries surrounding a PHC point represent the area from which it collects the patient sample. PHC: primary health centre, UHF: urban public health care facility.

district are present both in urban and rural areas. It is present in all the 12 urban public health care facilities (UHF) and in all 42 rural PHCs. Only 23 out of 42 PHCs meet the IPHS standards in having at least one LT and hence, are able to perform blood smear examination for malarial parasite. The remaining PHCs only collect malaria sample and send it to the nearby urban or rural PHC laboratory facility (Appendix I). This paper considers the PHC with LT as 'central PHC' and the PHC that sends a sample to the other PHC facility as 'peripheral PHC'. Finally, a cluster is formed by one central PHC along with peripheral PHCs from which central PHC gets samples. The locations of current central PHCs, peripheral PHCs, and clusters are given in Figure 3.

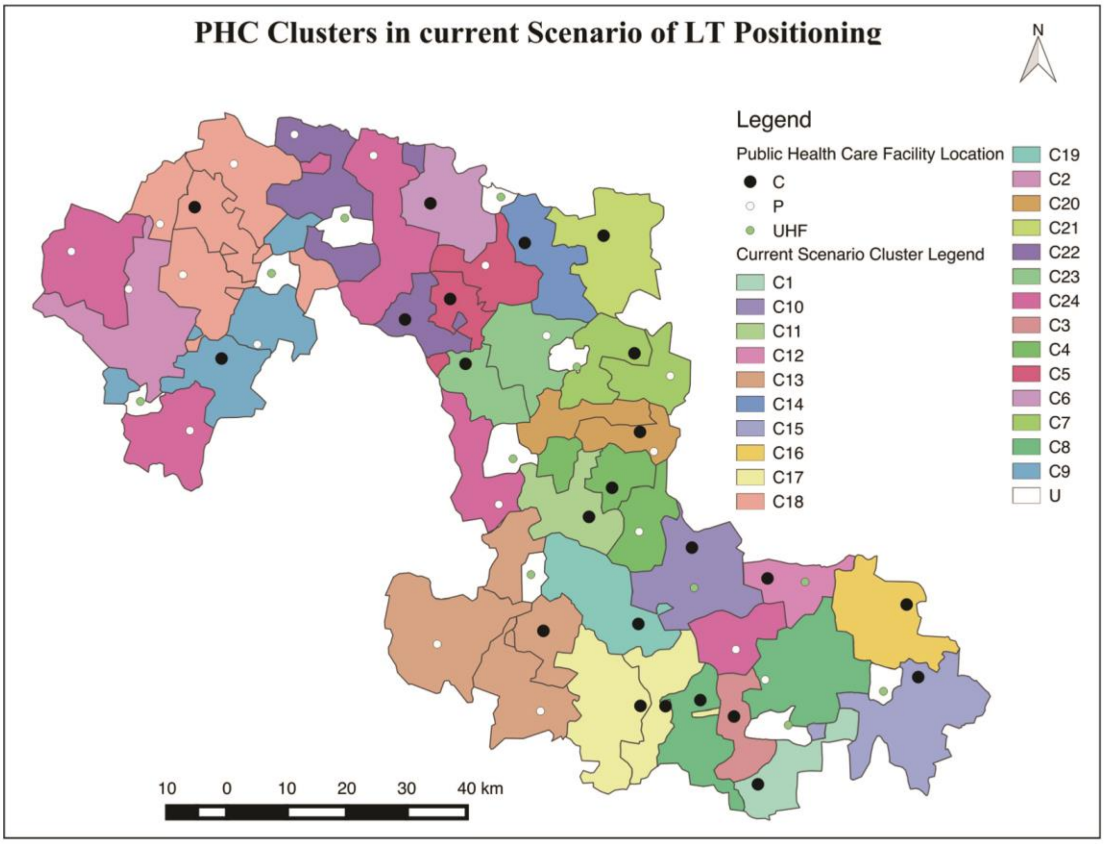

Figure 3. Current scenario of LT allocation across the PHCs in Osmanabad district. C: central PHC, P: peripheral PHC and U or UHF: Urban Public Health Care Facility. C1–C23 represent clusters with central PHC, C24: PHC sending sample to UHF.

The lack of a quantitative model for decision-making in selecting health care facility for sending samples could have caused inappropriate resource allocation. For example, an in-house LT was available for a PHC with 883 malaria samples in a year, but no LT was available for PHC with 4452 malaria samples in a year. The PHCs may have to send samples as far as 96.8 km. Further, the number of malaria samples tested in different PHCs varies from 883 to 13,302 (mean = 6049 samples per year) samples per year. The contribution of malaria samples from other PHCs increases workload on PHC which can vary from 0% to 72% (mean = 21%). The current system creates an enhanced workload on UHF. The UHFs perform tests on around 2% of total malaria samples from PHCs. While the number of samples of the PHCs to be tested by the urban health care facilities is low, at the individual UHF level, these samples can account for up to 15% of the total malaria samples of the UHF.

It is desirable to create a system in which (i) samples are not sent to the UHF and (ii) national policy and local scenario constraints are optimally used. In this study, different scenarios are created based on the extent to which national policy is desired to be implemented as shown below. In scenario 1A to 1C, the national IPHS policy is completely followed and the malaria samples are tested in rural areas, i.e., no malaria samples are sent to UHFs. This scenario differs in terms of reallocation of LT and PHCs.

- Scenario 1A: All LTs and PHCs are allowed to reallocate to create new central and peripheral PHCs.
- Scenario 1B: Only current peripheral PHCs are allowed to reallocate to the existing central PHCs.
- Scenario 1C: Only current peripheral PHCs linked to UHF are allowed to reallocate to the existing central PHCs.

In scenarios 1D to 1E, the national IPHS policy is partially followed, i.e., malaria sample is tested in the rural area itself in PHCs that are currently not linked with UHF. No system change happens to the existing peripheral PHCs linked to UHF.

- Scenario 1D: Only current peripheral PHCs not linked to UHF are allowed to reallocate to existing central PHCs.
- Scenario 1E: All LTs and current peripheral PHCs not linked to UHF are allowed to reallocate to create new central and peripheral PHCs.

Table 1. Results of geospatial optimization based LT reallocation (scenarios 1A, 1B, 1C, 1D and 1E) on resource disparity and health system functioning

Parameters	Scenario					
	Current	1A	1B	1C	1D	1E
Number of LT reallocated	0	6	0	0	0	8
Number of peripheral PHCs reallocated	0	22	12	5	8	19
Average workload on LT (malaria samples tested per year)	6049	6174	6174	6174	6049	6049
Average distance travelled by peripheral PHC staff to access LT						
Both in central PHCs and UHF (km)	17.9	14.5	15.0	14.4	18.5	18.0
Only in central PHCs (km)	13.8	14.5	15.0	14.4	14.7	14.0
Workload* disparity						
Minimum workload on LT (malaria samples tested by a PHC LT per year)	883	2560	1803	883	1803	2925
Maximum workload on LT (malaria samples tested by a PHC LT per year)	13,302	10,532	10,532	13,302	10,532	10,532
Percentage coefficient of variation in LT workload (%)	57.62	30.54	39.36	54.38	41.95	33.75
Overall LT access disparity for peripheral PHC staff (including central PHCs and UHF LT)						
Minimum distance travelled by peripheral PHC staff to access LT (km)	4.6	4.6	4.7	4.6	4.7	4.7
Maximum distance travelled by peripheral PHC staff to access LT (km)	96.8	31.3	30.7	41.9	96.8	96.8
Percentage coefficient of variation in distance travelled by peripheral PHC staff to access LT (%)	116.36	49.31	47.75	58.68	109.31	110.68
Central PHC only LT access disparity for peripheral PHC staff						
Minimum workload on distance travelled by the peripheral PHC staff to access the LT (km)	4.6	4.6	4.7	4.6	4.7	4.7
Maximum workload on distance travelled by the peripheral PHC staff to access the LT (km)	41.9	31.3	30.7	41.9	30.7	25.9
Percentage coefficient of variation in distance travelled by peripheral PHC staff to access LT (%)	69.99	49.31	47.75	58.68	55.80	48.60

*Workload is the number of malaria samples tested by the LT which is calculated as sum of the number of malaria samples collected by the LT's healthcare facility and number of malaria samples received from other PHCs.

The common local constraints for all these scenarios are described below along with the measurable indicators used for those constraints.

(1) Reducing staff workload disparity to reduce the risk of social conflict (C1): the measurable indicator used for this constraint is that the number of samples tested by each PHC LT should be the same, i.e. the standard deviation of the number of samples tested by each LT (σ_{C1}) should be zero.

(2) Increasing the performance of public laboratory system to improve the health status of the district (C2): the measurable indicator used for this constraint is that the delay in delivery of samples from peripheral PHCs to central PHCs is minimum. This indicator is determined by aggregating the distance between each peripheral PHC and central PHC in a cluster. Accordingly, the mathematical variable used is that the mean of the total distance travelled from peripheral PHCs to central PHC for all clusters (μ_{C2}) should be zero.

(3) Among the clusters in the district, reducing disparity in public laboratory performance for enabling uniform district development (C3): the measurable indicator used for the constraint is that the variation in delivery delay of samples across the clusters should be minimum. This indicator is determined by estimating the variation in 'the sum of distance travelled by each peripheral PHCs to send sample to the central PHC in a cluster' across the clusters. Accordingly, the mathematical variable used is that standard deviation of the 'total distance travelled from the peripheral PHC to central PHC' across all clusters (σ_{C3}) should be zero.

Importance value (IV) of each of the three constraints (C1, C2 and C3) can range from [0 to 1] based on the decision-maker's choice, wherein zero represents no importance and one represents total importance. The total IV as sum of all three constraints must be one. In the current context, based on field experience, it is found that decision-makers are most interested in the performance of the public health system. While workload is an issue and reducing performance disparity across PHC is desirable, they are not in the priority list. Accordingly, based on preliminary optimization trials, the IV for the three constraints C1, C2 and C3 used are 0.05, 0.99 and 0.05. In this study, with different combinations of constraints, IV will change the result of the objective function. The objective function for the current study is the LT allocation optimization for reducing LT disparity in a given local setting by minimizing the objective function score. The

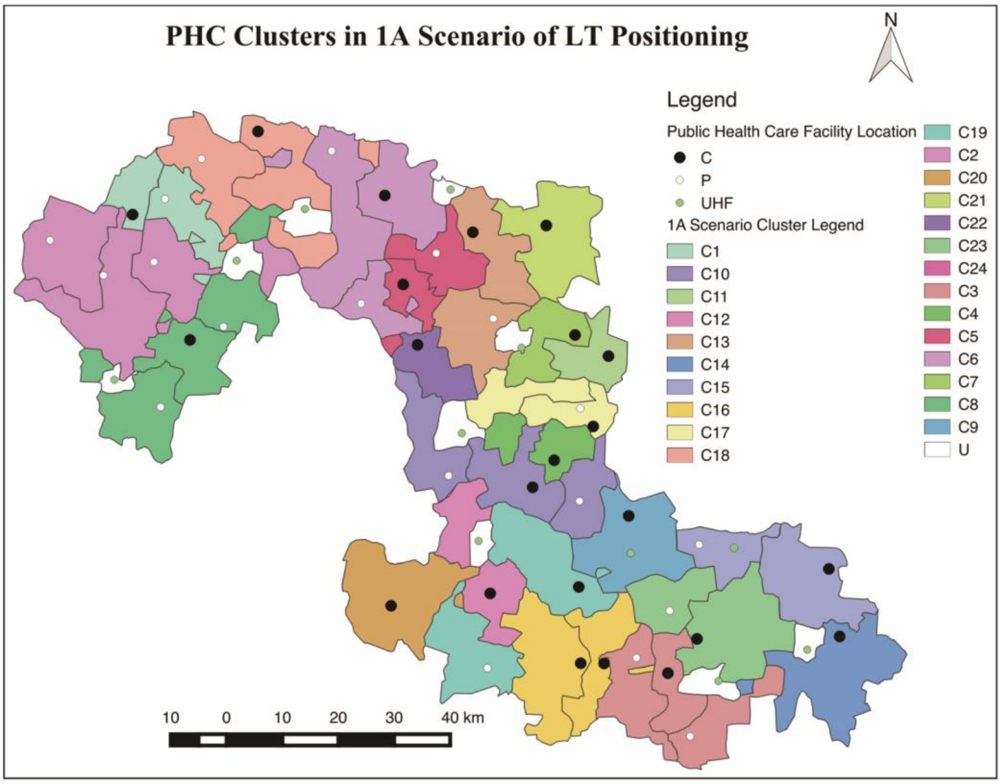

Figure 4. Scenario 1A of LT allocation across the PHCs. C: central PHC, P: peripheral PHC and U or UHF: urban public health care facility. C1–C23 represent clusters with central PHC, C24: PHC sending sample to UHF.

objective function is a linear additive model incorporating both constraints and their IVs as given below

$$\min.[(\sigma_{C1} * IV_{C1}) + (\mu_{C2} * IV_{C2}) + (\sigma_{C3} * IV_{C3})].$$

In the above equation IV_{C1}, IV_{C2} and IV_{C3} are importance values for constraints C1, C2 and C3. All the values of constraints C1, C2 and C3 are normalized such that values of σ_{C1}, μ_{C2} and σ_{C3} always lie in the range [0 to 1]. The optimization algorithm was run in R (Appendix II) for solving the objective function.

The optimization results for different scenarios are shown in Table 1. Different scenarios have different reallocation results (Figure 4 and Appendix III). In the case of scenario 1A, which encompasses both national policy and local setting constraints, the six LTs and 32 PHCs need to be reallocated (Figure 4). Overall, each scenario is able to reduce variation in both workload and distance of travel by peripheral PHC to central PHC; but, not all scenarios are able to reduce the maximum distance travelled by any peripheral PHC to central PHC.

Discussion and conclusion

In the current environment, where decentralized decision-making is encouraged, the policies needed are to (i) delegate decision-making power to local-level governing bodies, and (ii) empower local-level governing bodies to make informed and optimal decisions. Such an approach will enable better policy integration and help local decision-makers address the locally relevant service needs.

The proposed optimization technique reduces resource disparity in terms of LTs allocated across the districts in rural areas, which indicates the impact of resource allocation based on the proposed optimization model. Room for further improvement exists by reducing the disparity in other resources like hospital beds and medical officers.

Although, a decision-maker may not always implement the best optimization results[16], multiple viable options give more flexibility that can reduce resource disparity and improve health system functioning (Table 1). We recommend implementation of scenario 1B initially, as it will not lead to a change in LT posting, but reduce LT disparity by reorganizing their access to the peripheral PHCs. This may be followed by implementation of scenario 1A.

Overall, the study concludes that it is important to have a framework in national policies that enables local-level resource allocation optimization within national policy and local setting constraints. Further, the current subjective judgment-based decision-making, may not provide optimal solutions.

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