uninvolved individuals, there is an urgent need for heightened public awareness, parental education, safety measures, and stricter legislation against hazardous materials like Chinese *manjha*.

Ethics approval: IEC, IMS-BHU; No. Dean/2015-2016/EC/361, dated Oct 5, 2016.
Funding: None; *Competing interests*: None stated.

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District-Wise Treatment Gaps and Hospitalizations in Under-Five Children With Diarrhea in India

India bears greatest under-5 diarrheal burden and mortality. We studied geographical variation in under-5 diarrhea prevalence, oral rehydration solution (ORS) and zinc supplementation treatment gaps and hospitalization rates. We point to treatment gap in western Maharashtra, Andhra Pradesh and Gujarat. Diarrheal hospitalization rates were not significantly associated with ORS and zinc treatment gaps.

Keywords: *Dehydration, ORS use, Zinc.*

India ranks second in under-5 diarrheal disease burden and mortality [1]. Diarrhea is India's third leading cause of under-5 mortality [2]. Oral rehydration solution (ORS) and zinc can avert 93% of diarrheal deaths [3,4]. Depending on severity, diarrhea may need healthy facility visits/ hospitalizations. The ORS and zinc utilization rate for under-5 diarrhea in India is 60.6% and 30.5%, respectively [5]. The ORS and zinc utilization, health facility visits, and hospitalizations vary across Indian districts. However, these geographic variations have not been studied yet. Understanding geographical differences in health-seeking behavior for under-5 diarrhea can help target interventions to increase the uptake of ORS and zinc in low utilization areas and divert health system resources to high hospitalization areas. Our study thus had three aims: Measure district-wise treatment gap (TG) for ORS and zinc in under-5 diarrhea; Study district-wise health facility visits and hospitalization rates in under-5 diarrhea; and, analyze the association of ORS and zinc TGs with health facility visits and hospitalization rates across districts.

We conducted a cross-sectional retrospective secondary- data analysis for 2019-20 using National Family Health Survey (NFHS) 5 - Phase 1 and Health Management and Information System (HMIS). Details on data sources are given in **Web Annexure I**.

We extracted district-wise percentages of prevalence of diarrhea in under-5 children, children receiving ORS and zinc each, in the two weeks recall period from NFHS-5. Raw treatment gaps (TG_R) were defined as the percentage of children with diarrhea who did not receive ORS and zinc.

ORS $TG_R = 100 - (\%\ under\text{-}5\ children\ received\ ORS)$

Zinc $TG_R = 100 - (\%\ under\text{-}5\ children\ received\ Zinc)$

Districts were ranked (r_p) in descending order of under-5 diarrhea prevalence and weights (W_p) were calculated by dividing district's prevalence rank by the sum of all ranks.

$$W_p = \frac{\gamma_p}{\Sigma\gamma_p}$$

Prevalence-weighted treatment gap (TG_W) was calculated by multiplying TG_R with W_P.

$$TG_W = W_p * TG_R$$

TG_W was scaled ($TG(scaled)_W$) from 0 to 100 using min-max scaling.

$$TG\,(scaled)_w = \frac{[TG_W - TG\,(min)_W]}{[TG\,(max)_W - TG\,(min)_W]}$$

Six ORS and zinc TG groups were created using the targets suggested for Indian states by Clinton Health Access Initiative [6]. $TG(scaled)_W$ was used to classify districts into these groups (**Web Table 1**).

HMIS data was used to calculate district-wise under-5 diarrhea hospitalization rate.

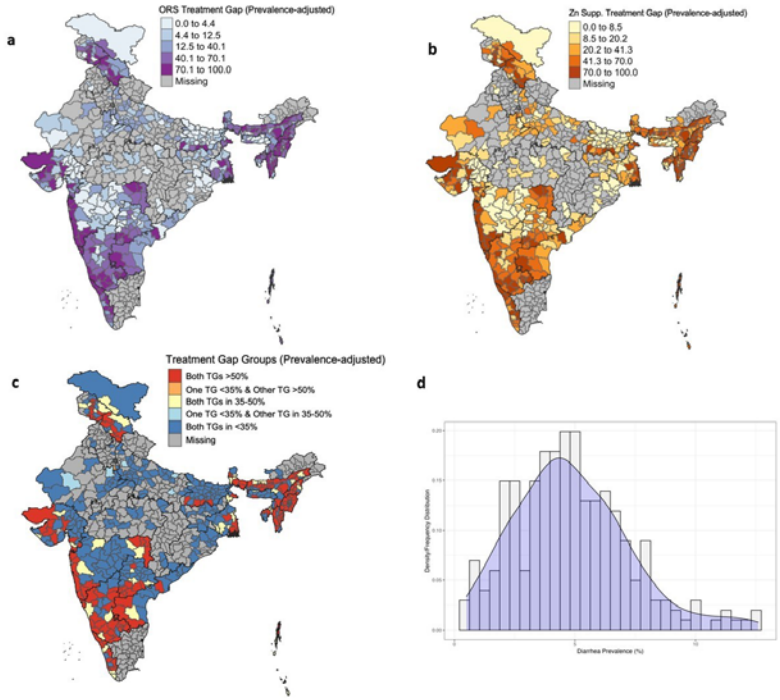
$$Diarrhea\ \ hospitalization\ \ rate = \frac{No.\ of\ under\text{-}5\ children\ received\ inpatient\ treatment\ for\ diarrhea}{No.\ of\ under\ -5\ children\ with\ diarrhea} \times 100$$

We evaluated if health facility/provider visits and diarrhea hospitalization rates varied across TG groups. All analyses were conducted for scaled and raw TG groups. Details on data availability are given in **Web Annexure I**.

The western Maharashtra, Andhra Pradesh, and Gujarat, North Eastern states, Kerala, and Karnataka had districts with high (>40%) ORS and zinc $TG(scaled)_W$ **(Fig. 1a, b)**. The district distribution across TG groups based on $TG(scaled)_W$ is given in **Fig. 1c** (**Web Table I)**. Further, 242 districts with under-5 diarrhea prevalence ranging from 1%-10% had no ORS or zinc utilization and no health facility visits indicative of the true TG **(Fig. 1d)**. District-wise diarrhea prevalence, ORS TG_R, Zinc TG_R, and distribution across TG groups based on TG_R are presented in **Web Fig. 1-4.** State-wise match rate in TG groups assigned using $TG(scaled)_W$ and TG_R is given in **Web Fig. 5**.

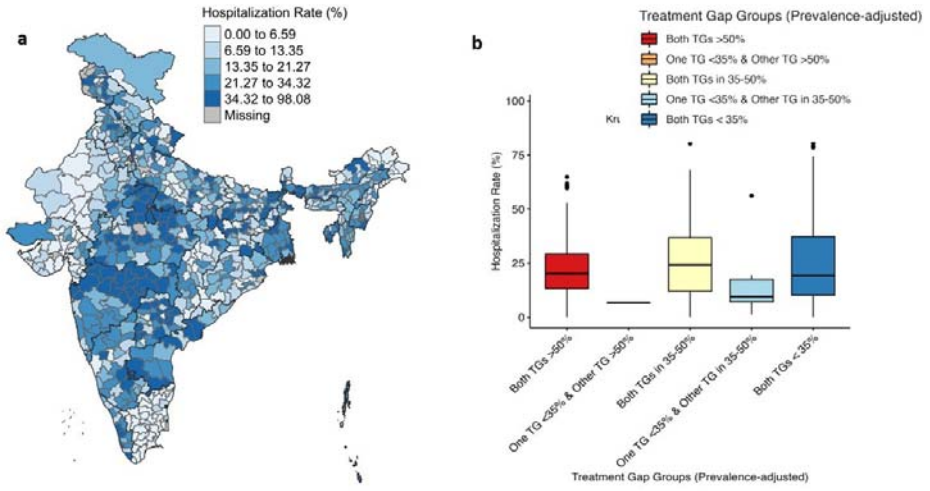
The hospitalization rate was high (>34%) in central India districts, especially in eastern Maharashtra and northern Madhya Pradesh **(Fig. 2a)**. District-wise health facility/provider visits can be seen in **Web Fig 6**. Diarrhea hospitalization rates and health facility/provider visits were not significantly associated with $TG(scaled)_W$- or TG_R-based TG groups (**Fig. 2b , Web Fig. 7-9**).

The study presents a systematic district-level analysis of diarrhea treatment modalities that can help identify priority districts for interventions targeted to increase ORS and zinc uptake. ORS and zinc TGs vary across Indian districts with



Prevalence-adjusted treatment gap is the same as $TG(scaled)_W$. ORS: oral rehydration solution.

Fig. 1 District-wise treatment gaps for the year 2019-20, *a*) scaled-weighted treatment gap of ORS for 457 districts, *b*) scaled-weighted treatment gap of zinc for 457 districts, *c*) Treatment gap groups based on scaled-weighted treatment gap for 457 districts, *d*) True treatment gap for 242 districts.



Prevalence-adjusted treatment gap is the same as TG(scaled)$_W$. TG: treatment gap.

Fig. 2 Hospitalization rate and treatment gap groups *a*) District-wise diarrhea hospitalization rate for 724 districts, *b*) Association of hospitalization rates with scaled-weighted treatment gap groups for 457 districts.

over one-third of districts falling in the high-priority group. The findings can also assist in the optimal allocation of health-system resources to districts with higher hospitalization rates. However, these findings must be interpreted with caution as the TG for several districts could not be calculated due to a lack of data.

Ethics approval: Not applicable.
Contributors: SD conceptualized the study design, acquired, analyzed, or interpreted data, drafted the manuscript, and critically revised the manuscript for important intellectual content. DS acquired, analyzed, or interpreted data, and drafted the manuscript VW acquired, analyzed, or interpreted data, and drafted the manuscript. SZ - conceptualized the study design, drafted the manuscript, critically revised the manuscript for important intellectual content, provided administrative, technical, or material support, and supervised the study. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.
Funding: None; *Competing interest*: None stated.
Note: Additional material related to this study is available with the online version at *www.indianpediatrics.net*

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Web Annexure I

SUPPLEMENTAL METHODS

Data sources details

We accessed data from the National Data Analytics Platform (NDAP) to conduct a retrospective secondary data analysis for the year 2019-2020. From the NDAP, we extracted data from two sources - the first wave of the National Family Health Survey (NFHS) 5 covering June 2019- January 2020 and the Health Management and Information System (HMIS) covering the financial year 2019-20. NFHS is a nationally representative household survey and HMIS reports routine health facility data.

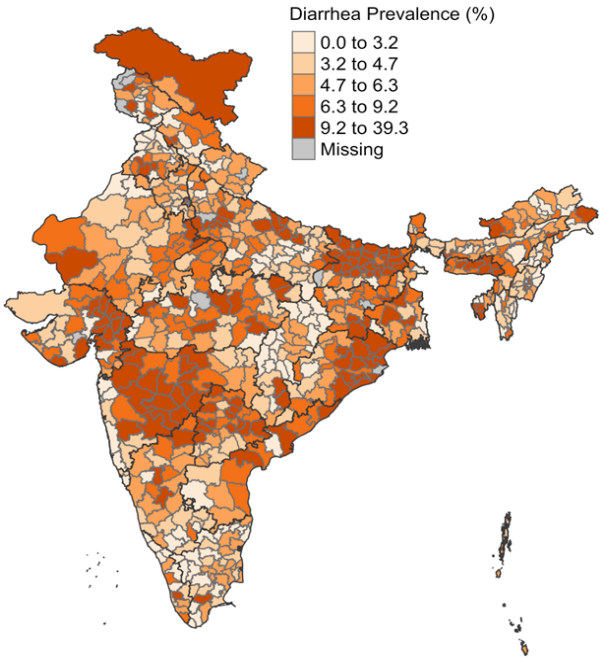
Data availability

Out of 733 districts used in the analysis, the percent prevalence of under-5 diarrhea data was available for 728 (99.3%) districts. The percentage of under-5 children who received ORS and zinc and visited a health facility/ provider was available for 457 districts. Thus, treatment gaps (both raw and scaled-weighted) were calculated for only 457 (62.3%) districts. The hospitalization rate was calculated for 724 (98.8%) districts.

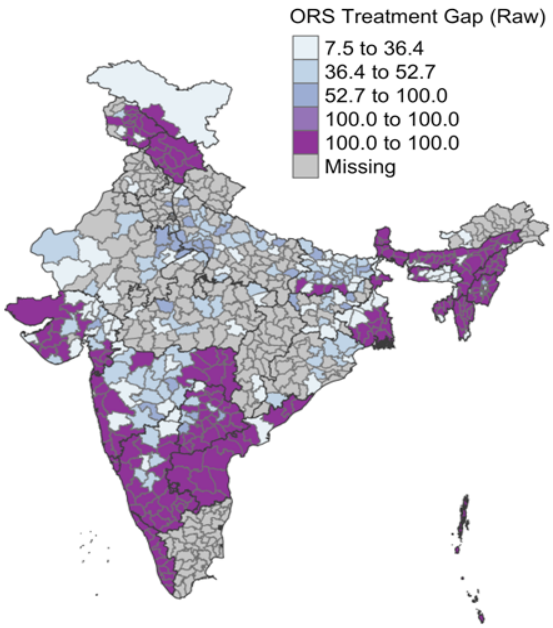
Web Table 1 Treatment Gap Groups Used to Classify 457 Districts based on ORS and Zinc Treatment Gaps. ORS: Oral Rehydration Solution

Treatment gap group	*ORS treatment gap*	*Zinc supplementation treatment gap*	*Number of districts in the group*
1	>50%	>50%	155
2	>50%	35%-50%	0
	35-50%	>50%	0
3	<35%	>50%	1
	>50%	<35%	1
4	35%-50%	35%-50%	47
5	35%-50%	<35%	6
	<35%	35-50%	6
6	<35%	<35%	248

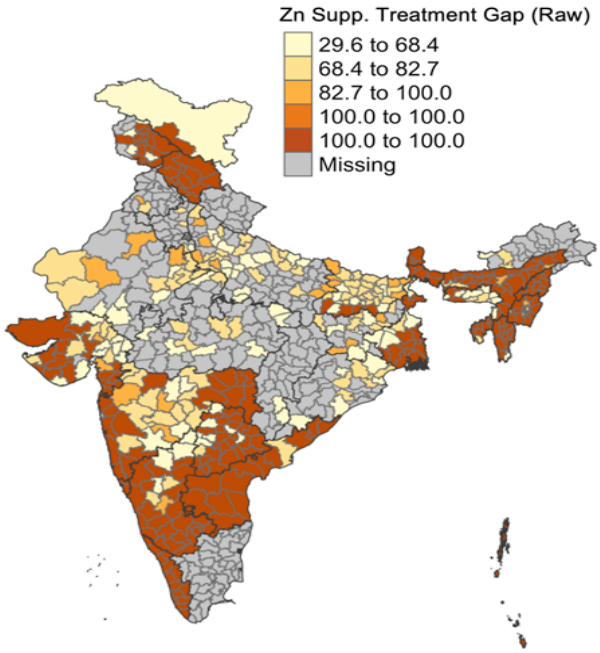
Districts in the first group had the highest need for diarrheacare intervention.



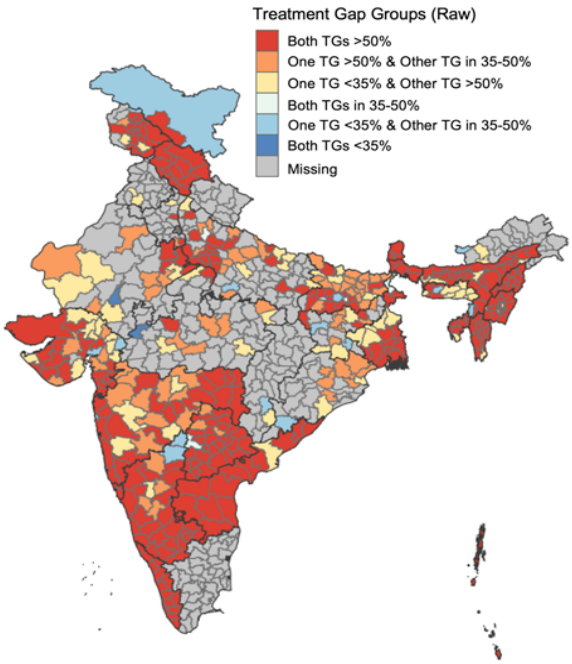
Web Fig. 1 District-wise diarrhoea prevalence for 728 districts of India, 2019-20.



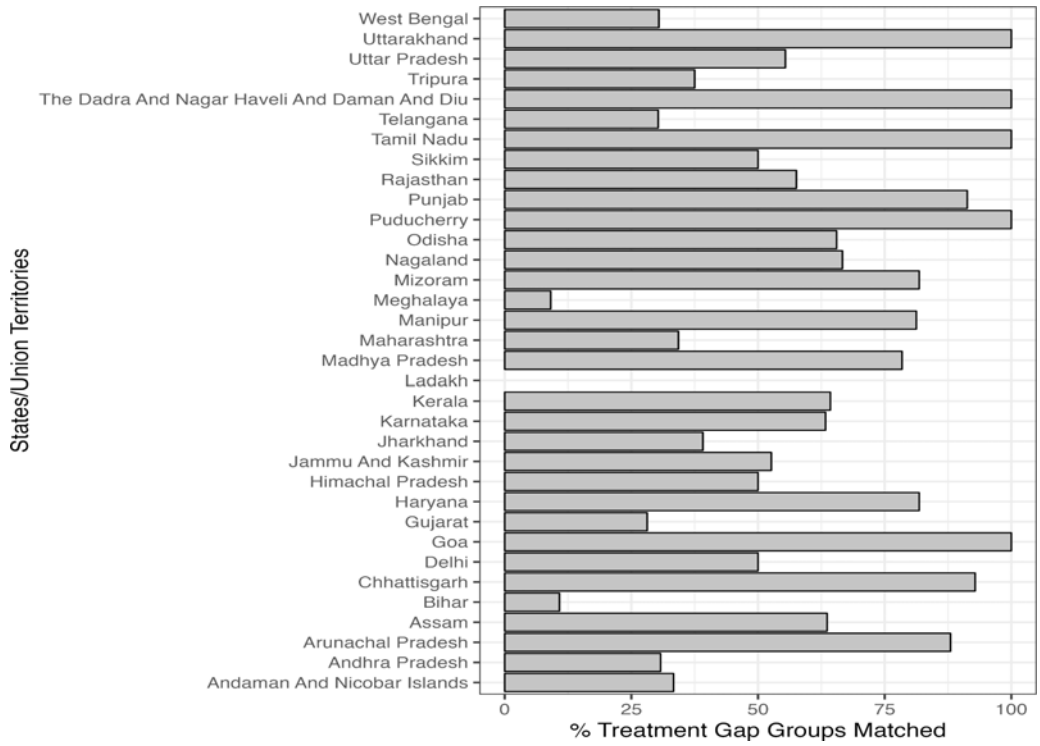
Web Fig. 2 District-wise raw Oral rehydration solution (ORS) treatment gap for 457 districts of India, 2019-20.



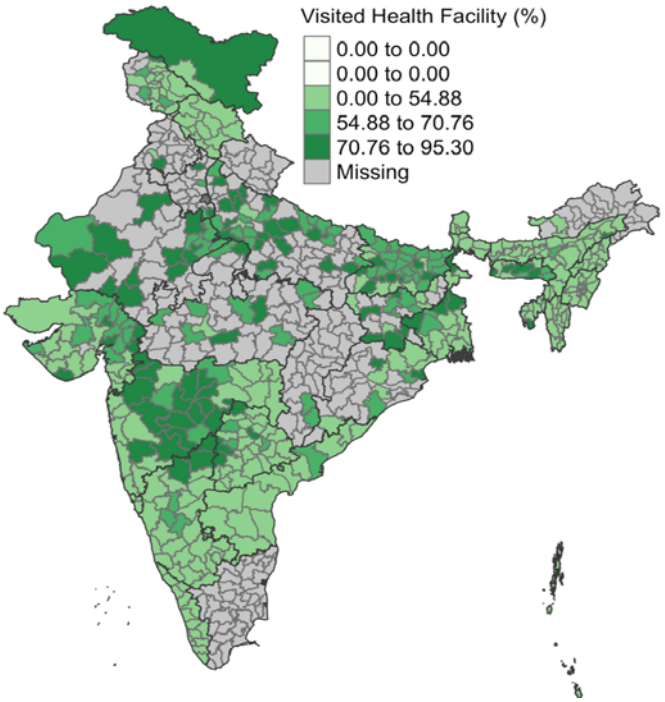
Web Fig. 3 District-wise raw zinc treatment gaps for 457 districts of India, 2019-20.



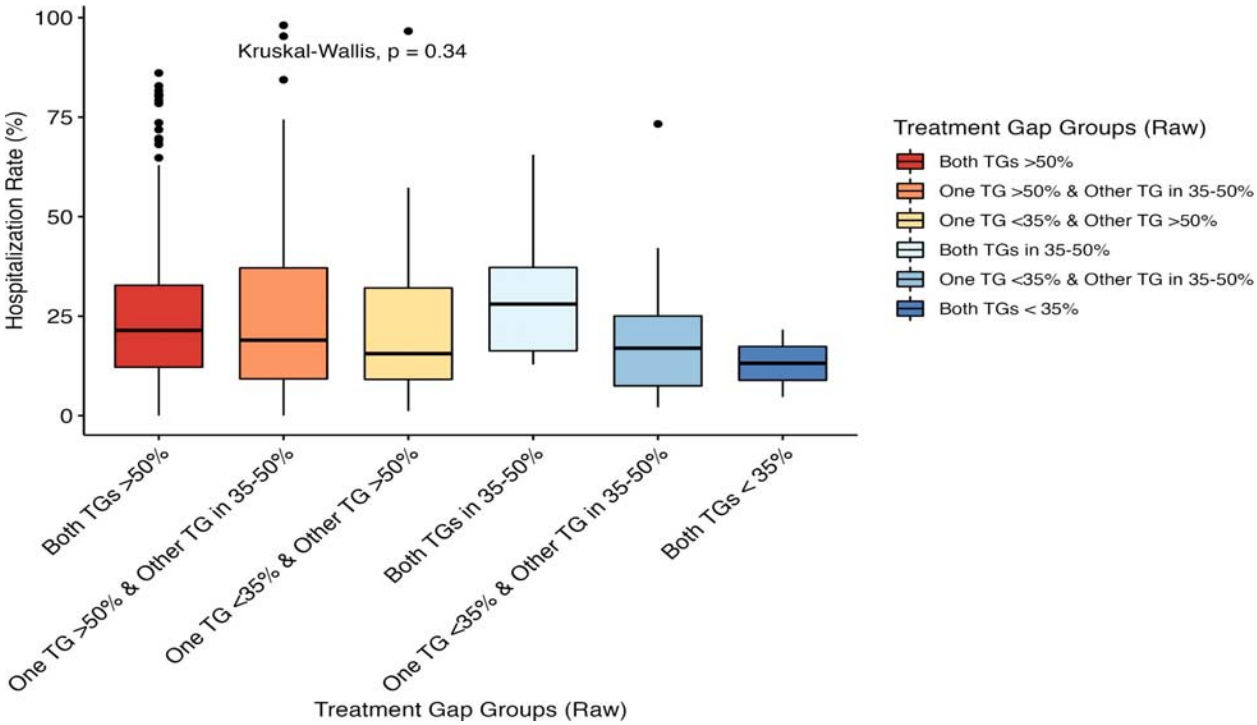
Web Fig. 4 Treatment gap groups based on raw ORS and zinc treatment gaps of 457 districts of India, 2019-20.



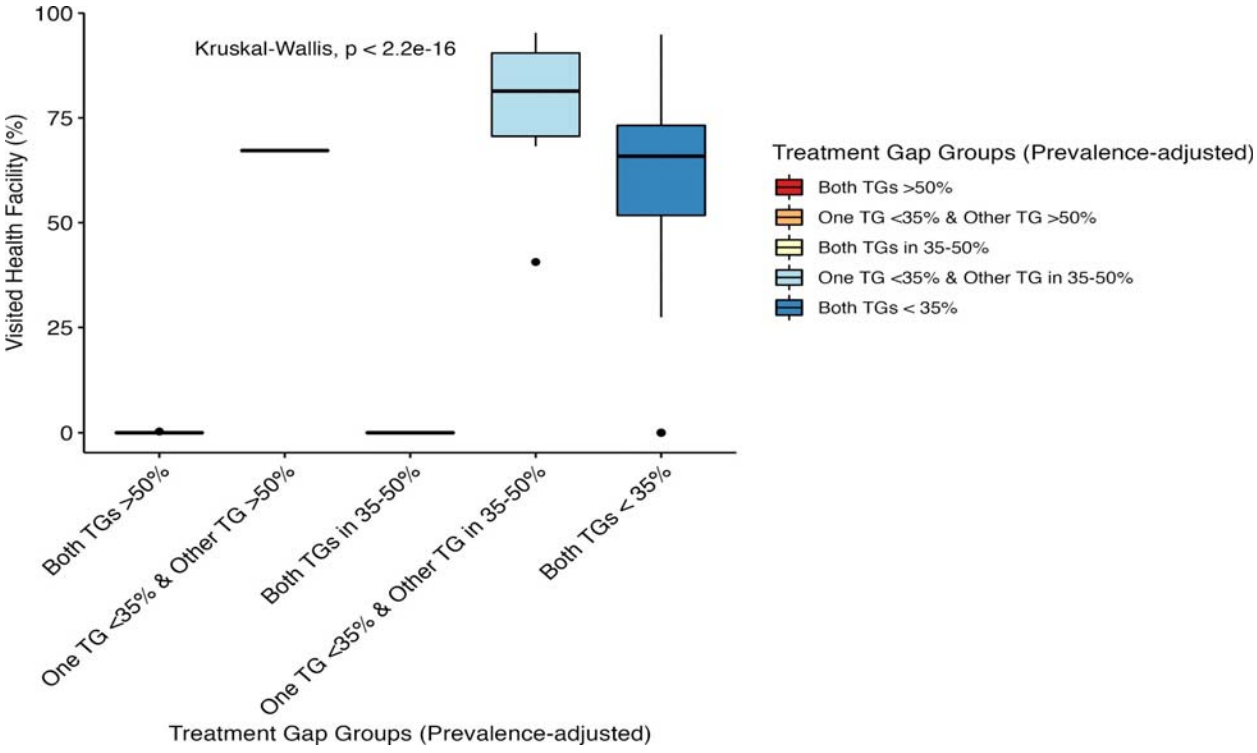
Web Fig. 5 State-wise match rate in treatment gap groups assigned using scaled-weighted and raw treatment gap.



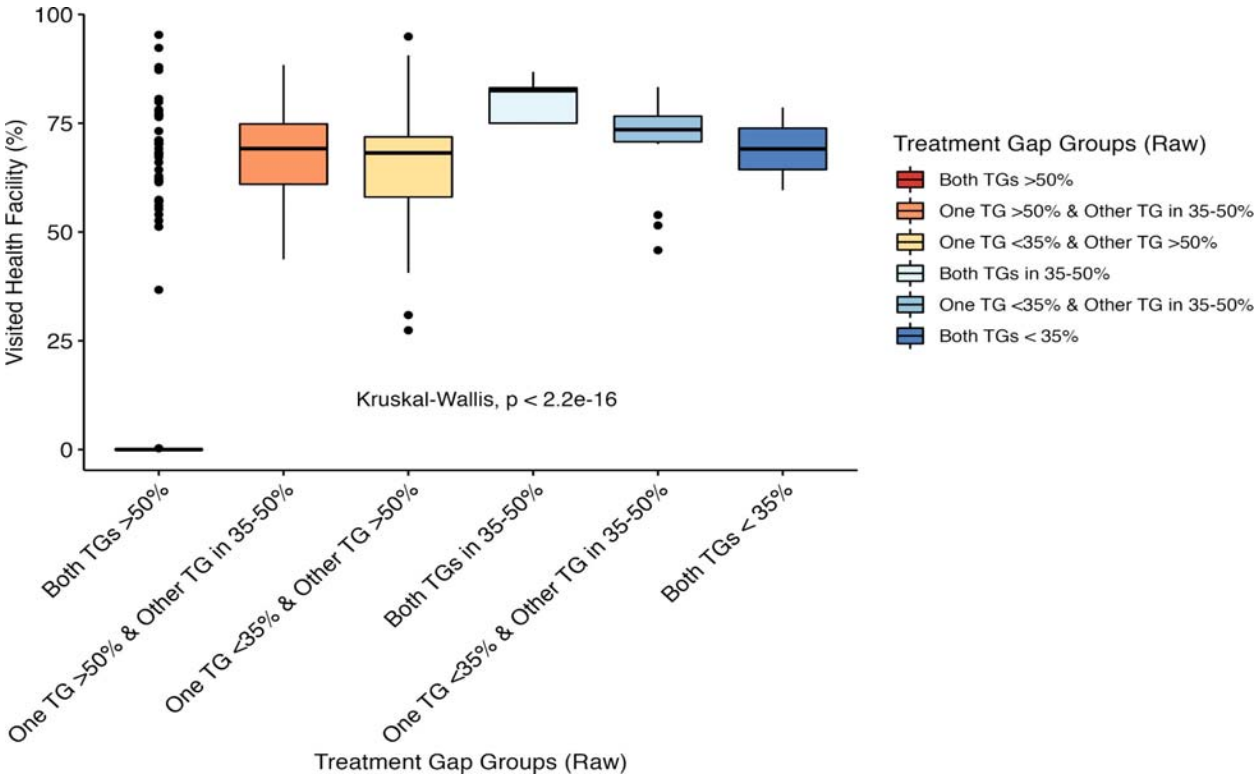
Web Fig. 6 District-wise health facility/provider visited for 457 districts of India, 2019-20.



Web Fig. 7 Association of hospitalization rates with raw treatment gap groups for 457 districts



Web Fig. 8 Association of health facility/provider visits with scaled-weighted treatment gap groups for 457 districts



Web Fig. 9 Association of health facility/provider visits with raw treatment gap groups for 457 districts