Measurement and Mapping of Maternal Health Service Coverage Through a Novel Composite Index: A Sub-National Level Analysis in India

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Abstract

Background: Expansion of maternal health service coverage is crucial for the survival and wellbeing of both mother and child. To date, limited literature exists on the measurement of maternal health service coverage at the sub-national level in India. The prime objectives of the study were to comprehensively measure the maternal health service coverage by generating a composite index; map India by categorizing it into low, medium and high zones and examine its incremental changes over time.

Methods: Utilising a nationally representative time series data of 15 key indicators spread across three domains of antenatal care, intranatal care and postnatal care, we constructed a novel 'Maternal Health Service Coverage Index' (MHSI) for 29 states and 5 union territories of India for the base (2017-18) and reference (2019-20) years. Following a rigorous procedure, MHSI scores were generated using both arithmetic mean and geometric mean approach. We categorized India into low, medium and high maternal health coverage zones and further generated geospatial maps to examine the extent and transition of maternal health service coverage from base to reference year.

Results: India registered the highest mean percentage coverage (93.66%) for 'institutional delivery' and lowest for 'treatment for obstetric complications' (9.25%) among all the indicators. Depending on the usage of arithmetic mean and geometric mean approach, the maternal health service coverage index score for India exhibited marginal incremental change (between 0.015- 0.02 index points) in the reference year. West zone exhibited an upward transition in the coverage of maternal health service indicators, while none of the zones recorded a downward movement. States of Mizoram (east zone), Puducherry (south zone) showed a downward transition. Union territories of Dadra & Nagar Haveli (west zone) and Chandigarh (north zone) along with the states of Maharashtra (west zone), Assam, as well as Jharkhand (both from the east & north east zone), showed upward transition.

Conclusion: Overall, maternal health service coverage is increasing across India. Our study offers a novel summary measure to comprehensively quantify the coverage of maternal health service, which can momentarily help India to identify lagged indicators and low performing regions, thereby warranting the targeted interventions and concentrated programmatic efforts to bolster the maternal health service coverage at the sub-national level.

Background

Reducing maternal mortality ratio is a pivotal target as part of the 'Sustainable Development Goal 3', which affirms 'to ensure healthy lives and promote wellbeing for all at all ages' [1]. Maternal mortality is a crucial health indicator largely resulted from causes which are preventable and treatable [2]. Maternal health, which refers to the health status of a woman during the period of pregnancy, childbirth, and postpartum [3] has the potential of affecting significant maternal and child health outcomes, therefore the domain of maternal health assumes a pivotal role from the development perspective of a nation. Health system strengthening in terms of increased quality of care, health infrastructure, finance, and human resources can help bolster the maternal health service coverage, which in turn can have multiple positive implications on maternal, neonatal and child health statuses. Government of India has initiated many schemes and programmes to improve accessibility, affordability and quality of the maternal health service coverage across the country. [4–6]. Reaffirming its commitment towards achieving better maternal health outcomes, the Indian Government under the National Health Mission (NHM) introduced a novel strategic approach for 'Reproductive, Maternal, Newborn, Child and Adolescent Health (RMNCH+A)' [7]. This 'continuum of care' of RMNCH+A refers to an integrated health service accessible to women, neonatal, infants or adolescents over the dimension of time (before pregnancy, during pregnancy, child birth and postnatal) and place (family and community care, outpatient and outreach services and hospital and health facilities) [8]. Maternal health, thus is one of the key

thematic areas under the strategy of RMNCH+A, which aims to promote linkages between diverse health interventions to reduce maternal, neonatal and child mortality rates.

According to a guideline by the Indian Ministry of Health and Family Welfare (MoHFW), based on time dimension, the health care services for a pregnant woman are classified mainly into three types, namely; antenatal/ prenatal care, intranatal/intrapartum care, and postnatal/postpartum care [3]. Antenatal care (ANC) which refers to the systemic care and supervision recommended for women during her pregnancy, is largely a platform for preventive and promotive health care services. ANC primarily aims to monitor the progress of fetal growth and wellbeing of the mother and fetus, thereby facilitating facilitates for a timely management of the obstetric complications. MoHFW guidelines recommends a minimum of four ANC visits in which the ANC registration and first ANC checkup within the first trimester (within 12 weeks) is accorded a high priority [3]. The World Health Organization (WHO) recommends various interventions ranging from dietary counselling, nutrient supplementation and a number of essential screening tests to improve the utilization and quality of antenatal care [9]. Another important stage of care in the continuum of RMNCH+A is the intranatal/ intrapartum care (INC), which refers to systemic care to a pregnant women during labour and delivery [3]. The time of birth is considered to be extremely crucial for both mother and the child as the chances of complication is high during this stage [10]. Sufficient literary evidence supports the prevalence of high-risk pregnancy and pre-term birth among the Indian and other south Asian population [11–15]. Therefore, the delivery of the baby crucially requires an appropriate setting, where lifesaving equipment is available and hygienic conditions are fully maintained. Utilization of public, private or charitable trust/Non-Governmental Organization health facility during the labour and child birth, referred as Institutional delivery, is a significant mean to timely management of obstetric complications [16]. However, literature reported that a considerable proportion still deliver at home in India attributed to social, cultural, physical and financial factors [17]. Increased skilled birth attendant(SBA) coverage is associated with reduced probability of maternal deaths [16] especially for those women who prefers to deliver at home in India. The third stage of care is the postnatal/postpartum care (PNC), which involves systemic care of women after delivery, where the first 42 days (6 weeks) is conventionally treated as the postpartum period [3]. MoHFW guideline recommends at least three postnatal visits to the health facility after an uncomplicated normal institutional delivery in India. Evidence indicates that larger proportion of the total neonatal deaths occurs in the first week of postnatal with highest number in the first three days [18].

Till date limited literature exists on measurement of maternal health service coverage at sub-national level in India. Prior research mainly focussed on the theme of Reproductive, Maternal, New born and Child Health (RMNCH) service coverage and their inequities at national and sub-national level in India. Majority of them used Coverage Gap Index (CGI) as an outcome measure of the RMNCH service coverage, which is primarily constituted by the domains of reproductive services, maternal and new born care, immunization and management of illness [19–21]. However, there were only two indicators namely 'skilled birth attendant' and 'antenatal care coverage' under the domain of maternal and new born care, which makes the measurement of maternal health service coverage narrow and incomplete. To the best of our knowledge, no published study has estimated and examined the maternal health service coverage using a composite index. The present study addresses this lacuna by constructing a comprehensive 'Maternal Health Service coverage Index' (MHSI), which includes cumulative set of relatively large maternal health indicators categorized into three domains of antenatal, intranatal and postnatal care coverage, which is a major highlight of the study. Further, the constructed MHSI has been used for the identification of the low, medium and high coverage regions across different time series points in India, a theme which was largely unexplored in the previous studies. In this backdrop, utilising a nationally representative data, the specific objectives of the study are; a) to comprehensively measure maternal health service coverage at sub-national level in India by constructing a composite index using a rigorous methodology; b) to map and categorize India into low, medium and high maternal health coverage zones; c)

to examine the sub- national areas (states and union territories of India) which have transitioned from low to higher category of coverage and vice versa across the different time points.

Methods

Data source

The study extracted secondary data for three financial years (2017-2018 to 2019-20) on various health indicators of maternal health service coverage from the Health Management Information System (HMIS) portal, an initiative under National Health Mission (NHM) by the Government of India. HMIS is free of cost publicly available web-based routine monitoring system of the vital Reproductive Maternal Newborn Child Health (RMNCH) data uploaded by the States and Union Territories (UT) in India. The HMIS portal that provides annual data on financial year basis has been reporting detailed data at sub-national level since the year 2017. A total of 29 states and 5 UTs have been included for examining maternal health service coverage at sub-national level in India during the period 2017-2018 (base year) and 2019-2020 (reference year). The Indian states and union territories under the study have also been classified into four geographical zones namely north, west, east & north east and south [22]. The raw and coded data has also been uploaded on Mendeley data repository [23] to provide free and unrestricted access to this time series data for facilitating transparency and reproducibility of the results.

Selection and classification of Indicators

The key HMIS indicators at sub-national level is segregated in to different domains namely child health, family planning, maternal health and the ‘other’ miscellaneous. Since, the present study aimed to construct composite indicator for maternal health service coverage at state and UT level, therefor the individual indicators have been selected from the domain of maternal health based on the opinion of medical experts and public health professionals along with extensive review of literature. The experts mainly considered relevance, usefulness, importance, and distinctiveness of the indicators in valuation of the maternal health service coverage. In consensus with the experts, the study finalized 15 individual indicators to compute the Maternal Health Service Coverage Index (MHSI). It is to be noted that because of the difference in population composition and territory of Indian states, it was not be appropriate to choose the indicators reported in the absolute values for the construction of maternal health service coverage. Hence, the study considered the relative measure of the selected indicators for the purpose of index construction.

The selected indicators were further classified under the 3 domains of Antenatal care (ANC) coverage, Intranatal care (INC) Coverage and Postnatal care (PNC) coverage based on various guidelines by WHO and Ministry of Health and family Welfare [3, 9, 10, 18]. Furthermore, the study classified the component indicators of ANC coverage domain in to 3 sub-domains namely ‘ANC registration & check-ups (ANC1)’, ‘Supplementation & prophylaxis in pregnancy (ANC2)’, and ‘Essential screening tests (ANC3)’. The detailed description of the maternal health service coverage indicators has been given in the Table 1.

Table 1: Operational definitions of indicators for Maternal Health Service Coverage Index (MHSI).

Domains/Sub-domains/Indicators	Definition	Numerator	Denominator
Domain I: Antenatal Care (ANC) Coverage			
ANC sub-domain I: ANC Registration & check-up (ANC1)			
1. ANC Registration (ANC1_1)	Percentage first Trimester registration to Total ANC Registrations.	Number of pregnant women registered for ANC within first trimester.	Total number of pregnant women registered for ANC.
1. ANC Check-ups (ANC1_2)	Percentage Pregnant Woman received 4 ANC check-ups to Total ANC Registrations.	Number of Pregnant Woman received 4 ANC check-ups	Total number of pregnant women registered for ANC.
ANC sub-domain II: Supplementation & prophylaxis in pregnancy (ANC2)			
1. Immunization against Tetanus (ANC2_1)	Percentage Pregnant women received TT2+ TT Booster to Total ANC Registration.	Number of pregnant women received TT2+ TT Booster	Total number of pregnant women registered for ANC.
1. IFA Supplementation (ANC2_2)	Percentage Pregnant women given 180 IFA tablets to Total ANC Registration.	Number of pregnant women given 180 IFA tablets.	Total number of pregnant women registered for ANC.
1. Anaemia treatment coverage (ANC2_3)	Percentage Pregnant Women having severe Anaemia (Hb<7) treated at institution to Total ANC Registration.	Number of pregnant women having severe Anaemia (Hb<7) treated at institution.	Total number of pregnant women registered for ANC.
1. Calcium supplementation (ANC2_4)	Percentage Pregnant women given 360 Calcium tablets to Total ANC Registration.	Number of pregnant women given 360 Calcium tablets.	Total number of pregnant women registered for ANC.
1. Deworming (ANC2_5)	Percentage Pregnant women given one Albendazole tablet after 1st trimester to Total ANC Registration.	Number of pregnant women given one Albendazole tablet after 1st trimester	Total number of pregnant women registered for ANC.
ANC sub-domain III: Essential screening tests (ANC3)			
1. Screening for Diabetes (ANC3_1)	Percentage Pregnant women tested for blood sugar using OGTT to Total ANC Registration	Number of Pregnant women tested for blood sugar using OGTT.	Total number of pregnant women registered for ANC.
1. Screening for Syphilis (ANC3_2)	Percentage Pregnant women tested for Syphilis to Total ANC Registration	Number of Pregnant women tested for Syphilis.	Total number of pregnant women registered for ANC.

1. Screening for HIV (<i>ANC3_3</i>)	Percentage Female screened for HIV to Total ANC Registration.	Number of females screened for HIV	Total number of pregnant women registered for ANC.
Domain II: <i>Intranatal care (INC) coverage</i>			
1. SBA attended home deliveries (<i>INC_1</i>)	Percentage SBA attended home deliveries to Total Reported Home Deliveries	Number of home deliveries attended by SBA trained (Doctor/ Nurse/ ANM)	Total number of home deliveries reported.
1. Institutional delivery (<i>INC_2</i>)	Percentage Institutional deliveries to Total Reported Deliveries	Number of deliveries conducted in both public and private institution.	Total number of reported deliveries.
1. C-Section deliveries (<i>INC_3</i>)	Percentage C-section deliveries (Public + Pvt.) to reported institutional (Public + Pvt.) deliveries	Number of C-section deliveries conducted in both public and private institution.	Total number of reported institutional deliveries.
1. Treatment for obstetric complications (<i>INC_4</i>)	Percentage cases of Pregnant women with Obstetric Complications and attended to reported deliveries	Number of Pregnant women with Obstetric Complications and attended.	Total number of reported deliveries.
Domain III: <i>Postnatal care (PNC) coverage</i>			
1. Postpartum check-up (<i>PNC_1</i>)	Percentage women getting 1st postpartum checkup between 48 hours and 14 days to total reported deliveries	Number of women getting 1st postpartum checkup between 48 hours and 14 days.	Total number of reported deliveries.

Data cleaning, Data quality, consistency checking

Five percent of the obtained data on the selected indicators of maternal health service coverage were randomly chosen and rechecked for the errors in the data entry [24]. A zero-error rate was observed. Followed by that, the data was checked for the missing values. Due to availability of data for 3 financial years only, the standard imputation techniques and extrapolation and interpolation techniques could not be applied to treat the missing values [25]. The states or UTs with missing values for more than one specific year on any indicator, have been excluded from the study. As per this criterion, Daman & Diu and Lakshadweep were removed from the study. The states/UTs having missing values only for one particular year were replaced by the available values of most recent year [26].

Computation of Maternal Health Service-coverage Index (MHSI)

Data normalization

The extracted data on selected Maternal Health Service Coverage Index (MHSI) from the HMIS were subjected to normalization based on the 'Minimum-Maximum approach' used by United Nations Development Programme (UNDP) for the computation of Human Development Index (HDI) values. Each of the selected 15 indicators are positive in nature, where the resultant higher index value shall represent the positive result (higher the value, better the maternal

health service coverage). Owing to “higher the better” nature of the individual values, the said data was normalised using the following formula [27]:

$$N_i = \frac{(A_i - L_i)}{(U_i - L_i)}$$

Where, N_i is the normalised value of the i^{th} indicator, A_i represents the Actual value of the i^{th} indicator, U_i and L_i denote the maximum and minimum values (goal posts) of the dimension indicators respectively. The UNDP in its reports [28], recommended the use of absolute goal posts over the observed goal posts in the normalization process. The study fixed 100% (aspirational goal) and 0% (natural zero) as the maximum and minimum value (goal posts) respectively, from which the individual indicators were standardised.

Construction of MHSI: Different scenarios

Followed by the calculation of normalized individual indicators, the Maternal Health Service Coverage Index (MHSI) involves three detailed steps. The first step was to estimate three sub-indices of the ANC that is ANC1, ANC2 and ANC3 and to estimate separate indices of INC and PNC. Since both domains of INC and PNC coverage have not been segregated further, the study directly computed INC and PNC index from its individual indicators. Followed by the step 1, the study computed ANC index from its three subindices. Finally in step 3, the study aggregated ANC, INC and PNC indices to compute a comprehensive cumulative index for ‘Maternal Health Service Coverage’. The study employed four alternate scenarios using the aforementioned three steps for the computation of MHSI. The different scenarios have been explained in detail in the Figure 1. Alternate scenarios differ by the choice of aggregation method, i.e., usage of arithmetic mean approach and geometric mean approach [28], which is primarily based on procedure followed for construction of Human Development Index (HDI) by United Nations Development Programme (UNDP). Microsoft office Excel 2019 and IBM SPSS version 24 was employed for construction of index and computation of related descriptive statistical measures.

Categorization and mapping of Indian states and Union Territories

The index values of the MHSI ranges between 0 and 1, where values close to 1 indicate high maternal service coverage and value close to zero correspond to low coverage. Furthermore, the study categorized Indian states in to low, medium, and high categories based on the MHSI score. The study considered the period 2017-2018 as the base year and calculated 33rd and 66th percentile score of the MHSI values of Indian states. This percentile values were used as the criteria for determining the category the Indian state belonged to. The Indian state with MHSI value below 33rd percentile categorised to low category, those with above 66th percentile was categorised to high category and the ones having score between 33rd and 66th percentile was assigned the medium category. The study categorised Indian states based on MHSI values in four alternate scenarios under study. The details of the 33rd and 66th percentile score in different scenarios have been described in the Additional file 1. Furthermore, the study geo-spatially mapped the Indian states into different MHSI zones using the Arc GIS 10.8 software.

Results

Descriptive characteristics of maternal health service coverage indicators

Table 2 and Figure 2 describes the characteristics of selected maternal health service coverage indicators at regional and national level. Out of the 15 indicators, institutional delivery showed the highest mean percentage across India and every region. The study observed that on an average, 93.66% of the total reported delivery delivered at institution (both public and private) in India. Across India, 'treatment for obstetric complications' was observed to be the lowest (9.25%) among all the indicators.

In most of the indicators, performance of south zone and west zone was notable. Of the 4 zones, the south zone recorded highest mean percentage coverage for ANC check-ups (88.36%), IFA supplementation (91.31%), institutional deliveries (99.79%), screening for diabetes (33.24%), screening for HIV (69.09%), SBA attended home deliveries (46.63%), c-section deliveries (38.59%), postpartum check-up (67.64%) and treatment for obstetric complications (13.91%). In contrast, the west zone registered highest mean percentage coverage for ANC registration (78.12%), immunization against tetanus (86.89%), anemia treatment coverage (75.02%), calcium supplementation (77.33%), deworming (59.71%) and screening for syphilis (56.35%). East & north east zone registered the lowest mean percentage coverage in 10 out of 15 indicators namely, ANC registration (63.95%), ANC check-up (60.25%), IFA supplementation (59.25%), anemia treatment coverage (52.63%), calcium supplementation (36.51%), deworming (25.78%), screening for diabetes (14.05%), institutional delivery (88.62%), c-section delivery (21%) and treatment for obstetric complications (6.13%).

On the other hand, north zone registered lowest mean percentage coverage for immunization against tetanus (73.58%), screening for HIV (37.89%), SBA attended home deliveries (17.30%) and postpartum check-up (54.71%). Among the indicators, none of the zones recorded more than 50% coverage in screening for diabetes, SBA attended home deliveries, c-section deliveries and treatment for obstetric complication. Furthermore, estimates of the coefficient of variation showed indicator of 'institutional delivery' has the lowest and the indicator of 'the screening for diabetes' has the highest variations in India.

Table 2

Descriptive characteristics of indicators of maternal health service coverage at regional and national level over a span of three years (2017-18 to 2019-20)

Indicators	Mean (%)					Coefficient of variation (%)				
	North zone	West zone	East & north east zone	South zone	India	North zone	West zone	East & north east zone	South zone	India
Domain I: Antenatal Care Coverage (ANC)										
ANC Sub-domain I: ANC Registration & check-up (ANC1)										
ANC Registration	66.34	78.12	63.95	71.72	68.46	21.67	18.05	30.71	29.91	26.81
ANC Check-ups	65.50	81.56	60.25	88.36	70.36	27.45	10.02	33.72	17.91	29.05
ANC Sub-domain II: Supplementation & prophylaxis in pregnancy (ANC2)										
Immunization against Tetanus	73.58	86.89	74.98	82.66	78.07	27.45	21.83	22.28	35.89	27.04
IFA Supplementation	66.24	88.44	59.25	91.31	71.91	28.58	12.12	39.98	28.04	34.61
Anaemia treatment coverage	65.73	75.02	52.63	56.04	60.65	22.79	21.94	39.39	33.13	32.79
Calcium supplementation	54.89	77.33	36.51	59.71	53.20	41.35	17.23	59.93	55.94	50.76
Deworming	32.89	59.71	25.78	31.72	34.70	63.83	33.22	79.81	69.43	68.52
ANC Sub-domain III: Essential screening tests (ANC3)										
Screening for Diabetes	16.89	20.74	14.05	33.24	19.37	97.18	120.45	151.51	135.87	140.00
Screening for Syphilis	42.86	56.35	36.99	35.21	41.64	47.61	92.80	59.51	53.63	70.60
Screening for HIV	37.89	64.64	45.41	69.09	50.99	58.58	81.32	81.81	48.54	74.68
Domain II: Intranatal care coverage (INC)										
SBA attended home deliveries	17.30	30.51	29.61	46.63	30.10	80.29	64.49	67.46	50.23	69.73
Institutional delivery	93.76	98.29	88.62	99.79	93.66	5.17	2.11	12.20	0.30	9.00
C-Section deliveries	24.04	23.04	21.00	38.59	25.27	48.85	47.94	44.93	18.17	46.45
Treatment for obstetric complications	11.76	7.60	6.13	13.91	9.25	79.76	43.73	69.20	121.21	101.92
Domain III: Postnatal care coverage (PNC)										

Indicators	Mean (%)					Coefficient of variation (%)				
	North zone	West zone	East & north east zone	South zone	India	North zone	West zone	East & north east zone	South zone	India
Postpartum Check-up	54.71	59.01	61.23	67.64	60.24	53.21	37.36	36.89	65.33	48.09

Composite Maternal Health Service Coverage Index (MHSI) and its comparison between base year and reference year

The study computed MHSI using different methodological based scenarios already explained in the figure 1. The MHSI values based on four different approaches for the base year (2017-2018) and reference year (2019-2020) have been presented in the Additional file 2. In scenario I, all the sub-indices and domain indices of MHSI were aggregated through arithmetic mean approach, whereas in the Scenario IV, the geometric mean approach was employed [28]. For conciseness, MHSI values across base year and reference year were compared only for scenarios I (Table 3) and IV (Table 4). However, in the interest of large audience, details of MHSI values across base and reference year for the scenario II and III have also been presented in Additional file 3 and 4, nevertheless these tables do not form the part of analytic inferences of the present study.

For scenario I (Table 3), the MHSI of India increased slightly from base year (0.523) to the reference year (0.538), however both values corresponded to medium level of maternal health service coverage. At regional level, MHSI value of west zone showed highest incremental change of about 0.049 index points, which transitioned it from the category of medium MHSI in base year to high MHSI level in the reference year. In contrast, there is negative change in value of MHSI (-0.042) of south zone, but it still remained under the category of high MHSI value. Overall, state of Kerala (South zone) topped both in the base and reference year with MHSI scores of 0.858 and 0.748, respectively. Rajasthan (North zone) with an MHSI score of 0.309 and Arunachal Pradesh (East & north east zone) with a score of 0.337 were in the last position for base year and reference year, respectively. The states/UTs namely, Dadra & Nagar Haveli (0.663), Goa (0.66) and Maharashtra (0.588) from west zone and Assam (0.626) from east zone transitioned upwards from medium to high category in the reference year, while others Chandigarh (0.470) and Delhi (0.439) from north zone as well as Jharkhand (0.467) from east zone moved upwards from low to medium category. Only the states of Mizoram (0.346) of east zone and Puducherry (0.388) of south zone showed a downward transition, from medium to low MHSI category. The state of Uttar Pradesh (0.119) from north zone and the UT of Dadra & Nagar Haveli (0.107) from west zone showed highest positive increment in MHSI value. While, the highest negative decrement recorded by the state of Mizoram (-0.135) and UT of Puducherry (-0.158).

Table 3

Incremental change of MHSI values and categorization of states in base year and reference year (Scenario I)

State/UTs	MHSI Values		MHSI Values		Incremental Changes in MHSI	
	in Base Year (2017-18)		in Reference year (2019-20)			
	Index value	Category	Index value	Category	Change in value	Change in category
North zone	0.462	Medium	0.502	Medium	0.04	→
Chandigarh*	0.370	Low	0.470	Medium	0.100	↑
Delhi*	0.437	Low	0.439	Medium	0.002	↑
Haryana	0.549	Medium	0.530	Medium	-0.019	←
Himachal Pradesh	0.608	High	0.699	High	0.090	→
Jammu & Kashmir	0.505	Medium	0.499	Medium	-0.006	←
Punjab	0.645	High	0.663	High	0.018	→
Rajasthan	0.309	Low	0.345	Low	0.036	→
Uttar Pradesh	0.318	Low	0.436	Low	0.119	→
Uttarakhand	0.419	Low	0.433	Low	0.015	→
West zone	0.530	Medium	0.579	High	0.049	↑
Chhattisgarh	0.597	High	0.572	High	-0.025	←
Dadra & Nagar Haveli*	0.556	Medium	0.663	High	0.107	↑
Goa	0.564	Medium	0.660	High	0.096	↑
Gujarat	0.568	High	0.654	High	0.086	→
Madhya Pradesh	0.356	Low	0.337	Low	-0.019	←
Maharashtra	0.540	Medium	0.588	High	0.048	↑
East & north east zone	0.478	Medium	0.491	Medium	0.013	→
Andaman & Nicobar Island*	0.644	High	0.669	High	0.025	→
Arunachal Pradesh	0.378	Low	0.337	Low	-0.042	←
Assam	0.533	Medium	0.626	High	0.093	↑
Bihar	0.334	Low	0.369	Low	0.035	→
Jharkhand	0.410	Low	0.467	Medium	0.057	↑

Note: ↑ Upward transition from a lower category to higher; → No change in category, but MHSI value increased; → No change in category but MHSI value decreased; ↓ Downward transition from a higher category to lower.

*Denotes Union Territory (UT).

State/UTs	MHSI Values in Base Year (2017-18)		MHSI Values in Reference year (2019-20)		Incremental Changes in MHSI	
	Index value	Category	Index value	Category	Change in value	Change in category
Manipur	0.438	Low	0.426	Low	-0.012	←
Meghalaya	0.340	Low	0.340	Low	0.000	→
Mizoram	0.481	Medium	0.346	Low	-0.135	↓
Nagaland	0.371	Low	0.372	Low	0.001	→
Odisha	0.591	High	0.692	High	0.101	→
Sikkim	0.629	High	0.628	High	-0.001	←
Tripura	0.479	Medium	0.504	Medium	0.025	→
West Bengal	0.584	High	0.614	High	0.030	→
South zone	0.620	High	0.578	High	-0.042	←
Andhra Pradesh	0.605	High	0.660	High	0.055	→
Karnataka	0.712	High	0.723	High	0.012	→
Kerala	0.858	High	0.748	High	-0.110	←
Puducherry*	0.546	Medium	0.388	Low	-0.158	↓
Tamil Nadu	0.462	Medium	0.476	Medium	0.015	→
Telangana	0.540	Medium	0.472	Medium	-0.068	←
India	0.523	Medium	0.538	Medium	0.015	→
Note: ↑ Upward transition from a lower category to higher; → No change in category, but MHSI value increased; → No change in category but MHSI value decreased; ↓ Downward transition from a higher category to lower.						
*Denotes Union Territory (UT).						

For scenario IV (Table 4), which is based on geometric mean approach, the MHSI value for India had marginally increased (by 0.015 index points) in the reference year (0.377) as compared to base year (0.358). India has remained in the medium category, thereby indicating no upward or downward transition with respect to maternal health service coverage. In terms of absolute index values, highest increment in MHSI score (0.046 index points) was achieved by north zone (0.362) in the reference year, however it remained in the medium category only. West zone is the only region, which transitioned from medium to high MHSI category in the reference year, and it recorded the highest MHSI value of 0.427 followed by south zone (0.389). Apart from south zone, MHSI index scores increased for all other zones in the reference year. The study observed an upward transition of MHSI category from low to medium in the following Indian states/UTs namely Chandigarh (0.331) and Uttar Pradesh (0.316) from north zone and Jharkhand (0.332) from east & north east zone, while Dadra & Nagar Haveli (0.477), Gujarat (0.49) and Maharashtra (0.477) from west zone and Assam (0.478) from east & north east zone showed an upward transition in category from medium to high.

Only two states, Mizoram (0.248) from east & north east zone and Puducherry (0.331) from south zone showed a downward transition in MHSI category. The state of Mizoram transitioned from medium to low category while that for the UT of Puducherry was from High to Medium category. The state of Goa (0.125) and UT of Chandigarh (0.148) recorded highest positive incremental change in MHSI value whereas, the state of Mizoram (-0.073) and UT of Puducherry (-0.135) registered highest negative decrement.

Table 4

Incremental change of MHSI values and categorization of states in base year and reference year (Scenario IV)

State/UTs	MHSI Values in Base Year (2017-18)		MHSI Values in Reference year (2019-20)		Incremental Changes in MHSI	
	Index value	Category	Index value	Category	Change in value	change in category
North zone	0.315	Medium	0.362	Medium	0.046	→
Chandigarh*	0.183	Low	0.331	Medium	0.148	↑
Delhi*	0.332	Medium	0.312	Medium	-0.020	←
Haryana	0.404	Medium	0.398	Medium	-0.006	←
Himachal Pradesh	0.483	High	0.575	High	0.092	→
Jammu& Kashmir	0.342	Medium	0.376	Medium	0.034	→
Punjab	0.504	High	0.545	High	0.041	→
Rajasthan	0.234	Low	0.224	Low	-0.009	←
Uttar Pradesh	0.211	Low	0.316	Medium	0.105	↑
Uttarakhand	0.307	Medium	0.311	Medium	0.005	→
West zone	0.393	Medium	0.427	High	0.034	↑
Chhattisgarh	0.504	High	0.469	High	-0.035	←
Dadra & Nagar Haveli*	0.412	Medium	0.477	High	0.065	↑
Goa	0.430	High	0.555	High	0.125	→
Gujarat	0.402	Medium	0.490	High	0.088	↑
Madhya Pradesh	0.241	Low	0.207	Low	-0.034	←
Maharashtra	0.422	Medium	0.477	High	0.055	↑
East& north east zone	0.324	Medium	0.337	Medium	0.013	→
Andaman & Nicobar Island*	0.528	High	0.532	High	0.004	→
Arunachal Pradesh	0.289	Low	0.252	Low	-0.036	←
Assam	0.384	Medium	0.478	High	0.094	↑
Bihar	0.201	Low	0.231	Low	0.030	→
Jharkhand	0.277	Low	0.332	Medium	0.055	↑

Note: ↑ Upward transition from a lower category to higher; → No change in category but MHSI value increased; → No change in category but MHSI value decreased; ↓ Downward transition from a higher category to lower.

*Denotes Union Territory (UT).

State/UTs	MHSI Values in Base Year (2017-18)		MHSI Values in Reference year (2019-20)		Incremental Changes in MHSI	
	Index value	Category	Index value	Category	Change in value	change in category
Manipur	0.310	Medium	0.305	Medium	-0.005	←
Meghalaya	0.258	Low	0.266	Low	0.008	→
Mizoram	0.321	Medium	0.248	Low	-0.073	↓
Nagaland	0.234	Low	0.247	Low	0.013	→
Odisha	0.456	High	0.570	High	0.114	→
Sikkim	0.488	High	0.492	High	0.004	→
Tripura	0.263	Low	0.269	Low	0.006	→
West Bengal	0.383	Medium	0.394	Medium	0.011	→
South zone	0.408	Medium	0.389	Medium	-0.019	←
Andhra Pradesh	0.454	High	0.516	High	0.062	→
Karnataka	0.567	High	0.596	High	0.029	→
Kerala	0.545	High	0.529	High	-0.015	←
Puducherry*	0.466	High	0.331	Medium	-0.135	↓
Tamil Nadu	0.180	Low	0.189	Low	0.009	→
Telangana	0.392	Medium	0.341	Medium	-0.051	←
India	0.358	Medium	0.377	Medium	0.020	→
Note: ↑ Upward transition from a lower category to higher; → No change in category but MHSI value increased; → No change in category but MHSI value decreased; ↓ Downward transition from a higher category to lower.						
*Denotes Union Territory (UT).						

The transition of states across different MHSI categories based on the MHSI index values in the base year and reference year have also been presented through geo-spatial maps in the Figure 3 (Figure 3A for scenario I and Figure 3B for scenario IV).

Discussion

Out of the 15 maternal health service indicators, institutional delivery (INC indicator), immunization against tetanus, ANC check-ups and IFA supplementation (ANC indicators) recorded relatively higher mean percentage (more than 70%) coverage at all India level for three years (2017-18 to 2019-20). The maternal health care services like institutional delivery and antenatal care coverage in India observed substantial progress in the past two decades with the implementation of plethora of targeted government driven programmes such as National Health Mission (NHM), Maternity Benefit programmes like Janani Suraksha Yojana(JSY), Pradhan Mantri Surakshit Matritva Abhiyan (PMSMA) and Pradhan Mantri Matru Vandana Yojana (PMMVY) to name a few [4, 5, 29]. Recently launched 'Anemia

Mukt Bharat' programme has given prime importance to IFA supplementation for pregnant women, which is a highly probable reason for enhanced IFA coverage [30]. However, national mean percentage coverage of some of the indicators of maternal health service coverage is quite perturbing, such as; screening for diabetes (ANC indicator), SBA attended home deliveries, c-section delivery and treatment for obstetric complications (all INC indicators) as they recorded relatively low mean percentage (around 30%) coverage across the country. Some state specific studies recorded prevalence of gestational diabetes ranged between 9.89–35% [31–35], which is quite alarming. In this regard, in compliance with the recommendations of WHO and International Association of Diabetes and Pregnancy Study Group (IADPSG), India requires region specific efforts to expand its coverage of screening for diabetes among pregnant women [34]. Though the present study observed lower mean percentage coverage for c-section delivery across India, nevertheless the growth rate of c-section delivery in India has doubled during 2005-06 to 2015-16 [36]. Low socio-economic status, awareness of available schemes, distance to health facility, absence of transport, and social cultural norms can be identified for preference of home delivery and related maternal complications in India [37–40].

Both southern and western zones of India have outperformed the other zones on the coverage of a number of maternal health indicators. South zone, particularly have performed sizable well with respect to institutional deliveries, IFA supplementation, ANC check-ups and screening for HIV. [41–44]. The states of Kerala, Tamil Nadu, Karnataka and Andhra Pradesh from south zone are the front runners in the overall 'Sustainable Development Goals' (SDGs) with relatively high SDG index scores, which has remarkably influenced their coverage and receipt of health care services such as institutional care and antenatal care coverage [45]. Consistently high HIV prevalence districts were clustered mainly in the south zone of the country [46], therefore, it is expected to have high percentage coverage in screening for HIV as a preventive measure. Furthermore, most of the states from south zone are known for its remarkable performance in literacy rates, particularly in female literacy [47], which can be a possible reason for increased awareness of HIV screening among south zone population. West zone particularly has recorded a substantial high coverage for immunization against tetanus, ANC registration, calcium supplementation and anemia treatment coverage. Effective planning and management of resources, re-establishment of outreach services, community links, supportive supervision and monitoring are the possible facilitating factors of immunization services including tetanus [48]. State governments of Gujarat, Chhattisgarh and Madhya Pradesh from west zone has collaborated with WHO for calcium supplementation to pregnant women [49] possibly the reason for high 'calcium supplementation' coverage in west zone.

North zone recorded lowest coverage for indicators particularly with respect to screening for HIV and SBA attended home deliveries. Low female literacy and rigid socio-cultural factors of majority of states from the north zone may have resulted in low SBA attended home deliveries [47]. However, Uttar Pradesh and Rajasthan from north zone are observed to be the states which require highest need for 'Prevention of Maternal to Child Transmission' (PMCTC) of HIV [50] and therefore demands high coverage in screening for HIV among pregnant women. East & north east zone has underperformed on a number of indicators, specifically for screening pregnant women for diabetes, c-section delivery and treatment for obstetric complications. Low female literacy rate [47] and high proportion of tribal population [51] are expected to account for low c-section delivery rates in this zone. Majority of states from east & north east zone recorded low prevalence of diabetes in a nationwide study [52], making it a likely cause for low diabetes screening coverage. Inaccessible regional terrain, poor transportation facilities, availability of prompt medical services and behavioural factors (tobacco and alcohol use) are significantly associated with low treatment coverage for obstetric complications [53].

The methodology adopted in the present study for data normalization and construction of MHSI is primarily based on United Nations Development Programme (UNDP)'s procedure to compute Human Development Index (HDI) [54], which is highly rigorous and standardized. Further, the study generated MHSI scores based on the choice of arithmetic mean and geometric mean approach for aggregating the 15 indicators into one composite index. Geometric mean approach (used in scenario IV) has an advantage over arithmetic mean approach (used in scenario I) as it is less affected by skewed data and extreme values, thereby integrating the overall balance in the data distribution [28]. However, usage of arithmetic mean is more suitable in those cases where the data normalization is carried from the observed values of the data distribution [55]. Therefore, comparison of index values across these two different approach-based scenarios are redundant in nature. The authors clarify that the study elucidates the comparison of MHSI values across two time periods (base year and reference year) within a given scenario and not across the two scenarios. Construction of MHSI for these two particular scenarios, facilitates the identification of those common states/union territories/regions, which have transitioned from a lower to higher category of maternal health service coverage or vice versa. The earlier attempts to measure maternal health service coverage have been limited and narrow in their approach. Composite Coverage Index (CCI), which comprised essential health interventions of RMNCH continuum of care [56], included only two indicators i.e., 'skilled birth attendant' and 'antenatal care coverage' under the domain of maternal and new born care. In contrast, the present study specifically emphasized on maternal health service coverage rather than considering the consolidated RMNCH coverage as studied in the previous literature [19–21, 56, 57].

Different states/UTs/zones in India have performed variedly as far as MHSI scores are concerned. The UTs of Dadra & Nagar Haveli and Chandigarh showed upward transition of MHSI category in both scenarios (I and IV). Dadra & Nagar Haveli transitioned from medium to high category and that of Chandigarh showed low to medium category. This might be likely due to concentrated efforts of respective governments and also partly because these UTs are the front runners or performers in specific SDGs related to poverty, health, quality education and economic growth [45]. The state of Maharashtra and Assam showed an upward transition in both scenarios from medium to high MHSI category, while Jharkhand showed upward transition from low to medium category. Assam and Jharkhand have remarkably improved its maternal health outcomes and have recently been accorded a position of 'achiever' in a health index released by National Institution for Transforming India (NITI) Aayog, which is Indian government's apex think tank [58]. While, the state of Maharashtra is a frontrunner across various dimensions of NITI Aayog's health index. On the other hand, the state of Mizoram and the UT of Puducherry displayed downward transition in both scenarios. This might be due to relatively less coverage on number of indicators like IFA supplementation [59], diabetes screening [52, 60], ANC check-ups and treatment of obstetric complications. Out of the 4 zones, only the west zone transitioned upwards in the reference year from the medium to high MHSI category. The state of Goa and Maharashtra and the UT of Dadra and Nagar Haveli from the west zone performed substantially well, which gave an upsurge in the MHSI scores of the west zone. None of the zones showed downward transition across two time points for both the methodological scenarios. Region/state/UT specific health interventions are required to be undertaken to target low coverage indicators of maternal health for bolstering their performance to achieve positive incremental changes in maternal health outcomes over time.

The present study faces some limitations. Due to limited data availability at sub-national level, the analysis pertains to a short time span of three years (2017-18 to 2019-20), hence inferences need to be drawn with caution. The incremental changes in the maternal health service coverage reflect only the preliminary estimates and therefore should not be used to draw inferences for long term policy purpose. More time series data is required to confirm and substantiate the inferences of these short time series-based results. This leaves a lot of scope for future research to undertake longitudinal analysis concerning the theme of the present study. Though, the composite 'Maternal Health

service Index' computed in the study involves a set of 15 indicators, which is relatively larger than the previous studies, however; data on only one indicator (postpartum check-up) was available and classified under the domain of postnatal care, which makes this domain under-represented for constructing the index. Government of India has initiated a number of schemes especially for nutritional interventions of pregnant and lactating women [61, 62] for antenatal and postnatal care. In this light, besides postpartum check-up, which is a globally recognised indicator [63], data on more indicators like nutritional support, screening for psychological wellbeing after delivery [64] and alike should be disseminated on government portal for better representation of the PNC domain, which is an important food for thought for a revised version of this novel index in future. Although, the study envisioned to examine each and every state as well as union territories, however the two union territories of Daman & Diu and Lakshadweep were excluded from the analysis as they both registered missing values for more than one specific year on a particular maternal health indicator, thereby rendering the standard imputation techniques and extrapolation/ interpolation procedures inapplicable. Nevertheless, the present study has some strong points and strengths to offer. The novel 'Maternal Health Service Coverage Index' envisaged and constructed in the present study is a pioneer attempt to comprehensively quantify the sub-national coverage of maternal health service in India by including within its ambit 15 indicators spread across each of the three domains of antenatal care, intranatal care and postnatal care. No published study has elucidated the measurement of maternal health service coverage in terms of broad spectrum of antenatal, intranatal and postnatal care coverage till date in India, though these domains hold prime importance and are widely valued by the reputed international and national organizations [3, 9, 65]. There is wide scope of usage for this unique 'composite index' as it provides a concise and quantified information of a complex and multifaceted facts representing maternal health service coverage, which makes it easy to communicate and report for the policy purpose [66] at sub-national level in the Indian setting. The study has further mapped and categorized India into different zones, thereby providing a snapshot of low, medium and high maternal health service coverage states/union territories and regions. Furthermore, the study by considering a nationally representing data published by Indian government, have facilitated the comparison of the maternal health service coverage performance at the sub-national level across different time points, which has allowed to identify which states/union territories and regions have transitioned from lower to a higher maternal health service coverage category and vice versa.

Conclusion

Measuring and mapping of maternal health service coverage at sub-national level can have significant policy implications for a developing country like India, which is making rapid strides in healthcare sector transformation. A composite summary measure to reflect the coverage of maternal health service can momentarily help India to identify low coverage maternal health service indicators and recognize lagged zones, thereby warranting the concentrated programmatic and clinical efforts to detect, examine and target specific characteristics of a particular state/UT/region that has significant effect on maternal health service coverage. The accessibility, availability and utilization of quality driven maternal health services are key for survival and wellbeing of both mother and the child. A regular longitudinal and extensive monitoring of the performance of states with regard to essential maternal health services shall induce the country towards achieving the SDG target of improved maternal and child health outcomes.

Abbreviations

ANC:	Antenatal care
CCI:	Composite Coverage Index
CGI:	Coverage Gap Index
DNH:	Dadra & Nagar Haveli
HDI:	Human Development Index
HIV:	Human immunodeficiency Virus
HMIS:	Health Management Information System
IADPSG:	International Association of Diabetes and Pregnancy Study Group
IFA:	Iron Folic Acid
INC:	Intranatal care
JSY:	Janani Suraksha Yojana
MHSI:	Maternal Health Service coverage Index
MoHFW:	Ministry of Health and Family Welfare
NHM:	National Health Mission
NITI:	National Institution for Transforming India
PMCTC:	Prevention of Maternal to Child Transmission
PMMVY:	Pradhan Mantri Matru Vandana Yojana
PMSMA:	Pradhan Mantri Surakshit Matritva Abhiyan
PNC:	Postnatal care
RMNCH:	Reproductive, Maternal, New born and Child Health
RMNCH+A:	Reproductive, Maternal, Newborn, Child and Adolescent Health
SBA:	Skilled Birth Attendant
SDG:	Sustainable Development Goals
UNDP:	United Nations Development Programme
UT:	Union Territories
WHO:	World Health Organization

Declarations

Ethics approval and consent to participate

The study is purely based on secondary data and does not involve any interaction with the participants/human subjects. The data used for the study is freely available and accessible to the general public through the web based HMIS portal, which is maintained by the Indian Ministry of Health and Family Welfare (<https://hmis.nhp.gov.in/>). Therefore, no ethics approvals were required for this study.

The authors assert that all methods carried out in the current study comply with relevant guidelines and regulations.

Consent for publication

Not applicable

Availability of data and materials

The dataset generated and/or analysed during the current study are available in the Mendeley data repository, DOI:10.17632/ngtpyv4zws.1, <https://data.mendeley.com/datasets/ngtpyv4zws/1>.

Competing interest

The authors declared that they have no competing interest.

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Author's contributions

TK & KJ conceived the study. TK, VR and MG contributed in identifying indicators of maternal health service coverage and categorizing the indicators into different domains of maternal health service coverage. KJ & DS extracted the data and rechecked for possible errors in the dataset. KJ & TK performed the data analysis and contributed in the interpretation of the results. KJ prepared the first draft of the manuscript and TK & DS thoroughly revised, conducted its final review and approved the final version of the manuscript. All authors reviewed the manuscript.

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Figures

Figure 1

Different scenarios of the aggregation of domains and subdomains of MHSI

Figure 2

Radar Diagram exhibiting the extent of Maternal health service coverage in India across different zones over the period 2017-2020

Figure 3

Extent of maternal health service coverage and transition of Indian states and Union territories for scenario I and scenario IV.

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