Multi-dimensional health indices in India: A review of literature

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Abstract

The composite indices have been widely used in different fields and different settings to measure and quantify a variety of multidimensional and complex concepts into a single construct. While many composite health indices are produced and applied in developed countries, there are relatively few studies for developing countries, and even considerably less in Asia. However, the indicators of health relevant in high-income countries will not be suitable for use in developing countries such as India due to differences in health system characteristics, differences in disease patterns, and data availability and quality. Therefore, it is important to consider the specific context and characteristics of a country when developing a composite health index to ensure its relevance and usefulness for policy and decision-making. In this paper, we review published studies on the multidimensional composite health indices in India, specifically focusing on the purpose of the index, the indicators chosen to represent population health, methods used in the calculation of the indices, geographical level of aggregation, sources of data, the application and validation of index. While doing so, we also assessed the policy or practical relevance of such indices.
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Keywords: Health index; India; Review; Population measurement

Highlights
- Many composite health indices are produced in developed countries.
- Knowledge gap exists about composite health indices in India.
- This study provides an insight into the existing population health indices in India.
- Data gaps in indicators have mostly governed the spatial scale and domains included in the indices.

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Ethic statement: Not applicable

Introduction

Health is a complex, multidimensional construct, and any attempt to create a health index needs to capture the multidimensional nature of health. Various indicators have been used globally to measure health and they vary from single indicators to multiple indicators. Traditionally, health has been measured using single indicators such as mortality rates, life expectancy, and health-adjusted life expectancy. The main advantage of using these indicators is the availability of data. However, these measures have analytical limitations. Additionally, due to changing health problems (e.g., increase in chronic diseases), their usefulness is also limited in measuring a concept as complex as health. The recent developments in measuring population health status and disease burden include composite health indices which use several mortality and morbidity/disease indicators into a single index. Such composite health indices (CHIs) are useful to make comparisons of health risks within and across populations in different geographical regions, to track progress over time and to monitor effectiveness of health interventions and serve as tools to assist in allocating resources.

While many CHIs are produced and applied in developed countries, there are relatively few studies for developing countries, and even considerably less in Asia (See for a review of literature on health indices). However, the indicators of health relevant in high-income countries will not be suitable for use in developing countries such as India due to differences in health system characteristics (e.g., well-funded, well-established vs limited resources and inadequate health systems), differences in disease patterns (e.g., the burden of communicable and non-communicable diseases), and data availability and quality. Applying the results from such studies may run the ‘risk of exporting failure’ because of different social and cultural context of health and health care in the developing world. As reported by Kaltenthaler et al., (2004) “For such an index to be useful in a health policy context, it is essential that such an index be suitable for needs assessment at community or national level and for monitoring and evaluating changes in health”. Therefore, it is important to consider the specific context and characteristics of a country or sub-national geographical region when developing a composite health index in order to ensure its relevance and usefulness for policy and decision-making.

In this paper, we conducted a literature review of published studies with the aim of providing the development, use and validation of multidimensional composite health indices in India. While reviewing the studies on health indices is of interest, it is particularly important in the Indian context. While India has made a significant progress in improving the health of the population over the last four decades - as reflected in reduction in infant mortality rate (IMR), crude death rate (CDR), crude birth rate (CBR), maternal mortality ratio (MMR) and improvement in life expectancy, - there are still significant regional, geographical, and socioeconomic inequalities in health across multiple axes of caste, class, and gender. Given India’s large
and diverse population, with varying levels of health outcomes across regions and population groups, greater focus on health indices which is sensitive to the many differences in India is needed to identify and address health inequalities. Following the international review of population health indices by Ashraf et al.,² and Kaltenthaler et al.,³ the review specifically focussed on the purpose of the index, the indicators chosen to represent population health, methods used in the calculation of the indices, sources and geographical level of data aggregation, the application and validation of index. While doing so, where possible, we also assessed the policy or practical relevance of such indices.

Methodology

We searched four databases (PubMed, EMBASE and Web of Science, Google Scholar), government sites up to January 2023, using the following search terms and truncations: India and health index* indices* indicator, or child health, or maternal health, or health coverage, or health service, or Sustainable Development Goals (SDGs). The reviewed articles were limited to health outcomes and did not include development index, deprivation index or nutrition indicators only. We also searched the references of the selected articles to find additional studies that were not retrieved in the initial search. We did not apply any restrictions based on the year of publication. We did put restrictions to studies published in English language only.

Findings

Table 1 presents the summary statistics of the composite health indices in India. One of the early attempts of creating health index for India was undertaken by Sekhar et al., (1991).¹⁰ They proposed an index of need for health resources rather than health per se in the Indian states. Their rationale for creating an index of need for health resources was that in India there is a huge inequality in sharing health resources. Hence, it was important to create and use an index of health resources to measure the health needs of the population. The indicators that they used were restricted by their availability, even the seven indicators used were available for 17 of the 22 states, and these data were available for year 1981. The indicators used were homicides per 100 000 population (HOMR), crude death rate (CDR), infant mortality rate (IMR), crude birth rate (CBR), doctors per 1000 population (DOCR), percentage of literates (LITR) based 1981 census and hospital beds per 1000 population (BEDR). The data for their index came from various sources such as police records, Sample Registration System (SRS), State Medical Council data on registered doctors, 1981 Census of India, and other government records. Factor analysis results were used to derive standardized indices which helped to compare quantitatively the health needs of the people of various States. Two factors explained 83% of the total variation. The first factor described as 'proximate determinants', consisted of HOMR, CDR, IMR and CBR, explained most of the variation (67%). The second factor described as 'socio-medical background' consisted of DOCR, LITR and BEDR accounted for some (16%) of the variation in ranking.

While acknowledging the need for creating an index for health resources at the ‘district level’ the authors undertook ‘State’ as the geographical unit of data analysis because of the paucity of data at the district level. They also acknowledged and discussed the need for including many other indicators such as morbidity measures, life expectancy at birth, neonatal and post-neonatal mortality in their calculation for the index, however, they did not include those measures because of the unavailability of data at the state level. Even the researchers’ plans for longitudinal data that would allow a better assessment of the need for health resources and assess the validity of the index were dropped. Yet Sekhar et al.,¹⁰ reiterated that their index could trigger the examination of the cause behind the poor ranking of the states and determining the corrective steps in resource allocation, health services, and awareness about States lagging in health status.

As early as 1994 Satyanarayana et al.,¹¹ developed a comprehensive index, the Index of Child Mortality. The Index was designed for monitoring of health status of children for longitudinal assessment and comparison between states. The five indicators used in the index were focused on different mortality rates, namely, the under-five mortality rate (U5MR), infant mortality rate, neonatal mortality rate (NMR), perinatal mortality rate (PEMR), and stillbirth rate (SBR). The data were obtained from the Sample Registration System (SRS) reports of the Registrar General of India which provide reliable estimates of births and deaths at the State
and the National level.

The data were available for fifteen states of India over the years 1972-1988. Factor Analysis based statistical methodology was used to compute the index. Factor analysis of data on various indicators of child mortality revealed two factors that together explained 78% to 93% of the total variation in different years. The first factor which explained 45.7% to 72.5% of the total variation included indicators of mortality after birth (U5MR, IMR, and NMR) and the second included indicators before and during birth (PEMR and SDR) explained 9.7% to 32.2% of variation. To examine the longitudinal changes in ICM and U5MR, the trend analysis was computed by using ordinary least squares linear regression method after logarithmic (natural) transformation.

While this was a good initiation for development of an index for cross sectional comparison across states and longitudinal monitoring of trends in child health status, many other indicators such as age-appropriate health morbidities, gender-based health inequities, availability, and quality of health service for children could have been included to make the index more reflective of child health. Moreover, the tedious statistical computations prohibited the widespread use of this comprehensive index of child mortality.

A composite index to explain variations in poverty, health, nutritional status and standard of living for different states of India was attempted by Antony and Rao in 2006. This composite index used five sets of indicators namely: demographic status, (e.g., male and female life expectancy in years at birth and at 5 years); socio-economic status (e.g., per capita gross domestic product; percentage of people below the poverty line); health status (e.g., prevalence of contraceptive usage (%), availability of sanitation (%), health services and safe drinking water (%), prevalence of severely and moderately underweight children younger than 4 years; food intake (per consumption unit/day in grams), and nutrients intake (per consumption unit/day and total fat (total calories; total protein)). They also used indices to measure poverty, human development and standard of living. The index was calculated for 14 large states because of availability of data for the same period. Discriminant function analysis and factor analysis were used to assess state ranking based on health inequality and standard of living. The first component which included the intake of cereals, male educational status, infant mortality rate, total fat intake, income, life expectancy at birth, and availability of sanitation facilities accounted for 60% of the variations. The second component included intake of fruits and explained 15% of the variation. Human Development Index (HDI) was used for the purpose of validation. Cohen’s Kappa statistics were calculated for validation and Bland and Altman plot was used to find agreement between the two methods. Primary data from an urban and rural site was used to validate the index.

However, this composite index gives a better indication of development and standard of living rather health per se. Only four health indicators were used in the creation of this index (prevalence of contraceptive usage, availability of sanitation, health services and safe drinking water, and prevalence of severely and moderately underweight children younger than 4 years) and these indicators do not represent different stages of life, difference in morbidity, accessibility and quality of health services, that are associated with health status. The index could have been improved by including the indicators on mortality, morbidity and per capita expenditure, however, due to non-availability of representative data for the same time period, this could not be done.

Health Management Information System (HMIS) (2014-15) score card was one of the first attempts of the Government of India to capture the disparity in the state of reproductive maternal and child health (RMNCHA) within States, districts, sub-districts or blocks in India. The main purpose was to strengthen the health care delivery system to achieve RMNCH strategy’s aims with a focus on adolescents. HMIS composite index was calculated using 16 reproductive, maternal, newborn, child, and adolescent health indicators covering four stages of lifecycle: pre-pregnancy/reproductive age, pregnancy care, childbirth/delivery, post-natal, maternal, and newborn care. The normalized index values of each of the 16 indicators for a district were combined by using an arithmetic average to arrive at an overall composite index for each district. One of the advantages of this index is the availability of data since they come from routinely collected HMIS data base. One can also use the data at smaller geographical levels such as district or block level. However,
evidence suggests HMIS data suffers from poor quality, incompleteness of records and a tendency to overreport the outputs and outcomes.\textsuperscript{14-16}

Anand (2014) created composite indices to measure the extent of inequality in health status and health care services in the two most populous states of India, namely, Uttar Pradesh and Bihar.\textsuperscript{17} Through this index they proposed to define ‘the inter-region and interdistrict variation there for appropriate policy prescription’. They used district level secondary data from Annual Health Survey (2011) and Statistical Diary (2011) on six health status and 5 health infrastructure indicators to compute composite indices for health status and health infrastructure. Health status indicators were crude birth rate, total fertility rate, institutional deliveries, infant mortality rate, and under five-mortality rate. The health infrastructure indicators included number of hospitals per one hundred thousand populations, number of doctors per one hundred populations, number of beds per one hundred populations, number of nurses/paramedical staff per hundred populations. They used Maher’s normalisation technique and principal component analysis to develop weights for the indicators. They also used inequality measures such as co-efficient of variation to measure disparities between the States for overall performance in terms of health attainment. The main advantage of the health index was the use of routinely available data at the district level. However, their choice of indicators was also based on data availability. Many important indicators in terms of achieving better health and health infrastructure such as maternal mortality rate and life expectancy at birth were not included in the study. Additionally, there was the comparability of data issue due to difference in the quality of data coming from different sources.

Meher & Patro (2016) created Composite Health Development Index (CHDI) to highlight the trends and levels of disparities in health status of population at State level.\textsuperscript{18} Using secondary sources of data such as National Family Health Survey (NFHS II and NFHS III), District Level Household Survey (DLHS), Census reports, Sample Registration System (SRS) data, Statistical Abstract of India and Health Statistics data of the states and central governments, they analyzed health status of people, health development programmes and public health services in the 17 major states of India for three different time periods 1998–99, 2005-06, 2009-10.\textsuperscript{18} The indicators forming the index were, (i) infant mortality rate per 1000 live births, (ii) birth rate per 1000 population, (iii) death rate per 1000 population, (iv) maternal mortality rate (MMR) per 100,000 birth delivery, (v) total fertility rate (TFR) of female in the reproductive age group and (vi) life expectancy at birth (LEB) of both males and females.

The index was calculated using the deprivation method as followed by Human Development Report 1990\textsuperscript{19} to the standardised values of the indicators. The states were classified into five groups ranging from ‘highly developed’ to ‘backward’ to highlight the differences in 'health development’ status. Since, the CHDI was computed for three time periods (1998–99, 2004-05 and 2009–10), a trend assessment was also undertaken. They also presented coefficient of variation (CV) value of the composite development indices of these major states for three time periods to find out the trend and level of disparities in the health status of population. One of the major strengths of this was to show the persistence of disparity at the interstate level because of their analysis at three points in time. However, no validation of the computed index was reported. The indicators used to create CHDI assess the status of people’s health and the public health care delivery services largely based on mortality indicators. However, for a more meaningful estimation of differences in health status via a composite index a wider list of indicators could have been chosen, to cover different stages of life, and other socioeconomic determinants of health.

Chauhan et al., (2017) attempted first to assess interstate variations in health-related indicators and then create a composite index (CI) to classify states based on the combined effects of indicators responsible for creating the CI.\textsuperscript{20} The aim of the index was to improve the performance of the health sector of the states to have ‘uniform efficiency level’ throughout the country, thereby accelerate action towards “health for all”. The study used state level secondary data related to health indicators published by the Ministry of Health and Family Welfare, Government of India, and other official sources. The index was based on 26 health-related push and pull indicators covering the States’ demographic (12 indicators), family planning (1 indicator), maternal health care (3 indicators), immunization of children (8 indicators), and health and other infrastructure facilities (2 indicators) (see Table 1). They used a statistical procedure to calculate the
CI similar to the one created by Prem and colleagues (2007). The CI was designed to range from 0 to 1. The states with the value of indices close to “0” were classified as top performers and those close to “1” as bottom performers. While this CI covered many indicators covering child health maternal health as well as health system characteristics, there was no rationale given for including those indicators. Nor was the statistical methodology for creating the CI. They did not use any theory or framework to calculate the CI. While assessing the state level performance of health-related indicators is important for improving the performance of the lagged behind states, however, given the disparities in India occur at smaller levels, their assessment masks the disparities within states.

Prinja et al., (2017), developed a composite universal health care index (CUHCI). The purpose of their study was to develop a methodology to compute a composite index for measuring the extent of universal health coverage (UHC) at the district level. The index was to rank area for availability of affordable health services to all. The index depended primarily on a cross sectional household survey of 275 550 individuals in all the districts of Haryana state in India conducted from 2012 to 2013. The index included only a few indicators from the routine national and sub-national surveys, and the routine health information system. Based on WHO’s framework for UHC, the CUHCI included indicators of three components 1) service coverage (the range of services that are covered), 2) financial coverage (the proportion of the total costs covered through insurance or other risk pooling mechanisms) and 3) population coverage (proportion of the population covered). To account for inequalities across population groups ranked by wealth status, the researchers compared service and financial coverage indicators across different wealth quintiles and education status, religion, caste or social group and occupation.

The focus of CUHCI was to develop methodology to measure and compare preventive and curative services which could be delivered at all levels of the health system. The index was computed using a variety of methods namely, Geometric mean aggregation, standardizing the multi-dimensional indicator values on same scale (0–1), principal component analysis (PCA) and regression methods. The index was validated using a variety of sensitivity and scenario analyses. While CUHCI has many strengths including coverage of indicators based on the list outlined by Government of India and using WHO’s framework, it falls short on measuring the health status of population. Universal health care coverage is an important determinant of health, there are many other indicators which were not included. For example, many social determinants of health were not included. Additionally, the study conducted a survey to collect the data to calculate the index. It was feasible given the index was created for one state. However, replicating the results for other states would be an expensive exercise. The authors have acknowledged the limitations of their measures of quality of care and financial risk protection measurements.

Doke attempted to assess community health status at block level (small administrative areas) in Gadchiroli district of Maharashtra State, using secondary data. He developed comprehensive health index (CHI) for ranking the blocks. The primary purpose for its creation was for Block level comparison of health status, financial allocation, and for focused attention. CHI used data collected from different datasets namely secondary data sources including Census, Survey of Causes of Death scheme, Health Management Information System, Directorate of Economics and Statistics, and Maharashtra Medical Council largely from 2013-14 or prior years. The index used a variety of indicators for different dimensions of health based on consultations with experts. These include indicators associated with health outcome (infant mortality rate, birth rate, sickle cell carrier rate, annual parasite incidence of malaria (API)), health system (doctor population ratio, nurse population ratio, bed population ratio), other health determinants (use of latrine, use of clean fuel for cooking), and health-care utilization (Institutional deliveries). Using Principal component analysis (PCA) the ranking was conducted at block level within the district of Gadchiroli. The PCA extracted three components which were responsible for most of the variations (three components explained 36.72%, 33.675%, and 15.67% of variance respectively). The first factor included API, sickle cell anaemia carrier rate, latrine use, clean fuel use, and institutional deliveries. The second factor included infant mortality rate, doctor population ratio, nurse population ratio, and bed population ratio. The third factor included birth rate. The results of comprehensive score were correlated with urbanization for validating the index-based ranking.
An element that stood out in the creation of CHI was the involvement of a multidisciplinary team and the assessment tools covered the questions about both health and health system. However, reliable block level data was one of the challenges reported by the researcher. Despite the expanded list of indicators using multiple data sources, the index did not include some important health indicators such as new and emerging problems related to different chronic morbidities, data on risk factors, and life expectancy because these data were not available at the block level. Hence, their assessment of community health was restricted due to limited coverage of indicators representing community health. Moreover, the authors gave different weightage to different groups (and sub groups) which could be contested.

In 2019, a health system performance index (HSPI) was undertaken by Sharma et al. (2019) to measure the health system performance at the district level in one of the States of India. The index used the 2007 framework of the World Health Organization (WHO) that identifies six core components or “building blocks” of the health systems: (i) service delivery; (ii) health workforce; (iii) health information systems; (iv) access to essential medicines; (v) financing; and (vi) leadership/governance. In all 70 input and process indicators were collected for the index through a survey which aimed to measure the performance of the health system. These indicators were grouped into 20 subdomains. For a few of the indicators, data was obtained from the Health Management Information System (HMIS), and several others were collected through a community-based household survey for all 21 districts of the State from 2012 to 2015. The survey included 377 public health facilities, interviews with 1762 health care providers, and 833 clients visiting health facilities. ‘Indicators were normalized and aggregated to generate domain-specific and overall composite health system performance index (HSPI) for each district.’

The normalized scores generated for the indicators were subjected to a preference-weighted approach by weighing equally each indicator, subdomain, and domain of the health system. The aggregation was done using the geometric mean approach. The validation of the index was computed using different methods of aggregation of indicators. They also performed several sensitivity analyses to assess robustness of results. The researchers of HSPI have stated that several other indicators could have been included, particularly in the domain of morbidity and mortality rates in the community; indicators of social systems that influence the health system; and private healthcare sector contributions to the health system. As several indicators are collected through especially conducted survey, unlike a routinely conducted survey, the reliability of data cannot be ascertained, and especially undertaken field survey adds additional cost therefore repeating and replicating such an index would be expensive.

NITI Aayog, a Government of India institute for national planning in a recent report titled ‘State Health Index Round 4, 2019-20’ reported a state level health index based on 24 indicators grouped in the domains of health outcomes, governance and information, and key inputs and processes for the large states, 19 indicators for small states and 16 for Union Territories (UTs). Each domain has been assigned weights based on its importance. Within a domain or sub-domain, the weight has been equally distributed among the indicators in that domain or sub-domain. The ranking is at state/ UT level and based on data collected every year. The data source was Sample Registration System (SRS), Family Planning (FP) Division, MOHFW, Health Management Information System (HMIS), RNTCP/NTEP MIS, Ministry of Health and Family Welfare (MoHFW), National Aids Control Organization (NACO), National Family Health Survey (NFHS), State Department of Health Report, Centre National Health Mission (NHM) Finance Data, Centre NHM Finance Data, Civil Registration System (CRS), Integrated Disease Surveillance Project (IDSP). However, large state, small states and UTs have been ranked in separate group. The data for each indicator in the index have been validated through Independent Validation Agencies.

As the index ranks either at the level of the larger states, smaller states or the UTs, it overlooks differences within states and between states/ UTs. The indicators are limited to health outcomes related to Reproductive Child Health (RCH)/ Maternal Child Health (MCH), no attempt is made to include non-communicable diseases, or use of disaggregated data, some indicators are not available for smaller states and UTs therefore are computed based on fewer indicators. The report acknowledges that health care provided by private sector is not captured by the index. The ranking was not validated. The aggregation uses weights based on
expert opinion, followed to by weighted arithmetic average thus the weights can introduce bias.

**Discussion**

This review has attempted to provide an overview of research on development of various health indices that measure a multidimensional health outcome in India. Our review reveals that Indian Health Indices are developed and used for various purposes which vary from measuring health resources to monitor child health status to explain variation in poverty, health, nutritional status and standard of living or to make block-level comparisons, financial allocation or inequity in health coverage. Hence, none of the health indices identified in this review gives a complete picture of health.

Except Prinja, Doke and Sharma who calculated their index using primary data collection, most studies used routinely collected data or data from various surveys. While it is critical for the evaluation and monitoring purposes to use routinely collected data, however the use of State level data masks the intrastate variations. There was little variation in the geographical scale used in the development of the health indices. Few used district level data as the geographical area of aggregation and one at Block level - the rest used State level data. The decision to use bigger geographical unit such as State was based on the pragmatic considerations, such as availability of data. Most often reported challenge has been a lack of data for certain indicators/themes or geographies. In order to address this challenge few researchers have modified the unit of geographical area, for example, Comprehensive Health Index (CHI), and still, others have limited the scope of the Index, other researchers undertook special surveys to fill data gaps, for example, CHI, and CUHCI. Acknowledging the importance of local geography for public policy, it is important to measure the health index at a lower administrative unit such as districts. This is also consistent with the evidence that magnitude and persistence of health inequalities is large when smaller geographical areas are considered as compared to the larger areas.

There was a variation in the way health was measured as well as the indicators used to create health indices. In most cases, some measures of mortality (e.g., infant mortality/child mortality) were used. To function as effective tools to monitor and evaluate health and to give an overall reflection of health, other indicators, which address the complex notion of health, should be incorporated. However, despite the importance of social determinants of health on different measures of health, such as morbidity or duration of illness, only the composite index of health by Antony & Visweswara included social determinants. Moreover, there was little discussion about the choice of indicators to include in creating the health indexes. Indicators were arbitrarily chosen depending upon the availability and without any justification given. Additionally, some indicators were discarded from the construction of the health indices because either they were available in certain States or not found at the required geographical level for the whole nation. This lack of data at a required level of geography hampers meaningful creation of health indices based on publicly available databases.

There is also wide variation in the way weights were assigned to different indicators while combining them into an overall index. Some studies did not give information on weighting, few Indexes had weights assigned through expert judgement, and other studies used a variety of methods to assign weights to the health indicators. For example index of child health, and composite health index for states of India have used factor analysis, a few have used principal component analysis for assigning weights, (for example, CUHCI).

Only few studies validated the indices. In one of the recent studies, multiple approaches have been adopted for computing the index and the internal validity of ranks has been based on different indices produced by different approaches. While NITI Aayog validated the indicator used in the index through Independent Validation Agencies, they did not validate the index State Health Index. Antony et al. validated the index with the Human Development Index. Additionally, except Prinja et al and Sharma there has been a lack of use of theory or conceptual framework in the selection of health indicators which shows that the studies have mainly used the health indices as a statistical tool rather than test out theories of disease or how to promote wellbeing. However, a theoretical or conceptual framework provides a structure to select the
independent indicators representing health, defines the analytical approach, and serve as the guide to discuss
the findings.\textsuperscript{28} Infect, a theoretical or conceptual framework should precede the selection of indicators.\textsuperscript{1} Despite the significance of a conceptual framework in creating a health index, only 7 out of 27 studies in a
scoping review of population health indices had a conceptual foundation guiding the choice of indicators.\textsuperscript{2} Given lack of consensus on the common criteria used to measure health, the usage of conceptual framework
in the selection of indicators gains added significance.

Our literature review has some limitations. First, we may have omitted some papers because of our specific
focus on health. Secondly, we did not include index using only one dimension (e.g., Indian Hunger index).
However, our literature review highlighted areas of improvement that future investigators should pay attention
to for the construction of health indices. We recommend selecting theory-based indicators for measuring
health, utilising data from small areas such as district to acknowledge local geography for public policy and
using routinely and repeatedly collecting data at uniform intervals to track progress over time and monitor
effectiveness of health interventions. We also recommend constructing the validity of the indices by examing
their associations with health outcomes or health inequality measures. One element that stood out in the
literature survey was the unavailability of quality data at small scale such as the district level. As data is the
main determinant of the accuracy and validation of the health indices, we recommend to the policy makers
to fund health data collection on both the processes (e.g., data related to health systems), determinants
of health (e.g., including both protective and risk factors affecting health,) representing different life stages
(e.g, childhood, adult and elderly) as well as the health outcome measures (e.g., morbidity and mortality
measures). Future research should not only develop CHIs using such recommended data but also examine
the use of CHIs to develop a better understanding of which to monitor the progress towards health.

Table 1 Summary of population-based Indian health indices
<table>
<thead>
<tr>
<th>First Author/ Developed by Institution (Year)</th>
<th>Health Vulnerability Index</th>
<th>Spatial unit, Data Type; Data Source</th>
<th>Domains-Indicators</th>
<th>Domains-Indicators</th>
<th>Statistical methodology</th>
<th>Statistical methodology</th>
<th>Major Limitations identified by Author</th>
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<tr>
<td>Sekhar et al. (1991) [10]</td>
<td><strong>Composite Health Index</strong></td>
<td>State; Secondary data; police records for the number of homicides, the Sample Registration System (SRS), the State Medical Councils, the 1981 national census, the hospitals, health centres and nursing homes registered with the government.</td>
<td>Homicides per 100 000 population, Crude death rate, Infant mortality rate, Crude birth rate, Doctors per 1000 population, Percentage of literates based 1981 census, Hospital beds per 1000 population.</td>
<td>Homicides per 100 000 population, Crude death rate, Infant mortality rate, Crude birth rate, Doctors per 1000 population, Percentage of literates based 1981 census, Hospital beds per 1000 population.</td>
<td>Factor analysis. Not Validated.</td>
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<td>Data gaps, indicators were available for 17 out of 22 states. Wherever data was not available, data from nearest year was used.</td>
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<td>Antony et al. (2007) [12]</td>
<td>Composite Index to explain variations in Poverty, Health, Nutritional Status</td>
<td>State; Secondary, data sources included</td>
<td>Demographic: Male and Female life expectancy at birth; birth rate, death rate, maternal mortality rate, infant mortality rate, under five mortality rate, Socio-economic status (per capita GDP, percentage below poverty line, male and female school enrolment ratio, male and female literacy, government expenditure on education, Health status: Availability of proper sanitation facilities, drinking water, underweight in under five year children, contraceptive use), Food intake (per consumption unit/day in grams): cereals, pulses</td>
<td>Demographic: Male and Female life expectancy at birth; birth rate, death rate, maternal mortality rate, infant mortality rate, under five mortality rate, Socio-economic status (per capita GDP, percentage below poverty line, male and female school enrolment ratio, male and female literacy, government expenditure on education, Health status: Availability of proper sanitation facilities, drinking water, underweight in under five year children, contraceptive use), Food intake (per consumption unit/day in grams): cereals, pulses</td>
<td>Factor Analysis. Validated using Human Development Index (HDI) using Cohen’s Kappa statistics.</td>
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<td>Only 14 large states out of 28 states could be undertaken for ranking because of data gaps.</td>
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<tr>
<td>Ministry of Health &amp; Family Welfare (2014) [13]</td>
<td>Composite index (CI)</td>
<td>Districts; HMIS.</td>
<td>16 indicators covering four stages of lifecycle,</td>
<td>16 indicators covering four stages of lifecycle,</td>
<td>Arithmetic mean of standardized indicators.</td>
<td>Arithmetic mean of standardized indicators.</td>
<td>States have been classified into four levels based on quartile of CI score, colour coded as Red – depict very low performance, Pink – Low performing, Yellow – promising and Green – good performance. Not Validated.</td>
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<td>pregnancy/reproductive age:</td>
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<td>Post-partum sterilization against total female sterilization, Male sterilization to total sterilization conducted, IUCD insertions to all family planning methods,</td>
<td>Post-partum sterilization against total female sterilization, Male sterilization to total sterilization conducted, IUCD insertions to all family planning methods,</td>
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<td>pregnancy care: 1st Trimester registration to total ANC registration, Pregnant women received 3 ANC check-ups to total ANC registration, Pregnant women given 100 IFA to total ANC registration, Cases of pregnant women with Obstetric Complications attended to reported deliveries, Pregnant women receiving</td>
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<td>Anand (2014) [17]</td>
<td>Composite Indices of Health Status and Health Services</td>
<td>Districts of two states; Secondary data from Annual Health Survey (2011) and Statistical Diary (2011), Shankhikya Patrika (2010-2011), Uttar Pradesh Planning Commission and Bihar Statistical Handbook (2010-2011).</td>
<td>Crude birth rate, Total fertility rate, Institutional deliveries, Crude death rate, Infant mortality rate, Under five mortality rate, Number of hospitals per lakh population, Number of Primary Health Care facilities per lakh population, Number of doctors per lakh populations, Number of beds per lakh populations, Number of nurses/paramedical staff per lakh populations, Primary health centers.</td>
<td>Crude birth rate, Total fertility rate, Institutional deliveries, Crude death rate, Infant mortality rate, Under five mortality rate, Number of hospitals per lakh population, Number of Primary Health Care facilities per lakh population, Number of doctors per lakh populations, Number of beds per lakh populations, Number of nurses/paramedical staff per lakh populations, Primary health centers.</td>
<td>Maher's normalization technique and principal component analysis. Districts, have been classified into five levels of development, very high, high, average, very low and low. Not Validated.</td>
<td>Non-availability of data for indicators such as maternal mortality rate and life expectancy at birth, inconsistency across data from different sources make it difficult to jointly use data.</td>
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<td>Meher et al. (2014) [18]</td>
<td>Composite Health Development Index (CHDI)</td>
<td>State; Secondary data published by the Government of India, National family health survey (NFHS-II, 1998–99 &amp; NFHS-III, 2005–06), and Office of Registrar General, India, Special bulletin on maternal mortality in India 2007–09, Abridged life tables 2002–06, Sample registration system (SRS reports different years), Statistical report 2005 &amp; 2008.</td>
<td>Infant mortality rate per 1000 live births, birth rate per 1000 population, death rate per 1000 population, maternal mortality rate per 1000 birth delivery, total fertility rate of female in the reproductive age group and 6. life expectancy at birth of both males and females.</td>
<td>Infant mortality rate per 1000 live births, birth rate per 1000 population, death rate per 1000 population, maternal mortality rate per 1000 birth delivery, total fertility rate of female in the reproductive age group and 6. life expectancy at birth of both males and females.</td>
<td>Arithmetic mean of standardized indicators, deprivation method was followed to compute the index. Not Validated.</td>
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Limited number of health outcomes were included in the index.
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<tr>
<td>Chauhan et al. (2017) [20] Composite Index</td>
<td>State; Secondary data published by the Ministry of Health and Family Welfare, Government of India, and other official sources.</td>
<td>26 health-related indicators related to demographics: share of slum population to urban population, population density, population growth rate, total literacy rate, female literacy rate, population sex ratio, child sex ratio, dependency ratio, total fertility rate, crude birth rate, crude death rate and infant mortality rate, family planning: (contraceptive method), maternal health care (% Tetanus expectant mothers, IFA full course, % of institutional delivery), immunization of children: including TT 10 year, prophylaxis against blindness,</td>
<td>26 health-related indicators related to demographics: share of slum population to urban population, population density, population growth rate, total literacy rate, female literacy rate, population sex ratio, child sex ratio, dependency ratio, total fertility rate, crude birth rate, crude death rate and infant mortality rate, family planning: (contraceptive method), maternal health care (% Tetanus expectant mothers, IFA full course, % of institutional delivery), immunization of children: including TT 10 year, prophylaxis against blindness,</td>
<td>Standardized indicators were aggregated into an index by statistical method proposed by Prem N et al. [21]. Not Validated.</td>
<td>Standardized indicators were aggregated into an index by statistical method proposed by Prem N et al. [21]. Not Validated.</td>
<td>Limited number of indicators to account for different critical stages of life and aspects of health such as mental health</td>
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<td>Prinja et al. (2017) [22]</td>
<td>Composite Universal Health care Coverage Index (CUHCI)</td>
<td>District; Primary data collection, cross section survey of 51656 households across all districts the state.</td>
<td>Maternal and Child Health Iron and folic Acid, TT (2 injection), &gt; 3 Antenatal check-ups, Institutional delivery, Postnatal care, Full immunization, ORS use rate</td>
<td>Maternal and Child Health Iron and folic Acid, TT (2 injection), &gt; 3 Antenatal check-ups, Institutional delivery, Postnatal care, Full immunization, ORS use rate</td>
<td>Multiple approaches were used for aggregation of indicators by geometric mean, principal component analysis, and regression models. The index was generated by different statistical approaches and correlation between these indices was used for validation.</td>
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<td>Data gaps were noted on coverage of ART, treatment of HIV, coverage of palliative care, social determinants, catastrophic expenditure, quality of health care provided.</td>
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Doke (2018) used Comprehensive Health Index to assess vulnerability. The index includes data from various secondary sources including Census, Survey of Cause of Death scheme, Health Management Information System, Directorate of Economics and Statistics, and Maharashtra Medical Council. Data was largely from 2013-14 or prior years. Special survey was conducted (preferred health-care provider, drug addiction). Interactions with key informants (morbidity and mortality experiences, functioning of public and private health...
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<td>Sharma et al. (2019) [24] Health system performance index (HSPI).</td>
<td>Health system</td>
<td>District; Primary data was collected through a community-based survey and Secondary data from HMIS.</td>
<td>Health system outputs: Primary care coverage; Curative care utilization; Equity in health financing; Efficiency and equity in service delivery.</td>
<td>Health system outputs: Primary care coverage; Curative care utilization; Equity in health financing; Efficiency and equity in service delivery.</td>
<td>Value of indicators was normalized and aggregated using geometric mean approach, to generate domain-specific and overall index. The index was generated by three different statistical approaches and for validation correlation of index generated using these approaches was computed.</td>
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<td>Data gaps in different domains (morbidity and mortality rates in the community, social systems that influence health system, Information on private health care sector).</td>
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<td>NITI Aayog, (2022) [25]</td>
<td>State Health Index</td>
<td>State; State Department of Health, Health Management Information System (HMS), National Tuberculosis Control Programme (RNTCP), National Family Health Survey (NFHS), Centre NHM Finance Data, Reserve Bank of India (RBI) Reports, reports of Ministry of Health &amp; Family Welfare (MoHFW)-Government of India, Civil Registration System, Integrated Disease Surveillance Project (IDSP).</td>
<td>Upto 24 indicators grouped in the domains of health outcomes: Neonatal Mortality Rate, Under-five Mortality Rate, Sex Ratio at Birth, Maternal Mortality Ratio, Modern Contraceptive Prevalence Rate, Full immunization coverage, Proportion of ANCs registered within first trimester against total registrations, Proportion of pregnant women who received 4 or more ANC, Proportion of institutional deliveries, Total case notification of tuberculosis (TB).</td>
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<td>Weighted Average of Standardized indicators. Weights determined by technical expert opinion. Data validated, however Index not validated.</td>
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<td>Non availability of data for infectious diseases, non-communicable diseases, mental health, governance, and financial risk protection, private-sector data on health services. In smaller states and UTs the index was calculated without several indicators because of unavailability of data for several indicators.</td>
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