

Original Research Article

Regional health inequalities in Karnataka: translating NFHS-5 evidence into better district health planning

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ABSTRACT

Background: Karnataka, one of India's most socio-economically diverse states, exhibits considerable regional inequalities in health outcomes. Northern districts consistently lag behind southern districts in socio-demographic development and maternal and reproductive health indicators. These inequalities reflect the effectiveness of local policy implementation. The study assesses district and regional-level inequalities in socio-demographic and maternal and reproductive health indicators across Karnataka and identify priority districts for targeted health planning and resource allocation.

Methods: District-level data from National Family Health Survey (NFHS-5) (2019-21) were analyzed. Indicators were aggregated into four administrative divisions using weighted averages. Composite Health Index (CHI) scores were calculated for socio-demographic and maternal and reproductive health dimensions. Regional inequalities were examined using descriptive statistics, quartile deviation, and district-level rankings, and spatial mapping in QGIS.

Results: Districts with higher female education, improved sanitation, access to clean cooking fuel, and health insurance coverage achieved higher socio-demographic CHI scores and better maternal and reproductive health outcomes. Northern districts, including Kalaburagi, Yadgir, Raichur, Koppal, and Vijayapura recorded comparatively lower CHI scores, while southern districts performed better across most indicators. Significant intra-divisional variation highlighted substantial inequalities within administrative regions.

Conclusions: Persistent regional inequalities in Karnataka are driven by adverse social determinants of health and unequal access to maternal healthcare services. Region-specific interventions focusing on female education, sanitation, gender equity, and strengthened maternal health services are essential to reduce inequalities and improve maternal and reproductive health outcomes across the state.

Keywords: Composite health index, Karnataka, Maternal health, NFHS-5, Regional inequalities, Socio-demographic indicators

INTRODUCTION

Karnataka, one of India's most socio-economically diverse states, exhibits substantial regional inequalities in health outcomes, with wide variations observed across districts and regions.¹ These inequalities stem from a complex interplay of factors, including socio-economic inequality, uneven health infrastructure, difference in educational attainment, and variations in local governance

and policy implementation, shaped by historical development patterns and administrative capacity.^{2,3} Districts with better transport connectivity, higher urbanization, better institutions in place, and easier access to public and private health facilities generally demonstrate better health and social indicators.^{1,4} In contrast, less developed districts particularly in northern and northeastern parts of Karnataka continue to face inadequate infrastructure, shortages of skilled health

personnel, weak service delivery, and limited resources, thereby reinforcing inter-district inequalities.^{5,6} Although Karnataka has achieved measurable improvements in overall health indicators, these gains have been unevenly distributed across regions, resulting in persistent inter-regional inequalities.⁷ These differences reflect not only economic inequality but also uneven allocation of resources, infrastructure, and policy implementation.⁸ Administratively divided into regions such as Bengaluru, Mysuru, Belagavi, and Kalaburagi, the state exhibits distinct socio-economic, cultural, and infrastructural characteristics.⁹ Region-wise analyses consistently show sharper advantages in southern divisions particularly Bengaluru and Mysuru which benefit from stronger health infrastructure, higher institutional deliveries, better availability of skilled health personnel, and greater utilization of maternal and child health services, supported by higher urbanization, better connectivity, and sustained public and private investments.¹⁰⁻¹³ These factors contribute to lower maternal and infant mortality in the south.⁷ In contrast, northern divisions such as Kalaburagi and Belagavi continue to experience poorer health outcomes due to historical neglect, weaker administrative capacity, delayed socio-economic development, and inadequate staff and equipped public health facilities, resulting in limited access to antenatal care, emergency obstetric services, and child immunization.^{8,10,14,15} Financial protection through health insurance also shows marked regional inequalities in Karnataka. Families in southern regions are more likely to be covered under public or private schemes, while coverage remains low in northern areas due to limited awareness, administrative barriers, and socio-economic vulnerability.¹⁶⁻¹⁸ Women in less developed regions face difficulties accessing institutional deliveries, skilled birth attendants, and essential maternal healthcare.¹³ Inadequate public health facilities and shortages of medicines and diagnostics often lead to higher out-of-pocket expenditures, especially in economically backward districts.¹⁹ Socio-demographic factors, particularly female education, strongly influence health-seeking behavior and outcomes, with districts having higher female literacy showing greater utilization of antenatal, skilled birth, and postnatal care, along with lower fertility and mortality rates.^{20,21} Understanding the link between education and regional background is therefore crucial for explaining uneven health progress across Karnataka.²²

In northern Karnataka, district-level analysis reveals significant inequalities. High-burden districts such as Kalaburagi, Yadgir, Raichur, and Koppal exhibit low female literacy, poor health infrastructure, and suboptimal maternal and child health outcomes, with women facing barriers like long distances to facilities, limited transport, and shortage of skilled birth attendants, affecting antenatal care and institutional deliveries.^{7,13,14} In contrast, districts like Dharwad and Belagavi show moderate improvements, highlighting the role of governance, urbanization, and education in shaping health

outcomes.¹⁷ Similar intra-division disparities exist in southern Karnataka, in Bengaluru division; Bengaluru Urban and Rural outperform peripheral districts, while in Mysuru division; Mysuru and Mandya perform better than relatively less developed districts such as Chamarajanagar, where tribal populations and geographical constraints limit healthcare access.^{9,13}

The study aimed to assess district and regional-level inequalities in socio-demographic and maternal and reproductive health indicators across Karnataka and identify priority districts for targeted health planning and resource allocation.

METHODS

Data source

This study utilized secondary data obtained from the district fact sheets of the National Family Health Survey-5 (NFHS-5), available from the official NFHS website (www.nfhsiips.in). NFHS-5 was conducted during 2019-21, by the International Institute for Population Sciences (IIPS), Mumbai, under the guidance of the Ministry of Health and Family Welfare (MoHFW), Government of India. NFHS is a large-scale, nationally representative household survey that provides comprehensive information on population, health, nutrition, and socio-economic characteristics at the national, state and district levels. The survey includes key indicators related to fertility, reproductive and child health, nutritional status, anemia, and utilization of health inequalities, making it an important source for examining regional and district-level inequalities in Karnataka. Although NFHS-6 fact sheets have recently been released, the corresponding unit-level data are not yet publicly available for research purposes. Therefore, NFHS-5 remains the most recent publicly accessible and appropriate data source for the present analysis.

Data variables

The study considered the following health related indicators.

Positive indicators: birth registration among children under five years of age; households with access to improved sanitation facilities; households using clean fuel for cooking; household members covered under any health insurance or health financing scheme; women with ten or more years of schooling; mothers who received antenatal care (ANC) during the first trimester and completed four or more ANC visits; institutional births; and institutional births conducted in public health facilities.

Negative indicators: women aged 20–24 years who were married before attaining 18 years of age; total unmet need for family planning; and unmet need for spacing. Since higher values of these indicators reflect poorer health

outcomes, they were reverse normalized during the construction of the composite health index (CHI).

Data analysis

Descriptive statistical techniques were employed to examine district-level variations in selected health indicators across Karnataka. Initially, district-level estimates were aggregated to the state's four revenue divisions using weighted average to assess inter-divisional inequalities. Regional inequalities were further examined using measures of dispersion, including range and quartile deviation. To assess overall district-level health performance, a CHI was constructed by combining multiple health indicators into a single summary measure. All indicators were first normalized using the min-max normalization method to eliminate differences in measurement scales. Subsequently, equal weights were assigned to all indicators, and the CHI for each district was calculated as a weighted average of the normalized indicator values, with each indicator receiving an identical weight. Districts were then ranked according to their CHI scores, enabling comparative assessment of overall health performance.

Positive indicators were normalized as: (where higher is better)

$$X' = \frac{X - X_{\min}}{X_{\max} - X_{\min}}$$

Whereas; negative indicators were normalized as: (where lower is better)

$$X' = \frac{X_{\max} - X}{X_{\max} - X_{\min}}$$

In the CHI formula:

$$CHI = \frac{\sum_{i=1}^n Xi'}{n}$$

The symbol i is an index that represents each indicator included in the CHI, Xi' = normalized value of the i^{th} indicator., $i = 1, 2, 3, \dots, n$, n = total number of health indicators considered.

Further, quartile deviation was used to examine the dispersion of CHI scores across the 30 districts of Karnataka and to classify their relative performance. Quartile deviation, defined as half of the interquartile range i.e. $(Q3-Q1)/2$, was employed as a robust measure of variability because it is less sensitive to extreme values than other measures of dispersion. Following the computation of CHI scores, the first quartile ($Q1$), median or second quartile ($Q2$), and third quartile ($Q3$) were determined. Based on these quartile cut-off points; districts were classified into four performance categories: 1) low performing (CHI score $\leq Q1$), 2) moderately low

performing (CHI score $>Q1$ to $\leq Q2$), 3) moderately high performing (CHI score $>Q2$ to $\leq Q3$) and 4) high performing (CHI score $>Q3$)

The Composite Health Index was developed not only as a measure of overall health performance but also as a planning tool for identifying districts requiring priority interventions. District rankings and performance categories were used to identify areas requiring varying levels of policy attention and resource allocation. This approach facilitates evidence-based decision making and supports decentralized health planning under state and national health programs. For geographical comparison and visualization of spatial inequalities, thematic maps were generated using QGIS software, and divisional comparison charts were prepared to illustrate variations in health performance across Karnataka's revenue divisions.

RESULTS

The health and development status of districts in Karnataka varies considerably due to differences in socio-demographic and maternal health characteristics. To assess these inequalities, CHI scores were calculated separately for socio-demographic and maternal and reproductive health indicators. Socio-demographic CHI reflects factors such as education, living conditions, and population characteristics, while the maternal and reproductive health CHI captures variations in access to antenatal care, institutional deliveries, and maternal health services across districts.

Inter-district and regional socio-demographic inequalities

Table 1 presents district wise inequalities in socio-demographic indicators and corresponding CHI scores. Higher CHI scores were consistently associated with better socio-demographic conditions, including improved sanitation, clean fuel use, health insurance coverage, and female education.

For instance, Udupi and Dakshina Kannada characterized by high sanitation coverage ($>90\%$), low prevalence of early marriage ($<5\%$), and higher levels of female education, recorded the highest CHI scores (0.82). In contrast, Yadgir recorded the lowest CHI score (0.09), reflecting poor sanitation (37%), low clean fuel use (49%), limited health insurance coverage (17%), low female education (26%), and a high prevalence of early marriage (33%).

Similarly, Raichur (CHI=0.21) and Vijayapura (CHI=0.23) also exhibited lower scores, corresponding to less favorable socio-demographic conditions. Overall, the findings indicate a strong positive association between socio-demographic development and CHI scores across districts in Karnataka.

Table 1: Distribution of socio-demographic indicators along with CHI scores by district in Karnataka.

Districts	Birth registration (%)	Women married <18years (%)	Improved sanitation ² (%)	Clean fuel usage ³ (%)	Health insurance coverage (%)	Women with ≥10yrs schooling (%)	CHI score (socio-demographic indicators)
Bellary	96.91	22.23	64.13	76.19	25.66	39.92	0.47
Bidar	97.89	19.24	56.50	65.15	21.44	44.98	0.44
Gulbarga [@]	97.02	29.84	36.53	58.52	17.36	42.03	0.27
Koppal	95.07	27.06	58.79	47.39	20.62	34.36	0.26
Raichur	88.73	21.90	53.02	64.92	17.75	31.67	0.21
Yadgir	92.69	33.19	37.37	48.79	16.74	26.43	0.09
Kalaburagi division	94.72*	25.26	51.25	62.12	20.22	37.57	
Uttara Kannada	99.20	11.59	89.61	73.42	32.02	49.18	0.68
Dharwad	99.67	17.78	79.32	79.05	24.48	51.36	0.62
Haveri	98.55	16.54	68.87	60.67	28.77	39.99	0.50
Belgaum	96.55	32.80	67.67	74.82	20.72	47.80	0.43
Gadag	99.73	27.69	55.20	56.27	28.27	45.12	0.43
Bagalkot	97.75	38.72	51.29	56.64	22.29	37.71	0.28
Bijapur [@]	95.47	39.24	44.84	60.61	21.20	37.13	0.23
Belagavi division	98.13*	28.66	64.75	67.89	23.88	44.42	
Bangalore	99.33	14.47	90.41	97.20	28.83	70.05	0.82
Ramanagara	100.00	11.81	89.63	91.98	35.71	54.45	0.79
Bangalore rural	99.01	14.11	88.80	93.56	34.88	56.30	0.77
Kolar	99.59	26.69	89.22	89.92	33.89	55.01	0.70
Shimoga	100.00	11.08	85.44	85.65	26.54	49.06	0.70
Tumkur	98.73	24.80	86.14	85.26	30.95	58.92	0.67
Chitradurga	99.50	20.69	63.05	80.59	35.33	48.28	0.61
Chikkaballapura	97.60	27.06	84.91	89.35	26.12	47.96	0.59
Davanagere	96.97	19.10	83.28	79.07	25.22	47.07	0.57
Bengaluru division	98.97*	17.33	86.87	91.55	29.75	60.96	
Udupi	98.52	4.41	94.45	67.77	50.87	55.42	0.82
Dakshina Kannada	97.78	4.89	97.10	82.04	36.29	62.79	0.82
Mandya	100.00	13.13	86.67	90.48	39.94	52.54	0.79
Kodagu	97.21	12.83	93.86	78.32	45.63	58.86	0.78
Hassan	98.41	16.15	87.87	86.13	36.89	51.26	0.72
Mysore	99.63	17.50	86.44	94.73	26.24	49.64	0.70
Chamarajanagar	100.00	19.29	75.16	88.96	34.37	41.69	0.65
Chikmagalur	98.48	19.48	92.31	78.97	29.97	48.32	0.65
Mysuru division	98.75*	13.35	89.20	85.69	35.46	52.76	

Source: National Family Health Survey (NFHS-5), 2019-21 district factsheets. Note: ²Flush to piped sewer system, flush to septic tank, flush to pit latrine, flush to don't know where, ventilated improved pit (VIP)/biogas latrine, pit latrine with slab, twin pit/composting toilet, which is not shared with any other household. This indicator does not denote access to toilet facility completely. ³Electricity, LPG/natural gas, biogas. *Unweighted averages. @ Gulbarga & Bijapur officially renamed as Kalaburagi and Vijayapura; respectively

The Figure 1 compares key socio-demographic indicators across the four divisions of Karnataka - Kalaburagi, Belagavi, Bengaluru, and Mysuru and highlights clear regional inequalities in development. Birth registration is consistently high (95-100%) across all divisions, indicating widespread awareness and institutional coverage. Health insurance coverage is lowest in Kalaburagi (20%) and higher in Bengaluru and Mysuru (30-35%), with Belagavi at an intermediate level. Improved sanitation ranges from about 51% in

Kalaburagi to nearly 90% in Bengaluru and Mysuru, while clean fuel usage is highest in Bengaluru (92%) and lowest in Kalaburagi (62%). Women's educational attainment (≥10 years of schooling) is higher in Bengaluru and Mysuru but remains low in Kalaburagi, reflecting persistent educational and gender inequalities. In contrast, child marriage is more prevalent in Kalaburagi (25%) and Belagavi (29%) than in Bengaluru (17%) and Mysuru (13%). Overall, the figure underscores substantial regional inequalities and highlights the need for targeted interventions, particularly in Kalaburagi.

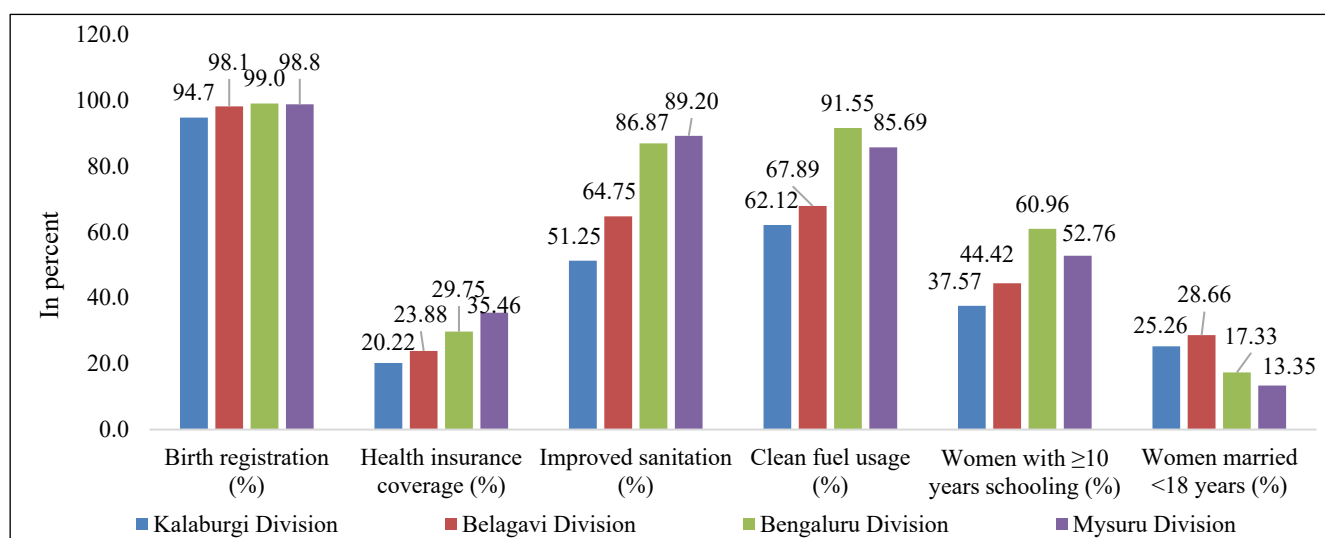


Figure 1: Regional comparison of socio-demographic indicators.

Inter-district and regional maternal and reproductive health inequalities

The comparison of maternal and reproductive health indicators with CHI scores in Table 2 demonstrates a strong association between higher maternal healthcare service coverage, lower unmet need for family planning, and better CHI performance across Karnataka districts. Districts with high coverage of first-trimester ANC, ≥ 4 ANC visits, and institutional births, along with lower unmet need for family planning, consistently achieved higher CHI scores.

For instance, Chamarajanagar recorded high first-trimester ANC (83%), ≥ 4 ANC visits (84%) and

institutional births (100%), and low total unmet need (3%), corresponding to the highest CHI score (0.91). Similar patterns were observed in Chikkaballapura (CHI: 0.91) and Mandya (CHI: 0.87), where early ANC exceeded 82%, institutional births were nearly universal, and unmet need remained below 4%. In contrast, Kalaburagi, with lower first-trimester ANC (59%), ≥ 4 ANC visits (54%), institutional births (89%), and higher total unmet need (13%), recorded a low CHI score (0.18), while Koppal (0.22) and Raichur (0.28) showed similar trends. Overall, districts with better maternal healthcare utilization and lower family planning unmet need consistently reported higher CHI scores, underscoring the importance of timely and comprehensive maternal and reproductive healthcare in improving health outcomes across Karnataka.

Table 2: Distribution of maternal and reproductive health indicators along with CHI scores by district in Karnataka.

Districts	ANC in 1 st trimester (%)	≥ 4 ANC visits (%)	Institutional births (%)	Institutional births in public facility (%)	Total unmet need ⁷ (%)	Unmet need for spacing ⁷ (%)	CHI Score (maternal and reproductive health indicators)
Bellary	67.47	56.36	95.74	76.79	5.63	2.91	0.59
Bidar	62.72	55.27	98.98	73.42	8.13	3.64	0.53
Yadgir	57.41	63.59	93.34	73.36	7.47	5.90	0.40
Raichur	66.39	67.45	88.93	64.43	9.98	6.82	0.28
Koppal	52.41	50.67	90.74	68.15	9.71	6.02	0.22
Gulbarga [@]	59.31	53.63	88.66	60.52	12.60	5.28	0.18
Kalaburagi division	61.80	57.57	92.57	69.05	9.02	4.93	
Dharwad	78.74	85.21	99.69	69.19	6.32	3.75	0.75
Belgaum	71.19	63.74	97.52	60.63	5.51	2.06	0.63
Uttara Kannada	80.39	57.88	99.27	69.48	7.36	3.70	0.62
Haveri	73.30	58.65	97.17	82.57	8.38	3.51	0.60
Bagalkot	78.17	76.21	95.20	57.05	5.84	4.04	0.60
Gadag	52.56	68.68	96.19	67.48	7.03	3.82	0.50
Bijapur [@]	60.27	56.37	91.75	59.59	6.97	4.02	0.38
Belagavi division	71.13	66.23	96.64	64.67	6.46	3.26	

Continued.

Districts	ANC in 1 st trimester (%)	≥4 ANC visits (%)	Institutional births (%)	Institutional births in public facility (%)	Total unmet need ⁷ (%)	Unmet need for spacing ⁷ (%)	CHI Score (maternal and reproductive health indicators)
Chikkaballapura	82.60	90.52	98.97	83.02	3.78	2.62	0.91
Ramanagara	91.84	88.74	100.00	68.78	5.06	3.05	0.87
Kolar	78.03	90.91	99.60	76.14	5.12	3.54	0.82
Bangalore rural	81.82	90.92	100.00	72.04	5.90	4.05	0.80
Bangalore	75.34	74.60	99.34	54.71	4.72	2.99	0.68
Tumkur	68.58	80.35	100.00	66.86	5.34	4.37	0.68
Chitradurga	66.27	79.32	98.32	68.83	5.00	3.50	0.68
Shimoga	58.71	79.43	99.66	74.06	5.26	3.87	0.67
Davanagere	62.99	63.05	98.31	68.87	11.46	4.82	0.44
Bengaluru division	73.42	78.02	99.34	63.39	5.40	3.43	
Chamarajanagar	83.18	84.11	100.00	82.65	3.38	2.56	0.91
Mandya	85.56	90.07	99.45	60.19	3.75	1.90	0.87
Hassan	67.63	75.77	100.00	71.70	5.22	1.77	0.76
Chikmagalur	69.50	74.30	98.39	77.85	3.83	2.81	0.75
Kodagu	70.56	74.36	98.43	73.31	5.55	2.22	0.73
Mysore	82.02	85.74	100.00	56.17	5.57	4.43	0.71
Dakshina Kannada	86.14	82.00	100.00	41.85	9.54	6.62	0.52
Udupi	75.13	59.40	98.88	37.60	7.08	4.69	0.45
Mysuru division	79.13	80.14	99.61	59.15	5.79	3.75	

Source: National Family Health Survey (NFHS-5), 2019-21 district factsheets. Note:⁷Unmet need for family planning refers to fecund women who are not using contraception, but who wish to postpone the next birth (spacing) or stop childbearing altogether (limiting). Specifically, women are considered to have unmet need for spacing if they are: 1) at risk of becoming pregnant, not using contraception, and either do not want to become pregnant within the next two years, or are unsure if or when they want to become pregnant. 2) Pregnant with a mistimed pregnancy. 3) Postpartum amenorrhoeic for up to two years following a mistimed birth and not using contraception. @Gulbarga and Bijapur officially renamed as Kalaburagi and Vijayapura; respectively

Figure 2 illustrates regional differences in maternal and reproductive health indicators across the four divisions of Karnataka. First-trimester antenatal care (ANC) is lowest in Kalaburagi (62%) and higher in Belagavi (71%), Bengaluru (73%), and Mysuru (79%). Similarly, the proportion of women receiving ≥4 ANC visits increase from 58% in Kalaburagi to 66% in Belagavi, (78%) in Bengaluru, and (80%) in Mysuru. Institutional births remain consistently high across all regions (93-100%). However, institutional births in public health facilities decline from (69%) in Kalaburagi to (65%) in Belagavi, (63%) in Bengaluru and (59%) in Mysuru, indicating greater reliance on private facilities in the more developed regions. Total unmet need for family planning is highest in Kalaburagi (9%) and lowest in Bengaluru (5%), while unmet need for spacing is also highest in Kalaburagi (5%). Overall, Bengaluru and Mysuru perform better maternal and reproductive health performance, whereas Kalaburagi continues to lag behind.

District-wise performance and ranking across socio-demographic and maternal and reproductive health indicators

Table 3 summarizes the district-level performance and ranking based on CHI scores across the socio-

demographic and maternal and reproductive health dimensions in Karnataka. The findings reveal substantial inter-district variation, with southern districts consistently performing better than northern districts.

In the socio-demographic dimension, Udupi, Bengaluru and Dakshina Kannada (0.82 each) followed by Ramanagara and Mandya (0.79 each), are the highest performing districts, whereas Yadgir (0.09), Raichur (0.21), Vijayapura (0.23), Koppal (0.26) and Kalaburagi (0.27) record the lowest scores. In the maternal and reproductive health dimension, Chikkaballapura and Chamarajanagar (0.91 each) rank highest, followed by Mandya and Ramanagara (0.87 each) and Kolar (0.82), while Kalaburagi (0.18), Koppal (0.22), Raichur (0.28), Vijayapura (0.38) and Yadgir (0.40) remain at the bottom. Based on the combined CHI scores, Ramanagara and Mandya (0.83 each) rank first, followed by Bengaluru Rural and Chamarajanagar (0.78 each) and Kolar (0.76), whereas Kalaburagi (0.22), Koppal (0.24), Raichur and Yadgir (0.25 each), and Vijayapura (0.30) occupy the bottom ranks. Overall, districts with stronger socio-demographic performance tend to achieve better maternal and reproductive health outcomes, highlighting persistent regional inequalities between southern and northern Karnataka.

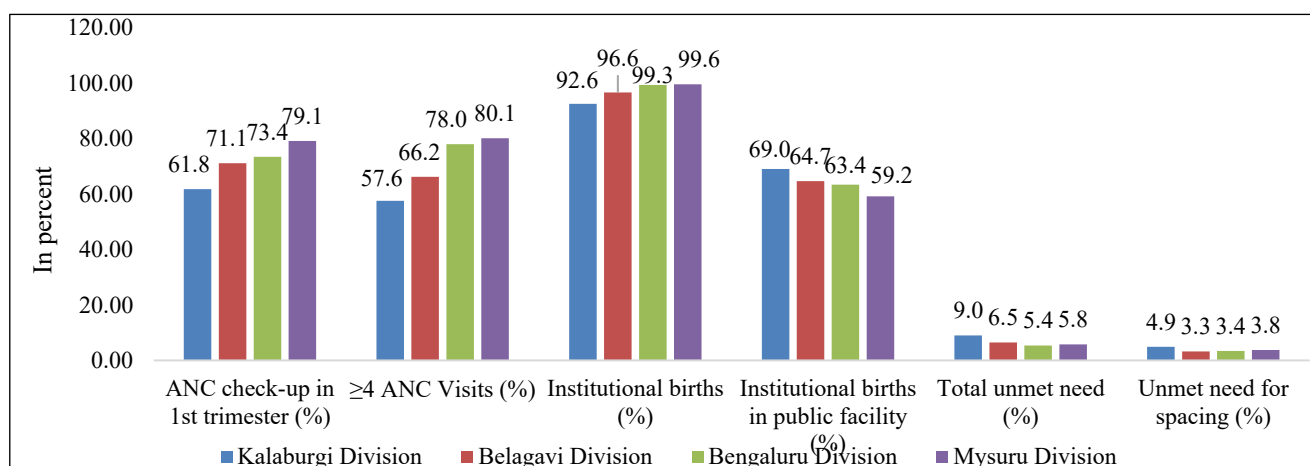


Figure 2: Regional comparison of maternal and reproductive health indicators.

Table 3: District-level performance and ranking of composite health index scores across socio-demographic and maternal and reproductive health indicators in Karnataka.

Districts	Socio-demographic		Maternal and reproductive health		Combined	
	CHI score	Rank	CHI score	Rank	CHI score	Rank
Ramanagara	0.79	4*	0.87	4*	0.83	1*
Mandya	0.79	5*	0.87	3*	0.83	2*
Bangalore rural	0.77	7	0.80	6	0.78	3*
Chamarajanagar	0.65	14	0.91	2*	0.78	4*
Kolar	0.70	9	0.82	5*	0.76	5*
Kodagu	0.78	6	0.73	10	0.75	6
Bangalore	0.82	2*	0.68	12	0.75	7
Chikkaballapura	0.59	18	0.91	1*	0.75	8
Hassan	0.72	8	0.76	7	0.74	9
Mysore	0.70	11	0.71	11	0.70	10
Chikmagalur	0.65	15	0.75	8	0.70	11
Shimoga	0.70	10	0.67	15	0.68	12
Dharwad	0.62	16	0.75	9	0.68	13
Tumkur	0.67	13	0.68	14	0.68	14
Dakshina Kannada	0.82	3*	0.52	22	0.67	15
Uttara Kannada	0.68	12	0.62	17	0.65	16
Chitradurga	0.61	17	0.68	13	0.64	17
Udupi	0.82	1*	0.45	24	0.63	18
Haveri	0.50	20	0.60	18	0.55	19
Bellary	0.47	21	0.59	20	0.53	20
Belgaum	0.43	24	0.63	16	0.53	21
Davanagere	0.57	19	0.44	25	0.51	22
Bidar	0.44	22	0.53	21	0.49	23
Gadag	0.43	23	0.50	23	0.46	24
Bagalkot	0.28	25	0.60	19	0.44	25
Bijapur@	0.23	28#	0.38	27#	0.30	26#
Yadgir	0.09	30#	0.40	26#	0.25	27#
Raichur	0.21	29#	0.28	28#	0.25	28#
Koppal	0.26	27#	0.22	29#	0.24	29#
Gulbarga@	0.27	26#	0.18	30#	0.22	30#

*Top five performing districts within the dimension, #Bottom five performing districts within the dimension, @Gulbarga and Bijapur officially renamed as Kalaburagi and Vijayapura respectively

Table 4: Performance classification based on domain-specific cut-off values.

Performance category	Socio-demographic categories	Maternal and reproductive health categories	Combined categories
Low performing	≤ 0.43	≤ 0.50	≤ 0.49
Moderately low performing	>0.43 to ≤ 0.63	>0.50 to ≤ 0.65	>0.49 to ≤ 0.66
Moderately high performing	>0.63 to ≤ 0.71	>0.65 to ≤ 0.75	>0.66 to ≤ 0.75
High performing	>0.71	>0.75	>0.75

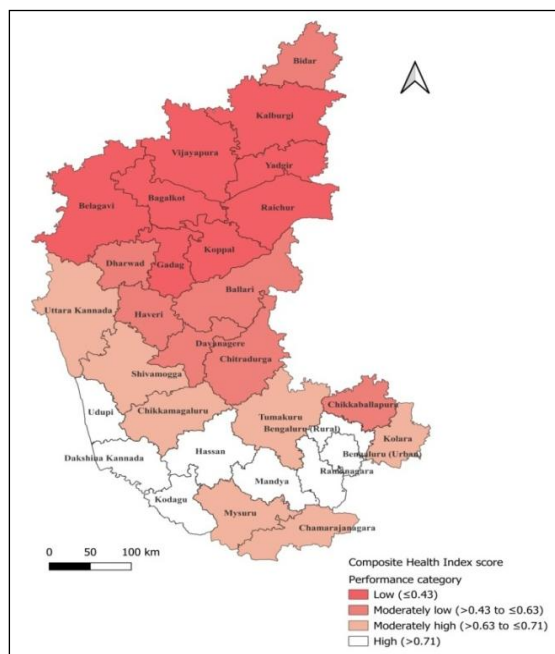
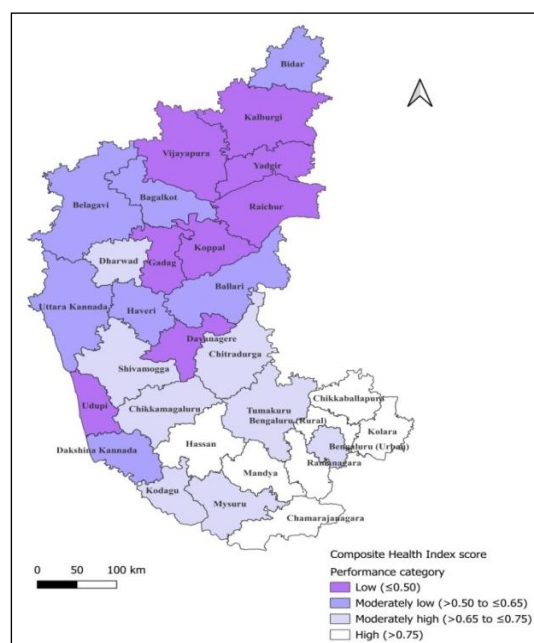
**Figure 3: District-wise CHI performance by socio-demographic indicators.****Figure 4: District-wise CHI performance by maternal and reproductive health indicators.**

Figure 3 and 4 reveal a clear north-south regional inequality across Karnataka. In Figure 3, most northern and north-eastern districts such as Kalaburagi, Yadgir, Raichur, Bidar and Vijayapura fall under low or moderately low categories, while southern districts including Bengaluru, Mysuru, Udipi and Dakshina Kannada are classified as moderately high to high categories. A similar spatial pattern is observed in Figure 4, where northern districts continue to show poor performance, whereas southern and urban districts consistently exhibit moderately high to high performance. Overall, the comparison indicates that districts with better socio-demographic development tend to achieve better maternal and reproductive health outcomes, while relatively backward regions of northern Karnataka lag behind on both indices, highlighting persistent regional inequality across the state.

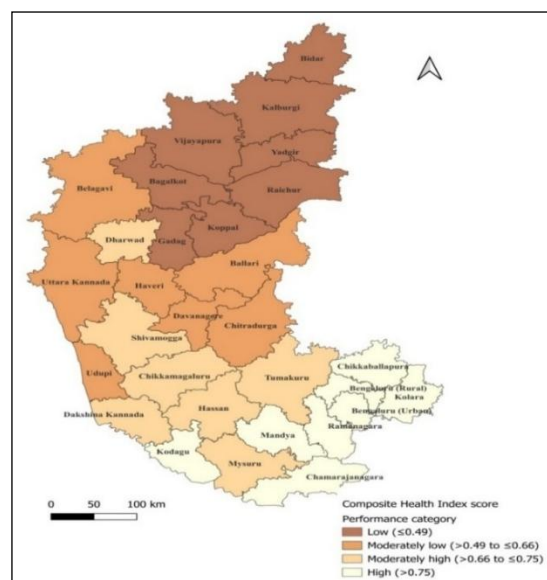
**Figure 5: District-wise CHI performance across combined health indicators.**

Figure 5 illustrates the composite health index performance across districts of Karnataka. Most northern districts, including Bidar, Kalaburagi, Yadgir, Raichur, Koppal, and Vijayapura fall under low to moderately low categories, indicating weaker health outcomes. Central districts show mixed performance, ranging from moderately low to moderately high. In contrast, southern and south-western districts including Bengaluru, Bengaluru Rural, Ramanagara, Mandya, Mysuru,

Kodagu, and Chamarajanagara fall under the high category, reflecting better health infrastructure and service delivery. Overall, the map highlights a clear regional health gap, with northern districts consistently lagging behind their southern counterparts.

DISCUSSION

The present study highlights substantial inter-district and regional inequalities in socio-demographic conditions and maternal and reproductive health outcomes across Karnataka, revealing a persistent north-south divide. Southern districts consistently record higher CHI scores, whereas northern districts such as Yadgir, Kalaburagi, Raichur, Koppal, and Vijayapura exhibit low performance. This spatial pattern strongly aligns with earlier evidence on regional health inequalities in India, which documents systematic disadvantages in northern and interior regions compared to southern counterparts.^{8,23} The strong association between improved sanitation, clean fuel use, women's education, and health insurance coverage with higher socio-demographic CHI scores supports the social determinants of health framework.²⁴ Previous studies similarly emphasize the central role of women's education and household living conditions in shaping health outcomes.^{22,25} High-performing districts such as Bengaluru, Udupi, and Dakshina Kannada characterized by better sanitation, higher female schooling, and lower prevalence of early marriage also record the highest socio-demographic CHI scores. In contrast, Yadgir, Raichur, and Koppal, characterized by low female education, poor sanitation, and higher prevalence of early marriage, reflect long-standing structural and developmental disadvantages in northern Karnataka.

Maternal and reproductive health outcomes show a similarly strong association with healthcare service coverage and unmet need for family planning. Districts with higher coverage of early ANC registration, ≥ 4 ANC visits, and institutional deliveries, along with lower unmet need, consistently achieve higher maternal CHI scores. This finding is consistent with the continuity-of-care model proposed by Campbell and Graham, which emphasizes timely and sustained maternal healthcare for improved maternal and neonatal outcomes.²⁶ High-performing districts such as Chamarajanagar, Chikkaballapura, and Mandya reflect the benefits of strong primary healthcare systems, consistent with findings by Rani et al and reported in NFHS-5.^{1,27} Conversely, districts like Kalaburagi and Koppal remain at the bottom due to lower service coverage and higher unmet need, indicating persistent gaps in access and utilization of maternal health services.

An important observation is the declining reliance on public health facilities for institutional deliveries in better-performing divisions such as Bengaluru and Mysuru. Although institutional delivery rates are high overall, the increased utilization of private facilities

reflects greater urbanization and purchasing power; however, it may also increase out-of-pocket expenditure and contribute to inequities in access and quality of care, particularly for vulnerable populations.^{13,28} The combined CHI analysis further demonstrates a strong interdependence between socio-demographic development and maternal health outcomes, with better socio-demographic performance translating into improved maternal and reproductive health. This reinforces the argument that health investments in education, sanitation, and social protection, consistent with Marmot's social gradient in health.²⁹ Finally, notable intra-divisional variation, particularly in Belagavi and Bengaluru divisions, indicates that geographic proximity alone does not ensure similar health outcomes. District-specific socio-economic conditions, governance effectiveness, and administrative performance play critical roles in shaping maternal and reproductive health outcomes.^{13,30} Overall, the findings suggest that health system interventions must be complemented by broader structural improvements in education, living standards, and gender equity to effectively reduce regional inequality particularly in northern Karnataka.

The study highlights regional inequalities in Karnataka but is limited by its reliance on secondary cross-sectional NFHS-5 data, which may not capture recent changes and only shows associations, not causal relationships, also restricted indicators, potential biases in self-reported information, and inability to capture intra-district variations. Despite these limitations, the study provides valuable evidence on regional health inequalities and offers useful insights to inform targeted public health policies and interventions in Karnataka.

CONCLUSION

The study demonstrates substantial regional inequalities in socio-demographic and maternal & reproductive health indicators across Karnataka, with northern districts consistently lagging behind their southern counterparts. Enhancing girls' education and literacy may improve health awareness and utilization of healthcare services. Strengthening livelihoods, housing, sanitation, and social protection can help to address underlying socio-economic barriers to health. Promoting women empowerment through greater autonomy, delayed age at marriage (≥ 18 years), and ensuring equitable access to resources is essential for achieving sustained improvements in maternal and reproductive health.

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