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An MCDA Approach to Assessing Mother and Child Health in Uttar Pradesh

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Abstract
Ensuring comprehensive and high-quality healthcare for mothers and children is vital for enhancing population health and achieving sustainable development goals. This study aims to evaluate the status of maternal and child healthcare in the districts of Uttar Pradesh (UP), India, using a multi-criteria decision analysis (MCDA) approach, based on data from the National Family Health Survey-5 (NFHS).We utilised data from NFHS-5, a nationally representative survey conducted in 2019-2020, which providescomprehensive information on maternal and child health. The study employs the MCDA technique, specifically entropy and TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), to evaluate the significance and proximity of various maternal and child healthcare criteria. These criteria include antenatal care, institutional delivery, postnatal care, immunisation coverage, and nutritional status. The overall performance of each district in terms of maternal and child healthcare is measured using a composite index developed based on TOPSIS methods, with the criteria weights determined by the entropy method.Some districts perform well in specific indicators, while others lag. The study highlights the districts needing immediate attention and targeted interventions to improve healthcare infrastructure, strengthen service delivery, and address the underlying social determinants impacting maternal and child health outcomes. Ultimately, this study aims to contribute to the overall improvement of the state's maternal and child health outcomes, thereby promoting the well-being of its population and advancing the achievement of sustainable development goals.
Keywords: Child health, MCDA, entropy, TOPSIS.

Introduction

For the future aspects, providing optimal mother and child healthcare is a vital component of public health in India. The most populous state in India, UP faces numerous challenges in providing effective healthcare services, especially in remote districts. Realizing the importance of mother and child health, the government launched many schemes such as Janani Suraksha Yojana(JSY), Pradhan Mantri Matru Vandana Yojana (PMMVY), Mission Indradhanush, National Health Mission (NHM), Integrated Child Development Service (ICDS), Kishori Shakti Yojana, Rashtriya Bal SwasthyaKaryakram (RBSK). The application of MCDA techniques is increasing within the field of health and nutrition research (Alicia *et al.*, 2011a; Andrzej Piegat& Wojciech Salabun, 2015; Dowie *et al*., 2015; French *et al*., 2014; Karacan *et al*., 2016; Venkaiah *et al.*, 2015). Assessing the performance and prioritizing interventions at the district level are essential for improving maternal and child health outcomes. This study presents an innovative approach that uses MCDA techniques.(Jitesh J. Thakkar, n.d.)explored the holistic utilization of various MCDA approaches, offering an extensive reference that covers over 15 techniques, along with in-depth and practical illustrations. Specifically, weights are evaluated by the entropy method and the TOPSIS method is used to rank the districts of UP. By employing MCDA techniques, the study aims to overcome the challenges associated with the complex and multidimensional nature of healthcare performance evaluation. Entropy-based weight calculation allows one to determine the relative importance of different indicators, ensuring a fair and unbiased assessment. The weights evaluated by the entropy approach are a way of gauging that combines qualitative measurement with quantitative analysis, and objective weights can be derived based on the variability of the indicator. This technique considers the level of heterogeneity in the dataset and assigns appropriate weights to each indicator, enabling a more accurate evaluation of district performance. (Meshram *et al.,* 2017) stated in his study thatthe TOPSIS method is superior to the conventional composite indices, as this method provides a solution that is relatively closer to the best solution and far from the inferior solution. The principal advantages of the TOPSIS method include simplicity, rationality, comprehensibility, enhanced computational efficiency, and the capacity to assess the comparative performance of each option through a straightforward mathematical representation. The TOPSIS method is applied to classify the districts according to their proximity to the ideal solution. By considering both positive and negative deviations from the ideal values, this technique helps identify the districts performing well and those requiring immediate attention and targeted interventions.

Assessing mother and child healthcare at the district level in UP can be effectively done by utilizing data from the NFHS and implementing tools like RAASTA for evidence-based district implementation plans (Aruldas& Kant, 2022; Hosseinpoor*et al.*, 2023). The Uttar Pradesh Health Management Information System (UP-HMIS) is crucial in providing managers with access to health data, enabling better planning and monitoring of health programs (Meghani *et al.,* 2022). Improving facility readiness for child health services in Uttar Pradesh has shown positive outcomes, especially when clinical mentoring is included in the support provided to facilities (Pelly *et al.*, 2021). Understanding the referral pathways followed by families and the experiences of frontline health workers can provide insights into the challenges faced in accessing maternal healthcare services in the state (Kumar *et al*., 2022). By leveraging these data sources and tools, a comprehensive assessment of mother and child healthcare in Uttar Pradesh can be conducted to drive targeted interventions and improvements at the district level.

The findings of this study will contribute to evidence-based decision-making, enabling policymakers and healthcare professionals to identify districts with suboptimal performance and allocate resources efficiently. Implementing targeted interventions in identified districts can improve overall maternal and child health outcomes in UP.Thispaper presents a cutting-edge methodfor assessing mother and child healthcare at the district level in UP, data extractedfrom NFHS-5. By integrating multiple criteria, determining relative weights, and ranking districts based on their performance, this study aims to provide valuable information and actionable recommendations for policymakers and healthcare stakeholders to improve the delivery of healthcare services and ultimately improve the well-being of mothers and children in UP.

Our objective in employing the MCDA approach is as follows:

(i) To develop our understanding towards maternal and child health scenarios in UP.

(ii) Establish effective district ranking based on maternal and child health indicators.

(iii) Draw meaningful inferences that shed light on the current health scenario in UP.

Uttar Pradesh exhibits significant geographical and demographic variations that affect health outcomes. An MCDA approach can accommodate these variations, ensuring that health assessments and interventions are tailored to the specific needs of different regions and population groups.With limited resources, it is crucial to identify and prioritize health interventions that offer the maximum benefit. MCDA helps policymakers allocate resources efficiently by providing a clear rationale for choosing certain interventions over others based on their potential impact.This study presents mother and child health being multidimensional convert into an optimal result under the constrained resource regime in UP.

Literature Review

According to UNICEF, all pregnant women should have access to prenatal care, expert care during childbirth, and care and support in the weeks following childbirth. All births should be assisted by skilled healthcare professionals, as timely management and treatment can make the difference between life and death for both the mother and child. Globally, the number of women and girls who die each year due to issues related to pregnancy and childbirth has dropped considerably, from 451,000 in 2000 to 295,000 in 2017, a thirty-eight percent decrease(*Unicef*).The Government of India has been focusing on initiatives to improve maternal health indicators. Much progress has been made in ending preventable maternal deaths in the past two decades. Many private and government agencies collaborate and support the capacities of health managers and supervisors at districts and blocklevels to plan, implement, monitor, and supervise effective maternal healthcare services with a focus on high-risk pregnant women and those in hard-to-reach, vulnerable, and socially disadvantaged communities. In this study,we aim to provide a specific zone that needs more attention. (Ghosh & Ghosh, 2020) estimated the contribution of India’s National Health Mission (NHM) to maternal health through supervising effective maternal healthcare services with a focus on high-risk pregnant women and those in hard-to-reach, vulnerable, and socially disadvantaged communities. Numerous methods exist for solving MCDA problems (Alicia *et al*., 2011b; Aruldoss*et al*., 2013; Jahanshahloo*et al*., 2009; Zavadskas*et al*., 2014). (Meidute-Kavaliauskiene& Ghorbani, 2021)applied the SWARA (Stepwise Weight Assessment Ratio Analysis) methodto obtain the primary weights, and the EMAR (Evaluation by an Area-Based Method of Ranking) method was used to evaluate 16 Supply Chain Management (SCM) contracts for governmental fertility centres.(Oluah*et al*., 2020)considered four criteria: heat of fusion, thermal conductivity, density, and costto estimate the selection of phase-change materials for optimum Trombe wall performance. They(Hajduk & Jelonek, 2021) used MCDA for the evaluation of smart cities. The study used the TOPSIS method to classify smart cities based on their energy performance measurements.(Shi *et al*., 2019) studied measures of universal health coverage in emerging 7 (E7) economies employing a novel approach, using the Decision-Making Trial and Evaluation Laboratory (DEMATEL) with triangular fuzzy numbers to weight five dimensions and 14 criteria, and MOORA to rank E7 economies for Universal Health Coverage (UHC) performance.(Boz et al., 2018) employed Multidimensional Scaling (MDS) and the MOORA method to assess Turkey's position within OECD countries. Evaluated the sustainable development of islands using entropy (Zhao *et al*., 2022) and TOPSIS models to understand its exhibit excellent development potential. (Wu *et al*., 2022) estimated dynamic changes in child healthcare status from 2000 to 2020 and determined whether the policies and measures implemented in the medical and health reforms effectively promoted the development of child healthcare in China.

(Jato-Espino *et al*., 2023)studied the recurrent occurrences of zoonotic infectious diseases, which emphasize the need to recognize the interlinkages between human, animal and environmental health in disease prevention and control, MCDA methodologies, notably the Entropy and TOPSIS approaches, were applied to integrate the indicators and establish a comprehensive measure for evaluating the propagation of zoonotic diseases.(Wang *et al*., 2018) conducted empirical evaluations on China's energy regulation effectiveness from 1999 to 2015. The findings indicate that the relationship among the performance indicators leads to notable variations between the evaluation results of E-M-TOPSIS and the conventional TOPSIS method. These approaches aim to explicitly consider multiple criteria when aiding the decision-making process (Alinezhad& Khalili, n.d.; Coat, 1960; Diakoulaki, *et al*., 1995; Olson, 2004).

Methodology

Study Area and Data Source

(NFHS-2021) provides district-level information for the whole country on fertility, infant and child mortality, the practice of family planning, maternal and child health, reproductive health, nutrition, anaemia,and family planning services. The final iteration of the NFHS concluded in the fiscal year 2019-20, and the information on children's well-being across different facets is documented in the fact sheets. This investigation was carried out utilizing the information presented in the district-specific fact sheet concerning child vaccination, vitamin intake, and medical examinations.This study shows a comprehensive dataset that provides valuable information on various maternal and child health care indicators at the district level as well as zone-wise in UP.

UP has solidified its status as the most populous state in India and stands at the fourth rank in terms of geographical area. In the examination of maternal and child health in UP, the state was categorized into four primary regions: Eastern(Region 1), Western (Region 2), Central (Region 3), and Bundelkhand (Region 4). Each region displayed distinct characteristics concerning healthcare quality and outcomes.

Region1, recognized for its high population density and rural landscapes, encounters challenges such as insufficient healthcare infrastructure and restricted service accessibility. These factors may have adverse effects on maternal and child health, highlighting the necessity for targeted healthcare interventions.

Region2, despite being one of the most economically advanced areas in UP, still witnesses variations in maternal and child health outcomes among its districts. While certain districts excel, others encounter issues related to inadequate healthcare services.

Region3, encompasses significant urban hubs like Lucknow and Kanpur, where healthcare facilities are typically more developed. Nonetheless, there is notable diversity in the quality of maternal and child health across districts, with some regions demonstrating exceptional performance while others lagging.

Region4 confronts severe challenges concerning maternal and child health, with numerous districts receiving low ratings in terms of healthcare quality. Resource scarcity, inadequate infrastructure, and limited access to quality medical services contribute to the region's healthcare difficulties.

The study emphasizes the importance of implementing region-specific strategies and making investments to tackle the maternal and child health disparities prevalent across the various zones of UP.

Entropy Method

The entropy method is a technique used in MCDM to determine the weights or importance of criteria. Calculates the entropy value for each criterion based on the information contained in the data. The entropy method ensures that the weights assigned to the criteria are objective and reflect the available information.

First,normalize the decision matrix by this formula to get the outcome X_{ij} .

$$X_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (1)$$

Computation of the entropy measure of project results using the following equation

$$E_j = -k \sum_{i=1}^{m} X_{ij} In X_{ij} \quad (2)$$

Where k=1/In(m).

Defining the objective weight based on the entropy concept

$$w_j = \frac{1-E_j}{\sum_{j=1}^{n}(1-E_j)} \quad (3)$$

By using the entropy method, the relative importance of each criterion can be determined objectively, taking into account the information contained in the data. This enables a more accurate and fair evaluation of MCDA problems.

TOPSIS Method

The TOPSIS method is an MCDM used to determine the best alternative from a set of options based on multiple criteria (Hwang & Yoon).

The TOPSIS method involves the following steps:

Step 1: Construct a decision matrix where each row represents an alternative and each column represents a attribute. The matrix contains the performance scores of each alternative for each attribute.

$$Y_{ij} = \begin{bmatrix} y_{11} & y_{12} \cdots & y_{1j} \\ \vdots & \ddots & \vdots \\ y_{i1} & y_{i2} \cdots & y_{ij} \end{bmatrix}$$

Step 2: Normalize the matrix to eliminate the effects of different units and scales.

$$N_{ij} = \frac{Y_{ij}}{\sqrt{\sum_{i=1}^{m} Y_{ij}^2}} ; (i = 1,2 \ldots\ldots m; j = 1,2, \ldots\ldots. n). \quad (6)$$

Step 3: Multiply the normalized matrix by the weights assigned to each criterion.

$$\gamma_{ij} = N_{ij} * W_i, \quad (7)$$

Where $\gamma_{ij} = Weighted\ normalized\ matrix, W_i = Weights\ of\ the\ criteria$

Step 4: Calculate the PIS and NIS for the weighted normalized decision matrix.

$PIS(\gamma^+) = \{\gamma_1^+, \gamma_2^+, \gamma_3^+, \ldots. \gamma_n^+\}$, where $v_j^+ = \{(max(\gamma_{ij}), j \in J); (min(\gamma_{ij}), j \in J^|)\}$

$NIS\ (\gamma^-) = \{\gamma_1^-, \gamma_2^-, \gamma_{3,\ldots}^- \gamma_n^-\}$, where $v_j^- = \{(min(\gamma_{ij}), j \in J); (max(\gamma_{ij}), j \in J^|)\}$, (8)

Where J is related to endogenous criteria/attribute, $J^|$ is related to exogenous attributes.

Step 5: Calculate the Euclidean distance between each alternative and the PIS and NIS viz .S_i^+ and S_i^-.

Where $S_i^+ = \sqrt{\sum_{j=1}^{n} (\gamma_{ij} - \gamma_j^+)^2}$; i=1,2,….m , and $S_i^- = \sqrt{\sum_{j=1}^{n} (\gamma_{ij} - \gamma_j^-)^2}$; i=1,2,….m. (9)

Step 6: Calculate the relative closeness of each alternative to the PIS by dividing the distance from the NIS by the sum of the distances from the PIS and the NIS.

$$RC_i = \frac{S_i^-}{S_i^- + S_i^+}, 0 \le RC_i \le 1. (10)$$

Step 7: Rank the alternatives according to their relative closeness to the PIS.

Table 1- Maternal and Child Health Indicators

S.No.	Indicator	Description	Optimization Source
1	I_1	Full antenatal Care (Max)(Mothers who had at least 4 antenatal care visits (%)	Maximum
2	I_2	Mothers whose last birth was protected against neonatal tetanus(%)	Maximum
3	I_3	Mothers who consumed iron folic acid for 100 days or more when they were pregnant)	Maximum
4	I_4	Institutional Births	Maximum
5	I_5	Children aged 12-23 months fully immunized	Maximum
6	I_6	Children under age 3 years breastfed within one hours of birth	Maximum
7	I_7	Children under 5 years who are stunted (height-for-age)	Minimum
8	I_8	Children under 5 years who are wasted (weight-for-height) (%)	Minimum
9	I_9	Children under 5 years who are underweight (weight-for-age) (%)	Minimum
10	I_{10}	Women whose Body Mass Index (BMI) is below normal (BMI < 18.5 Min kg/m2) (%)	Minimum
11	I_{11}	Women who are overweight or obese (BMI ≥ 25.0 kg/m2) (%)	Minimum
12	I_{12}	Children age 6-59 months who are anemic (<11.0 g/dl) (%)	Minimum
13	I_{13}	All women age 15-49 years who are anemic(%)	Minimum
14	I_{14}	Infant Mortality Rate	Minimum

Table 1 presents maternal and child health indicators extracted from NFHS-5 reports.

Results and Discussion

By Entropy Method

Table 2 Indicator entropy weights in this study

	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9	I_{10}	I_{11}	I_{12}	I_{13}	I_{14}
e_j	0.9937	0.9995	0.9819	0.9991	0.9978	0.9838	0.9963	0.9869	0.9960	0.9934	0.9892	0.9981	0.9977	0.9811
w_j	0.0592	0.0046	0.1724	0.0085	0.0203	0.1543	0.0345	0.1241	0.0372	0.0622	0.1028	0.0176	0.0219	0.1796

The entropy method was utilized to determine the weights of each criterion or attribute. A decision matrix was prepared to normalize the results and indicator entropy weights were calculated. Table 2 displays the entropy weight values for each indicator, with I_{14} having the highest weight value of 0.1796, and I_2 having the lowest weight value of 0.0046.

Table 3 Ideal Positive and Negative Solutions

Ideal solution	**I_1**	**I_2**	**I_3**	**I_4**	**I_5**	**I_6**	**I_7**	**I_8**	**I_9**	**I_{10}**	**I_{11}**	**i_{12}**	**I_{13}**	**I_{14}**
V+	0.0118	0.0006	0.0732	0.0011	0.0031	0.0304	0.0025	0.0012	0.0093	0.0035	0.0050	0.0012	0.0017	0.0041
V-	0.0031	0.0003	0.0081	0.0007	0.0015	0.0055	0.0052	0.0214	0.0218	0.0114	0.0233	0.0025	0.0032	0.0376

Again, the TOPSIS method was used to analyze and rank the data based on positive and negative ideal solutions. Then, the ideal positive and negative solutions were determinedbased on the results. With the help of the normalized matrix prepared by TOPSIS, a weighted normalized matrix was constructed and using the results obtained from this matrix, ideal positive and negative solutions were summarized in Table 3.

Appendix 1 provides a comprehensive assessment of the relative proximity coefficient index and ranks for various districts. The Si+ and Si- values reflect the positive and negative impact factors, while the Pi value signifies the overall ranking. Districts have been systematically evaluated using the MCDA approach, revealing diverse performance across mother-and-child health care measures. Districts are categorized according to their pi value.

Economically UP is divided into four areas Region1, Region2, Region3, and Region 4. Following a comprehensive analysis employing TOPSIS and entropy methodologies, it has been determined that the district of Lucknow secures the top position, attaining the highest rank, while the district of Bhadohi occupies the final rank. Throughout this MCDA procedure, our objective revolves around the identification of district preferences, particularly those exhibiting superior or exceptional attributes in terms of maternal and healthcare indicators.

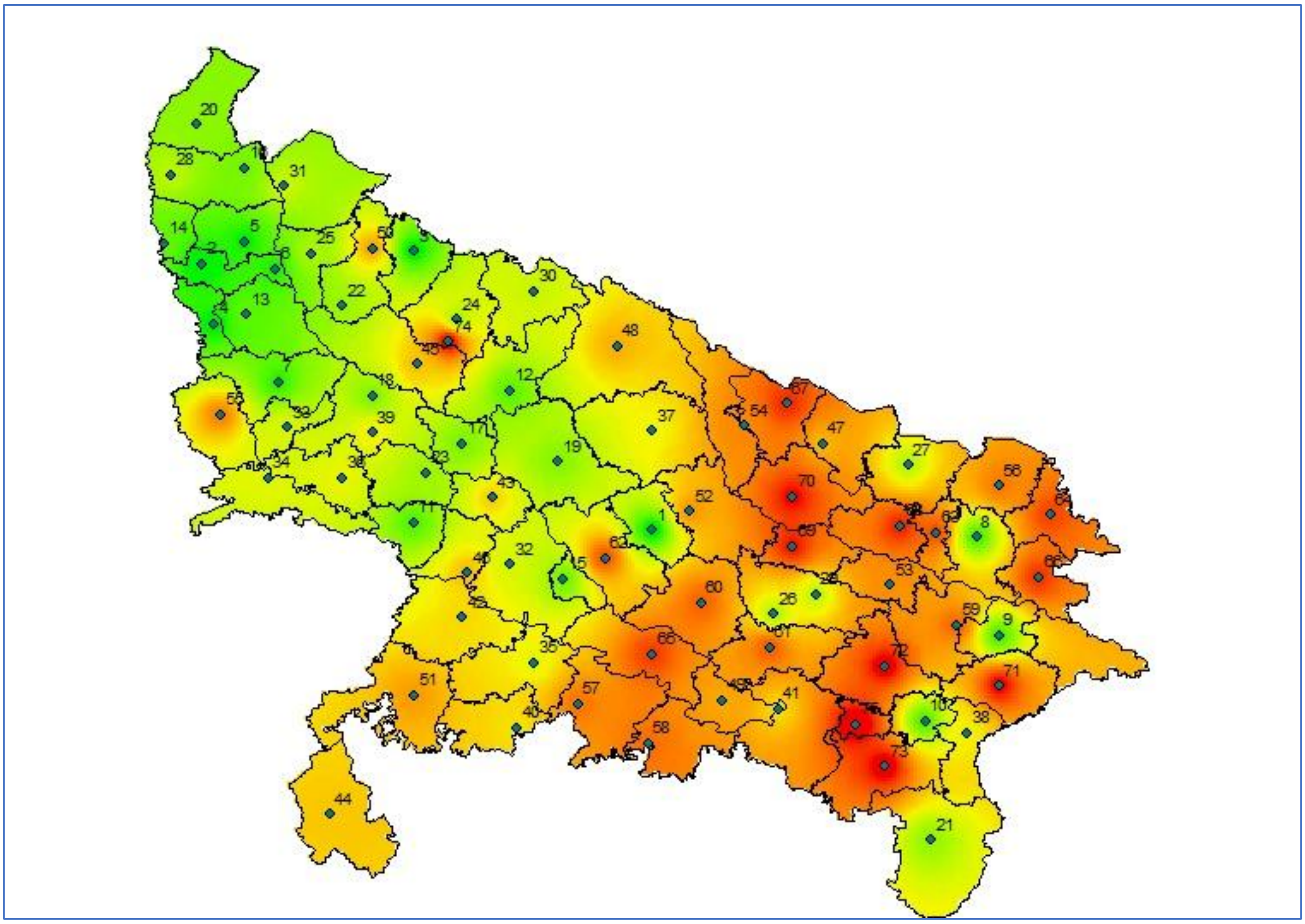
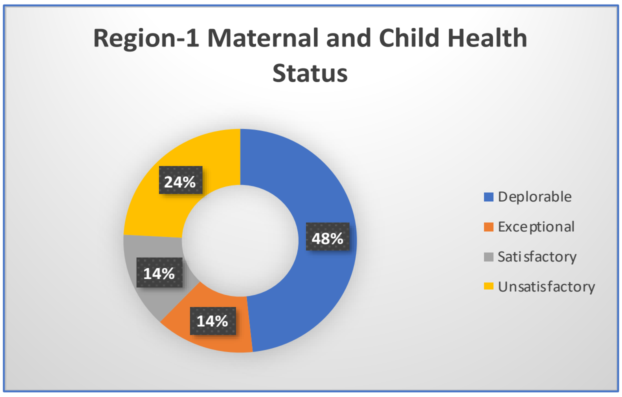
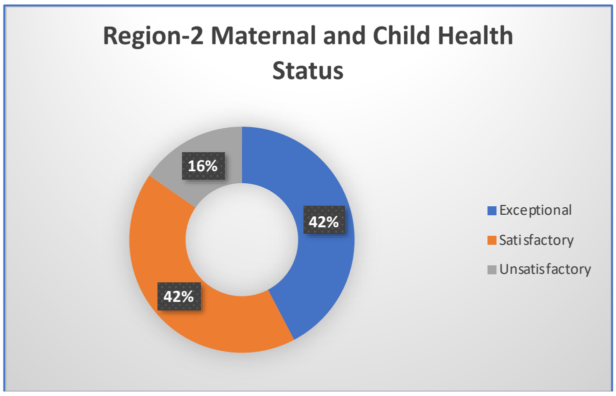


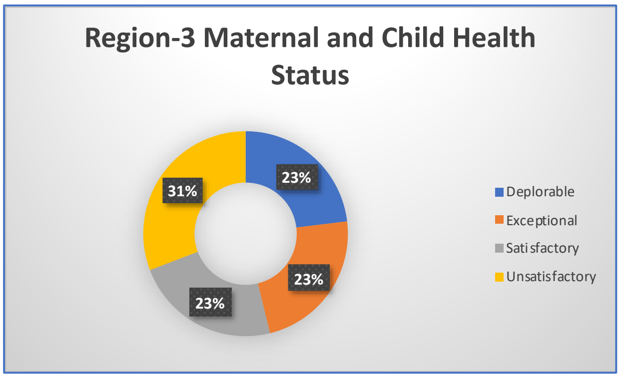
Figure 1 shows the district's visualization mapping of the ranking result.

The aforementioned figures 1 shown, the scarlet hue indicates districts of elevated ranking demonstrating heightened vulnerability, while the apricot hue signifies districts with a moderate level of vulnerability. The yellow hue is indicative of districts with a low level of vulnerability, whereas the green hue signifies the absence of vulnerability, thus denoting a safe zone or district.

Upon computation of rankings, the research has been segmented into four distinct regions to accurately depict the current conditions of various districts.







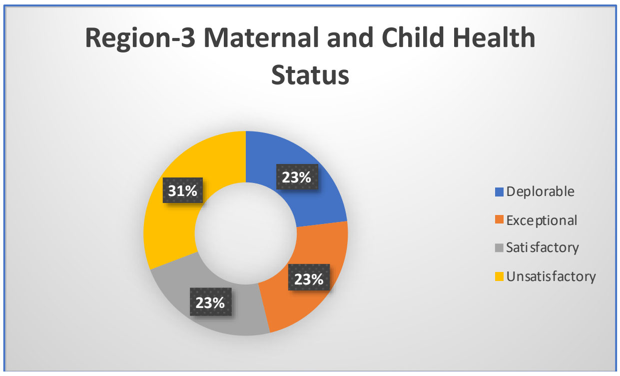


Figure 2(a), 2(b), 2(c) and 2(d) presents region wise percent of classified districts

Region1

The examination of Region1, demonstrates a diverse array of categorizations for the 29 districts under scrutiny. The majority of these districts are situated within the classification of "Deplorable," with 14 districts out of the total 29 (48%) falling under this category. These include Pratapgarh, Faizabad, Gonda, Deoria, Azamgarh, Basti, Ballia, Jaunpur, Ghazipur, Mirzapur, Shrawasti, Sant Kabir Nagar, Kushinagar, and Sant Ravidas Nagar (Bhadohi). The remaining districts are dispersed among different classifications: seven districts (24%) are labelled as "Unsatisfactory," four (14%) as "Satisfactory," and four (14%) as "Exceptional" based on their current state. The districts classified as "Exceptional" are Gorakhpur, Mau, and Varanasi. The prevalence of districts falling under the "Deplorable" category highlights substantial obstacles faced by the Eastern region of UP. These particular areas are likely grappling with infrastructural, economic, or administrative challenges that contribute to their inferior classification. Improving the general quality of life within these regions should be a primary concern for policymakers. Conversely, districts labelled as "Exceptional" exhibit promise and have the potential to be utilized.

Region2

The investigation into maternal and child health within Region2, indicates substantial discrepancies in healthcare service quality and results throughout the region. Rampur, Meerut, Baghpat, Gautam Buddha Nagar, Bulandshahar, Aligarh, Shahjahanpur, Etawah, Ghaziabad, Hapur, and Muzaffarnagar showcase remarkable (42%) levels of maternal and child healthcare services and outcomes, highlighting strong healthcare systems and effective program implementation. These districts can act as exemplars for other areas, offering valuable insights into successful strategies and approaches for enhancing health outcomes for mothers and children.In contrast, Mathura, Etah, Moradabad, and Budaun districts have been labelled (16%) as unsatisfactory, indicating significant deficiencies in delivering quality healthcare and the necessity for prompt interventions to tackle these shortcomings. Inadequate healthcare in these regions could result in elevated maternal and infant mortality rates as well as other health-related obstacles. Targeted strategies, enhanced healthcare financing, and the execution of focused programs are imperative in these areas to enhance maternal and child health.

Meanwhile, the districts exhibiting satisfactory performance, such as Saharanpur, Bijnor, Jyotiba Phule Nagar, Agra, Firozabad, Mainpuri, Bareilly,Pilibhit, Sambhal, Shamli, and Mahamaya Nagar, display moderate healthcare outcomes. Despite meeting fundamental healthcare criteria, these districts have room for enhancement to raise their services to exceptional standards. Decision-makers should concentrate on disseminating best practices from the outstanding districts and efficiently allocating resources to enhance healthcare standards throughout the entire region.

Region3

Region3demonstrates notable disparities in health outcomes among various districts. Districts such as Lucknow, Farrukhabad, and Kanpur Nagar displayed commendable performance (23%), indicating a robust health infrastructure and effective maternal and child health initiatives. Conversely, Unnao, Fatehpur, and Rae Bareli exhibited unfavourable conditions, pointing towards inadequate access to quality healthcare and systemic issues impacting maternal and child health. Sitapur, Hardoi, and Kanpur Dehat showed satisfactory results, suggesting a moderate level of performance with potential for enhancement. In contrast, districts like Kheri, Kannauj, Auraiya, and Bara Banki were considered unsatisfactory, underscoring the necessity for targeted interventions and resource allocation to address the existing challenges. In conclusion, the research emphasizes the importance of targeted efforts to narrow the disparities in healthcare provision and improve maternal and child health outcomes throughout the region.

Region4

The research on maternal and child health Region-4, reveals notable challenges present in the various districts. A majority of the districts within the region demonstrate substandard performance concerning maternal and child health, highlighting significant deficiencies in both healthcare infrastructure and services. Specifically, Jalaun, Jhansi, Lalitpur, and Mahoba exhibit inadequate conditions, characterized by issues such as limited healthcare accessibility, insufficient facilities, and a shortage of medical personnel. The poor assessments of Banda and Chitrakoot emphasize the critical need for targeted interventions in these particular areas. Conversely, Hamirpur displays favourable results, possibly due to more effective resource allocation and healthcare service provision in comparison to other districts. These results underline the necessity for holistic approaches and increased investments in healthcare to enhance maternal and child health outcomes throughout Region4.

Conclusion

Amplifying the healthcare system has emerged as a critical endeavour aimed at driving positive transformations within a nation's socio-economic landscape. The advancement of a country's socioeconomic status equals expanded opportunities for its citizens. Evaluating mother-and-child health statistics stands as a valuable metric for gauging demographic trends and serves as a vital barometer for a nation's progress in both socioeconomic development and overall well-being. The imperative of the government's attention to mother and child health is undeniable, as it represents an investment in the forthcoming societal framework. In the context of India's burgeoning population, there is a pressing need for a robust strategic framework that places healthcare at its core. This framework should encompass essential elements such as immunization drives, comprehensive maternal and infant care, initiatives to combat malnutrition, well-equipped primary healthcare centres, and a cadre of dedicated medical professionals.

Sensitivity to mother-and-child healthcare is an essential requirement in all regions of the country. Variations in performance between the districts could potentially stem from unequal access to healthcare services. Research highlights several notable patterns; however, except Azamgarh to Sant Ravidas Nagar, the majority are facing concerning levels of mother and child health challenges. The study functions as an initial exploration, offering insights into the conditions across different districts of UP Nevertheless, the study's ability to provide a comprehensive explanation is limited due to the absence of detailed, micro-level investigations that would enable a deeper understanding of nuances. Districts falling into the last category deserve particular attention, thus creating a promising avenue for future research. The successful implementation of this strategy could serve as a valuable blueprint for improving healthcare in other global regions.

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Appendix-1Index of the relative closeness coefficient and ranks

Districts	**Si+**	**Si-**	**Pi**	**Rank**
Saharanpur	0.06006	0.05061	0.45731	20
Bijnor	0.06071	0.04916	0.44740	31
Rampur	0.05596	0.05609	0.50057	3
Jyotiba Phule Nagar	0.06175	0.05102	0.45241	25
Meerut	0.05315	0.05090	0.48919	5
Baghpat	0.05470	0.04706	0.46248	14
Gautam Buddha Nagar	0.05402	0.05299	0.49519	4
Bulandshahr	0.05943	0.05180	0.46572	13
Aligarh	0.05936	0.05449	0.47857	7
Mahamaya Nagar	0.06645	0.05265	0.44208	33
Mathura	0.06728	0.04966	0.42466	55
Agra	0.06617	0.05242	0.44205	34
Firozabad	0.06887	0.05449	0.44169	36
Mainpuri	0.06987	0.05789	0.45311	23
Bareilly	0.06381	0.05284	0.45302	24
Pilibhit	0.05837	0.04729	0.44754	30
Shahjahanpur	0.06565	0.05745	0.46670	12
Kheri	0.07188	0.05453	0.43135	48
Sitapur	0.06954	0.05488	0.44107	37
Hardoi	0.06765	0.05708	0.45764	19
Unnao	0.06701	0.04741	0.41436	62
Lucknow	0.02384	0.08161	0.77395	1
Farrukhabad	0.06016	0.05092	0.45842	17
Kannauj	0.06477	0.05063	0.43870	43
Etawah	0.05725	0.05054	0.46887	11
Auraiya	0.06294	0.04881	0.43681	46
Kanpur Dehat	0.05980	0.04782	0.44436	32
Kanpur Nagar	0.05674	0.04855	0.46112	15
Jalaun	0.06016	0.04711	0.43914	42
Jhansi	0.06368	0.04746	0.42703	51
Lalitpur	0.05469	0.04267	0.43827	44

Districts	Si+	Si-	Pi	Rank
Hamirpur	0.06031	0.04776	0.44191	35
Mahoba	0.05998	0.04709	0.43982	40
Banda	0.06976	0.05123	0.42342	57
Chitrakoot	0.06936	0.05055	0.42157	58
Fatehpur	0.06767	0.04715	0.41067	65
Pratapgarh	0.06276	0.04510	0.41812	61
Kaushambi	0.06232	0.04708	0.43034	49
Allahabad	0.06259	0.04902	0.43921	41
Bara Banki	0.06923	0.05142	0.42619	52
Faizabad	0.06342	0.04340	0.40631	69
Ambedkar Nagar	0.05956	0.04411	0.42546	53
Bahraich	0.06446	0.04766	0.42507	54
Shrawasti	0.06795	0.04676	0.40763	67
Balrampur	0.06568	0.05066	0.43545	47
Gonda	0.06452	0.04370	0.40377	70
Siddharthnagar	0.05489	0.04529	0.45208	27
Basti	0.06901	0.04725	0.40641	68
Sant Kabir Nagar	0.06180	0.04337	0.41239	63
Mahrajganj	0.06065	0.04462	0.42387	56
Gorakhpur	0.05615	0.05141	0.47796	8
Kushinagar	0.06652	0.04664	0.41214	64
Deoria	0.06920	0.04766	0.40780	66
Azamgarh	0.06447	0.04651	0.41911	59
Mau	0.05801	0.05239	0.47452	9
Ballia	0.06924	0.04574	0.39780	74
Jaunpur	0.06571	0.04368	0.39930	72
Ghazipur	0.07231	0.04827	0.40033	71
Chandauli	0.05742	0.04518	0.44034	38
Varanasi	0.05420	0.04807	0.47007	10
Bhadohi	0.06993	0.04594	0.39650	75
Mirzapur	0.07126	0.04729	0.39890	73
Sonbhadra	0.05961	0.04968	0.45457	21
Etah	0.06355	0.04994	0.44004	39
Kanshiram Nagar	0.06405	0.05420	0.45833	18
Amethi	0.07383	0.06092	0.45212	26
Budaun	0.06699	0.05224	0.43813	45
Ghaziabad	0.04762	0.05331	0.52818	2
Hapur	0.05811	0.05517	0.48704	6
Moradabad	0.06779	0.05094	0.42901	50
Muzaffarnagar	0.05373	0.04595	0.46098	16
Rae Bareli	0.06392	0.04604	0.41871	60
Sambhal	0.06350	0.05264	0.45326	22

Districts	Si+	Si-	Pi	Rank
Shamli	0.06292	0.05128	0.44906	28
Sultanpur	0.05615	0.04551	0.44767	29