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District-Level Spatial and Temporal Variations in Maternal Healthcare in West Bengal: An Analysis Using NFHS-4 and NFHS-5

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Abstract : *Maternal healthcare remains a crucial dimension of women's well-being, especially in developing regions where social, economic and cultural inequalities restrict access to medical services. The study evaluates the maternal healthcare scenario across the districts of West Bengal using six indicators from NFHS-4 (2015-16) and NFHS-5 (2019-21), including ANC visits, TT injections, IFA intake, institutional delivery, contraceptive use and postnatal check-ups. A Maternal Healthcare Index (MHI) was constructed using Principal Component Analysis to assess district-level variation and temporal changes, followed by spatio-temporal clustering using Differential Local Moran's I. Although state-level performance improved overall, inter-district disparities widened. Significant progress was noted in IFA intake and institutional deliveries, yet TT and ANC visits stagnated. Districts such as North Twenty-Four Parganas, South Twenty-Four Parganas, Dakshin Dinajpur, Jalpaiguri and Maldah registered major improvements, whereas Bankura, Purba Medinipur and Puruliya experienced sharp deterioration. Spatial clustering revealed persistent low-low clusters in southwestern districts and high-high clusters emerging in the north. The changing structure of healthcare utilisation also indicates increasing separation between contraceptive practices and other maternal services. The study highlights the need for district-specific strategies, improved service delivery, targeted nutrition programmes and strengthened health awareness to reduce inequalities and support progress toward SDG-3 goals.*

Key words: *Maternal Healthcare, National Family Health Survey, West Bengal, District-level Disparities*

Introduction

Gender has a significant impact on health due to both biological and social differences. The health of women is of particular concern because, in many societies, they are disadvantaged by discrimination rooted in socio-cultural processes (WHO, 2025). Some of the socio-cultural factors that influence women's health include unequal power relationships between men and women, social norms that decrease education and paid employment opportunities, poverty that acts as an important barrier to positive health outcomes and an exclusive focus on women's reproductive roles. Prioritizing women's health enables societies to fully harness the potential of half of their population, fostering a more prosperous and equitable future for all. It is to be remembered in this context that among the United Nations Millennium Development Goals set in 2000 and to be

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achieved by 2015, the fifth goal was to promote maternal health, which was considered critical for saving the lives of hundreds of thousands of women. Subsequently, in the 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, the third goal attempts to ensure healthy lives and promote well-being for all at all ages. The first target of this goal calls for the reduction in the global maternal mortality ratio, while the seventh target focuses on ensuring universal access to sexual and reproductive healthcare services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes. Despite huge advancements in women's health over the past few decades, including longer life expectancies and better health outcomes (AbouZahr, 2014), problems still exist, especially for low-income women and in developing nations. There is proof that women face major barriers to receiving proper diagnosis and treatment of medical conditions, especially those with low educational, social, and financial resources (Albino & Tedesco, 1983). Though women now have better access to healthcare due to policy changes (Vyas et al., 2020), notwithstanding advancements, ongoing studies and policy initiatives are required to address enduring health inequalities and new issues about women's health. Perspectives on gender and sex have evolved even in the field of medical education, highlighting the significance of a woman-centred approach (Hoffman et al., 2000). Indian women face high mortality rates, especially during childhood and reproductive years, even though their life expectancy is comparable to that of men. Traditional customs, gender bias, and a lack of education all play a part in the disregard for women's health (Shukla, 2020). Anaemia, infections, and reproductive health problems are particular concerns (Sadgir, 2021) in association with factors such as HIV/AIDS, violence, nutritional status, and unequal treatment of girls. Research emphasises policy intervention to improve health facilities, female education, and supplemental nutrition programs for poor Indian women (Basu & Sidh, 2008). An examination of patterns and determinants of maternal healthcare use across different social settings in three states of South India, namely Andhra Pradesh, Karnataka and Tamil Nadu indicates literacy rates and differential in access to healthcare facilities between rural-urban areas are important factors (Navaneetham & Dharmalingam, 2002). Multilevel analyses of three maternity outcomes, namely, four or more antenatal care visits, skilled birth attendance and post-natal care after birth in nine high-focus states of India reveals that individual or household-level factors, community and district-level factors influence the pattern of utilisation of maternal healthcare services significantly, with rural areas and communities with a high concentration of poor and illiterate women being the worst sufferers (Singh et al., 2014). In case of poor rural women in Gujarat and Tamil Nadu, multivariate logistic regression analyses examined associations of Janani Suraksha Yojana/ Chiranjeevi Yojana and other salient healthcare system, socio-demographic, and obstetric factors with three outcomes, like adequate antenatal care, institutional delivery, and Caesarean-section, showing differential responses (Vora et al., 2015). In a study on Bihar, high-priority districts have been identified in terms of maternal health care, and this has been associated with high incidences of illiteracy, child marriages and adolescent pregnancy (Brahmapurkar, 2017).

In the assessment of the utilisation of healthcare services during pregnancy, delivery and post-delivery among rural women in Uttar Pradesh and its contact with the health worker and socio-economic marginalisation emerged as important factors for the utilisation of maternal health services (Singh et al., 2019). Empirical studies of maternal and women's health service utilisation in West Bengal have repeatedly shown that socio-economic factors play a definitive role in access and uptake of health services. National level analyses using binary logistic regression for pooled rural data shows that illiteracy, poverty and social marginalisation are key factors of suboptimal maternal healthcare utilisation in India as well as West Bengal (Debsarma et al., 2022). However, district level as well as state level studies reveal tremendous spatial and social heterogeneity in West Bengal. Although the state has reached relative economic and social development when compared with some states in the north of India, persistent gender differences prevail in the health sector and West Bengal is situated between high-performing states such as Kerala and lagging states such as Uttar Pradesh when it comes to maternal and reproductive health outcomes (Chaudhry, 2024). Micro-level studies have revealed a range of constraints plaguing the rural women of West Bengal, most importantly low level of education, inadequate health awareness, and nutritional deficiency. Nevertheless, evidence of positive deviance suggests that women who are engaged in income-generating occupations, are exposed to the mass media, or have minimally higher educational qualifications have better maternal and reproductive health outcomes (Mustaphi & Dobe, 2005). Panel data regression analyses also confirm female literacy rates and even distribution of primary health centres as the most salient determinants of inter district disparities in the reproductive and child health indicators across West Bengal (Bhattacharya & Haldar, 2014). At an intra-district level, large inequalities persist as exemplified in the study in which the Health Parity Index reveals extreme spatial variation in the status of women's health, which emphasises the need for site specific interventions (Chakraborty & Jana, 2025). Mitigating against such entrenchments requires an integrated policy package, with a focus on nutritional security, health awareness, strengthening of the public healthcare infrastructure and women empowerment through educational program and self-help groups (De & Sarker, 2011; Mustaphi & Dobe, 2005). Findings from both global and Indian public-health scholarship lend focus on why preventive interventions, community-based interventions, and primary care-level interventions are highly cost-effective and indispensable parts of achieving universal access to maternal healthcare services, especially in socio-economically heterogeneous states such as West Bengal (Adam et al., 2005).

There are a few studies that analysed maternal healthcare use in India at the state-level or the national-level (Debsarma et al., 2022; Chaudhry, 2024) and considered the variability at the district-level, temporal-level and spatio-temporal level. Many of them look at separate indicators like antenatal care or institutional delivery or separate socio-economic covariates independently. No studies to date have employed a composite index and dimension reduction techniques like PCA to quantify and compare the overall level of maternal healthcare in the districts at two-time points. As well studies have found the spatial heterogeneity of maternal healthcare, like

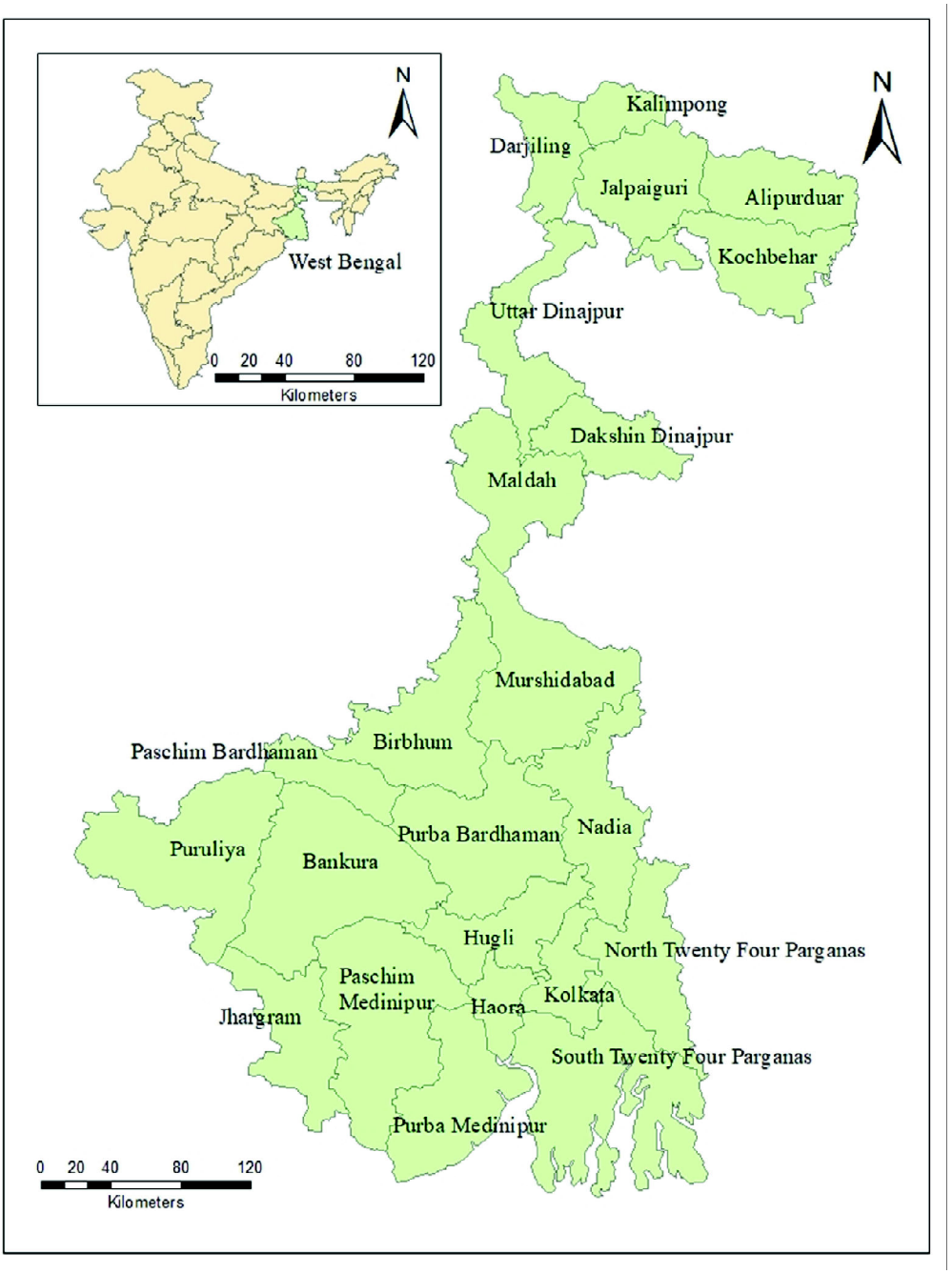

Fig. 1: Location Map

Bhattacharya and Haldar 2014 and Chakraborty and Jana 2025. No study has considered the use of spatio-temporal clustering methods such as Differential Local Moran's in I detecting the emergence and disappearance of high-high; low-low or outlier clusters from 2015-16 to 2019-21 period spanning over Millennium Development Goals (MDG) to Sustainable Development Goals (SDG) era. Similarly, no studies analysed the structural changes in integration of methods, like correlation and changes in PCA loadings of components ANC, TT injection, IFA and institutional delivery. At last, even though some of the analysis cover multiple NFHS rounds, a detailed assessment of temporal growth trajectories and heterogeneity of implementation in post-2015 following MDG-SDG policy landmark is quite limited.

The present study concentrates on female health condition in the districts of West Bengal, India, during the last decade (Fig.1). Maternal healthcare index has been prepared for 2015-16 and 2019-21 periods separately with an objective of providing precise ideas on the female health scenario in the state. The study also aims to identify the temporal trend of the same. However, the uniqueness of the study lies in its attempt to make cluster analysis of maternal healthcare level to find out district level changes in achievements under these two indices. It is to be mentioned in this context that the year of 2015 is a significant temporal milestone marking the end of the Millennium Development Goals and initiation of the Sustainable Development Goals, both considering female and maternal health as a priority area. Thus, it would be academically interesting to reveal the changes taking place in the female health scenario of the state after 2015.

Materials and Methods

Materials

For the present study, the last two reports of the National Family and Health Survey (NFHS), namely NFHS 4 (2015-16) and NFHS 5 (2019-21), have been used. Data on the following indicators (Table 1) have been taken into consideration for this purpose. Though NFHS covers a wide range of data, the nature and availability of district-level data on female health pose some limitations. Here, the study has excluded recently bifurcated districts such as Purba Barddhaman, Paschim Bardhhaman, Kalimpong and Alipurduar. Paschim Barddhaman district was constituted in April 2017 through the administrative bifurcation of the erstwhile Barddhaman district into Purba Barddhaman and Paschim Barddhaman. Consequently, during NFHS-4 (2015–16), survey data were reported only for the undivided Barddhaman district, and no disaggregated estimates were available for the area corresponding to the present Paschim Barddhaman and Purba Barddhaman districts. Similarly, Jhargram district was established in April 2017 by separating the western part of the former Paschim Medinipur district. But NFHS-4 and NFHS-5 provided data only for the undivided Paschim Medinipur district.

Table 1: Indicators used for Maternal Healthcare Index

Sl. No.	Indicators	Justification (with Citation/Reference)
1	Percentage of currently married women aged 15-49 years using any contraceptive method.	Contraceptive prevalence is a core indicator of reproductive health access and family planning integration, reducing unintended pregnancies, maternal mortality from high-risk births, and improving spacing for better maternal/nutritional recovery. It is widely used in NFHS-based composite indices and tracks progress toward SDG 3.7 (universal access to sexual/reproductive health services) (Alauddin, 2025; Panda et al., 2023).
2	Percentage of women with a live birth in the 5 years preceding the survey who had 4 or more antenatal care (ANC) visits.	Worldwide experience shows that four antenatal clinic (ANC) visits (WHO's Focussed Antenatal Care model, before 2016) can help lead to early recognition and management of complications; provide tetanus immunization, nutritional counselling, and birth preparedness; result in greater coverage of effective interventions with a simultaneous decrease in perinatal morbidity and mortality (Gupta et al., 2014).
3	Percentage of women with a live birth in the 5 years preceding the survey who received two or more TT (tetanus toxoid) injections during pregnancy.	Having two or more TT doses during pregnancy provides the neonate with reliable passive immunity, which protects the neonate from tetanus mortality. Notably, having two or more TT doses in a pregnancy will also protect the mother, especially in the face of incomplete prior vaccination. According to the NFHS-standard definition of 'protected at birth' in India and WHO recommendation a lifetime series of two or more TT doses is important (Blencowe et al., 2010).
4	Percentage of women with a live birth in the 5 years preceding the survey who took iron-folic acid (IFA) for at least 100 days.	Use of IFA daily for 100 days or more can prevent and treat iron-deficiency anaemia. Maternal morbidity and mortality in India are caused by a detachment of the placenta. In addition, it is also very important for the growth of the foetus. Moreover, this IFA regimen prevents low birth weight and preterm risk. Thus, one must observe that India's National Iron+(Kapil et al., 2019).
5	Percentage of live births in the 5 years preceding the survey delivered in a health facility.	The term 'institutional delivery' refers to giving birth in a hospital or health facility. This supplies expert delivery attendance to expectant mothers, plus prompt referral and treatment of life-threatening obstetric crises such as haemorrhage and obstructed labour. It provides access to emergency obstetric care and minimises maternal mortality and intrapartum neonatal death (Yakoob et al., 2011).
6	Percentage of women who had a live birth in the 5 years preceding the survey who received a postnatal check (PNC) within two days of birth for their most recent birth.	Postnatal care detects and manages postpartum haemorrhage, infection and hypertension and newborn problems within 48 hours, which is alarming for maternal and neonatal death (World Health Organization, 2022).

Source: Prepared by the author

Methods

Maternal Healthcare Index

The Maternal Healthcare Index (MHI) has been constructed to throw light on the general health condition of women in districts of West Bengal. These were done using Principal Component Analysis (PCA) based on indicators listed in Table 1. Principal Component Analysis is a form of dimensionality reduction method that aids in the formation of composite indices. Empirical studies have revealed that such methodology is quite appropriate in situations where observations are more than the components (variables) in case of small size samples (Hasan & Abdulazeez, 2021). Before calculating the principal component scores, all necessary assumptions were tested, including the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity. The final MHI was computed using the following formula:

$$MHI = \sum PC_i \times W_i$$

Where, PC_i indicates the individual principal component score like PC_1, PC_2,…., PC_n and W_i indicates the weight of the principal score, which is calculated by the percentage of explained variance of the individual PC to the total explained variance. The composite index was calculated by the weighted sum method. Maternal health services usage refers to the overall extent, quality, coverage and effectiveness of maternal health services accessed and utilized by women to assist them during pregnancy, at childbirth and in the care of their newborns immediately after childbirth. It is an overall indicator of the ability of a population (e.g. at district/state/national level) to achieve recommended levels of provision and uptake of maternal healthcare services. To put it another way, it means a composite measure of the level of availability and behaviour. The study applied natural breaking method in GIS platform for understanding the spatial variation across the state. Higher/positive MHI scores denote better overall maternal healthcare levels, while negative/ declining scores signal deterioration or persistent low performance in service uptake and integration.

Correlational Analysis

Correlation analysis was employed to examine the strength and direction of the relationships among the key variables of the study. Specifically, Pearson's correlation coefficient was utilized in this research to determine the linear relationships among the continuous variables. Here, the study considered ANC visits, TT injections, IFA supplementation, contraceptive methods, institutional delivery, and postnatal check-ups.

Spatio-temporal Differential Clustering

To analyse spatio-temporal changes, this study employed the Differential Local Moran's I statistic to detect differential clustering patterns across two time periods: 2015-2016 and 2019-

2021. Local Moran's I is a Local Indicator of Spatial Association (LISA) that identifies spatial clusters and spatial outliers by measuring the degree of similarity between a location and its neighbours. Moreover, it is universally applicable for the sample size for local Moran's I (global or local), which depends on the spatial arrangement, the weight matrix and how significance was assessed (Anselin, 1995; Chen, 2013). This study obtained the weight matrix through the queen contiguity method. To detect changes over time, the Local Moran's I values were computed for both 2015-2016 and 2019-2021. Differential clustering was then assessed by comparing the LISA cluster maps from both periods to identify locations where statistically significant spatial clustering patterns (e.g., High-High, Low-Low, High-Low, Low-High) have changed.

Results

The analysis has been done at the district level of West Bengal. Before that, the overall performance of the state for the selected indicators as per NFHS-4 and NFHS-5 has been briefly examined.

West Bengal: At a Glance

The study shows that all maternal health indicators have increased with time in the state, with a small decline in the proportion of the indicators showing the percentage of women with a live birth in the 5 years preceding the survey who had 4 or more antenatal care visits and who received two or more TT (tetanus toxoid) injections during pregnancy. However, the drop was less than 1 per cent point. Remarkable improvements have been observed in the case of percentage of women with a live birth in the 5 years preceding the survey who took iron-folic acid (IFA) for at least 100 days (34.5 per cent points) and then in the case of the percentage of live births in

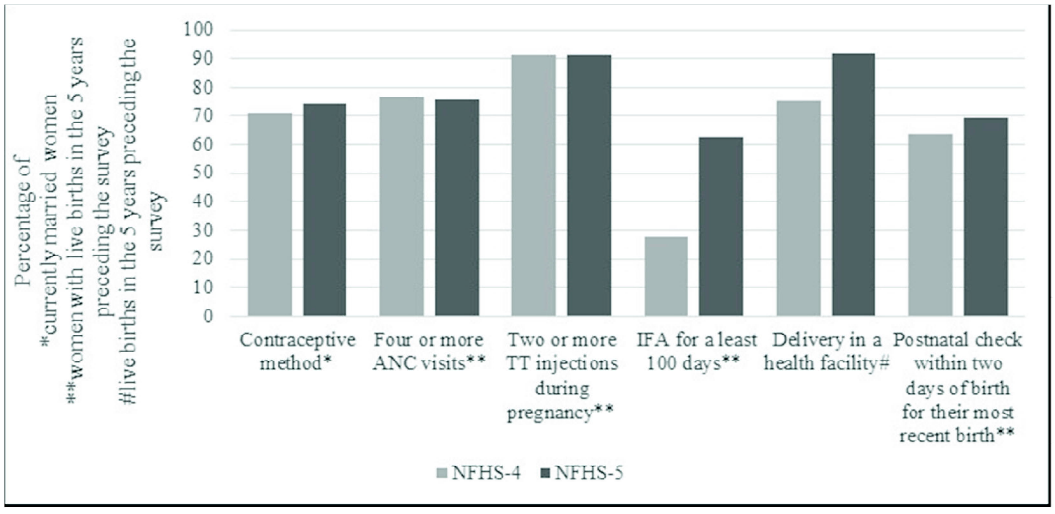

Fig. 2: Status of Maternal Healthcare Indicators in West Bengal

the 5 years preceding the survey delivered in a health facility (16.5 per cent points). It is to be noted here that the incidences of taking IFA for at least 100 days and a postnatal check within two days of birth for the most recent birth generally had poor performance in comparison to other indicators during both NFHS-4 and NFHS-5 (Fig. 2).

District Level Analysis

The comparison between the 2015-16 and 2019-21 component matrices indicates a structural shift in the underlying dimensions of maternal and reproductive health service utilisation among women at the district level. In 2015-16, a single dominant component explained a large proportion of the variance (46.8%) with high loadings for institutional deliveries (0.889), IFA intake (0.844), postnatal check-ups (0.836), and ANC visits (0.706), suggesting a highly integrated pattern of maternal health service uptake, where utilisation of one service was strongly associated with others. TT injections (0.901) and contraceptive use (0.782) were loaded onto a secondary component, indicating they represented a relatively distinct dimension of maternal healthcare.

However, by 2019-21, the factor structure changed substantially. Two components now explained almost equal proportions of the variance (38.16% and 34.2%), reflecting a bifurcation in healthcare-seeking behaviour. Notably, contraceptive use showed an exceptionally high loading (0.955) on Component 2, while maternal healthcare services such as institutional delivery (0.798) and postnatal check-ups (0.783) were parts of Component 1, having lower loadings than in 2015-16 (Table 2). Furthermore, in 2019-21 the loading intake dropped to 0.673 for IFA, increased to 0.955 for contraceptive use, and ANC visits remained moderate (0.731). In 2019-21 ANC visit was loaded on Component 2. The reduced KMO value in 2019-21 (0.555 compared to 0.758 in 2015-16) suggests a weakening in the overall correlation structure of the data rather than the variables themselves. Besides, the socio-economic conditions can weaken the relationships among the variables, which further increases the partial correlation among variables, and therefore, reducing the shared common variance at KMO measures (Kaiser, 1974).

The analysis of district-wise Maternal Healthcare Index (MHI) scores from 2015-16 to 2019-21 reveals significant spatial disparities and temporal shifts in maternal healthcare outcomes in West Bengal.

Districts such as Bankura (0.762 to -0.527), Birbhum (0.421 to -0.004), Hugli (0.524 to -0.076), Paschim Medinipur (0.379 to -0.096), Purba Medinipur (0.162 to -1.346), Puruliya (-0.436 to -1.478), and Murshidabad (-0.318 to -0.883) showed declines in MHI scores, indicating deterioration in maternal healthcare conditions. Meanwhile, urban districts like Kolkata (0.782 to 0.703) maintained high MHI scores with minor declines, indicating relative stability but pointing to areas requiring sustained intervention to prevent stagnation. The districts surrounding Kolkata, specifically North Twenty-Four Parganas (0.143 to 1.182) and South Twenty-Four Parganas (-0.553 to 0.545), show

remarkable trends of improvement Fig. 3. The exception here is Hugli (0.524 to -0.076). Among the districts of north Bengal, Jalpaiguri (-0.352 to 0.815), Dakshin Dinajpur (-0.127 to 0.729) and Koch Bihar (-0.185 to 0.247) achieved positive scores in 2019-21, unlike in 2015-16. Maldah (-1.412 to -0.235) and Uttar Dinajpur (-1.908 to -0.683) improved noticeably, reflecting a considerable positive change, though remaining on the negative side, which indicates partial progress. Only Darjiling (0.698 to 0.561) had a downfall during this period (Figure 3).

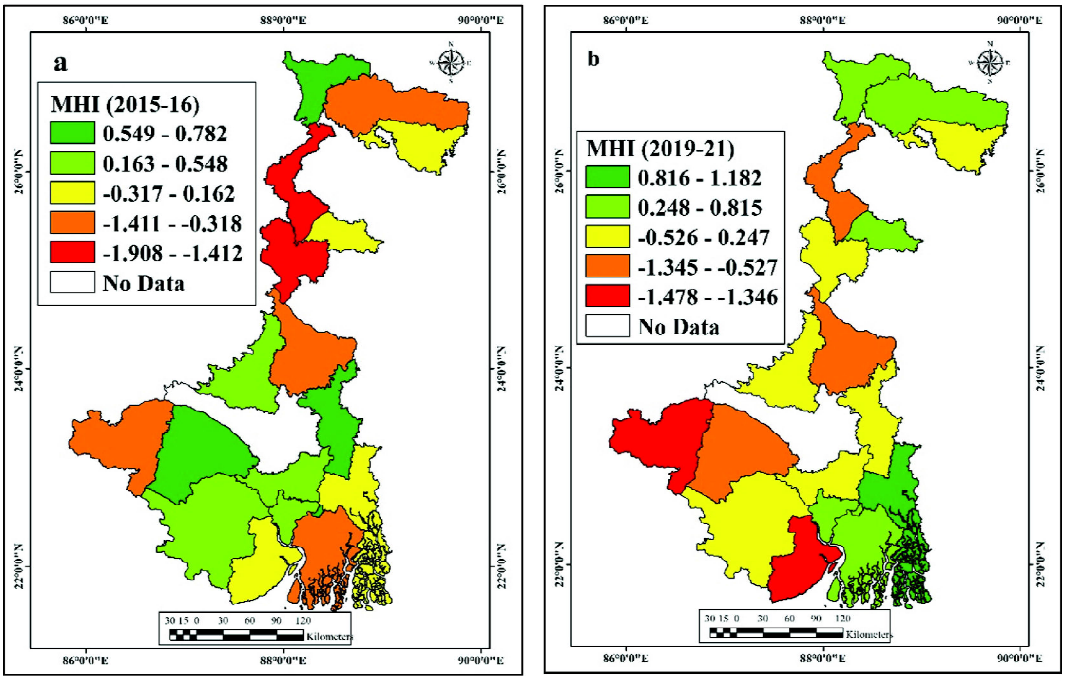

Fig. 3: District-wise Status of MHI (2015-16 & 2019-21)

The correlational structure between maternal health services indicators shows a conspicuous shift from 2015-16 to 2019-21 (Table 2a & b), which can be seen as changing patterns in service utilisation and integration of programmes. In 2015-16, there were significant and positive associations between antenatal care (ANC) visits and iron-folic acid (IFA) consumption ($r = 0.592$, $p = 0.008$), contraceptive use ($r = 0.521$, $p = 0.022$), institutional delivery ($r = 0.693$, $p = 0.001$) and postnatal check-up ($r = 0.503$, $p = 0.028$), which implies a relatively continuum-based maternal healthcare facility. Institutional delivery was also found to have a very strong association with postnatal care ($r = 0.755$, $p < 0.001$) indicating effective sequencing of services in this period also. In contrast, the correlations in 2019-21 show a partial fragmentation of this continuum, where institutional delivery is no longer significantly correlated with either ANC visits, contraceptive

Table 2: Principal Component Analysis of Maternal Healthcare Indicators, 2015-16 and 2019-21

Component Matrix (2015-16)			Component Matrix (2019-21)		
	Component			Component	
	1	2		1	2
Percentage of live births in the 5 years preceding the survey delivered in a health facility	0.889		Percentage of live births in the 5 years preceding the survey delivered in a health facility	0.798	
Percentage of women with a live birth in the 5 years preceding the survey who took IFA for at least 100 days	0.844		Percentage of women who had a live birth in the 5 years preceding the survey who received a postnatal check within two days of birth for their most recent birth	0.783	
Percentage of women who had a live birth in the 5 years preceding the survey who received a postnatal check within two days of birth for their most recent birth	0.836		Percentage of women with a live birth in the 5 years preceding the survey who took IFA for at least 100 days	0.673	
Percentage of women with a live birth in the 5 years preceding the survey who had 4 or more ANC visits	0.706		Percentage of women with a live birth in the 5 years preceding the survey who received two or more TT injections during pregnancy	0.631	0.587
Percentage of women with a live birth in the 5 years preceding the survey who received two or more TT injections during pregnancy		0.901	Percentage of currently married women age 15-49 years using any contraceptive method		0.955
Percentage of currently married women age 15-49 years using any contraceptive method		0.782	Percentage of women with a live birth in the 5 years preceding the survey who had 4 or more ANC visits		0.731
Rotated Eigenvalues	2.808	1.711	**Rotated Eigenvalues**	2.29	2.052
% of variance	46.8	28.53	**% of variance**	38.16	34.2
% of cumulative variance	46.8	75.33	**% of cumulative variance**	38.16	72.36
proportion of variance to total explained variance (weightage)	0.62	0.38	**proportion of variance to total explained variance (weightage)**	0.53	0.47
KMO	0.758		**KMO**	0.555	
Bratlett's test of spherecity	Chi-square 45.726, p-value 0.001		**Bratlett's test of spherecity**	Chi-square 53.568, p-value 0.001	
Extraction Method: Principal Component Analysis Rotation Method: Varimax with Kaiser Normalisation a. Rotation converged in 5 iterations			Extraction Method: Principal Component Analysis Rotation Method: Varimax with Kaiser Normalisation a. Rotation converged in 3 iterations		

Source: Prepared by the author

Table 2a: Correlation Analysis (2015-16)

		ANC visit	TT injection	IFA	Contraceptive method	Institutional delivery	Postnatal check
ANC visit	**Pearson's r**	—					
	df	—					
	p-value	—					
TT injection	**Pearson's r**	0.363	—				
	df	17	—				
	p-value	0.127	—				
IFA	**Pearson's r**	0.592	0.062	—			
	df	17	17	—			
	p-value	0.008	0.800	—			
Contraceptive method	**Pearson's r**	0.521	0.511	0.437	—		
	df	17	17	17	—		
	p-value	0.022	0.025	0.061	—		
Institutional delivery	**Pearson's r**	0.693	0.281	0.685	0.432	—	
	df	17	17	17	17	—	
	p-value	0.001	0.243	0.001	0.065	—	
Postnatal check	**Pearson's r**	0.503	0.184	0.540	0.246	0.755	—
	df	17	17	17	17	17	—
	p-value	0.028	0.451	0.017	0.309	<.001	—

Source: Prepared by the author

Table 2b: Correlation Analysis (2019-21)

		ANC visit	TT injection	IFA	Contraceptive method	Institutional delivery	Postnatal check
ANC visit	**Pearson's r**	—					
	df	—					
	p-value	—					
TT injection	**Pearson's r**	0.556	—				
	df	16	—				
	p-value	0.017	—				
IFA	**Pearson's r**	0.587	0.577	—			
	df	16	16	—			
	p-value	0.010	0.012	—			
Contraceptive method	**Pearson's r**	0.622	0.578	0.369	—		
	df	16	16	16	—		
	p-value	0.006	0.012	0.132	—		
Institutional delivery	**Pearson's r**	0.338	0.457	0.392	0.033	—	
	df	16	16	16	16	—	
	p-value	0.170	0.057	0.107	0.895	—	
Postnatal check	**Pearson's r**	0.461	0.708	0.579	0.116	0.344	—
	df	16	16	16	16	16	—
	p-value	0.054	0.001	0.012	0.647	0.162	—

Source: Prepared by the author

use or postnatal care, indicating possible saturation effects or possible decoupling of delivery services from routine maternal follow-up services. However, linkages among preventive and preparatory services were strengthened as shown by significant correlations between ANC services and tetanus toxoid (TT) injection ($r = 0.556$, $p = 0.017$), IFA intake ($r = 0.587$, $p = 0.010$) and contraceptive use ($r = 0.622$, $p = 0.006$). Notably, postnatal care in 2019 to 21 became increasingly associated with TT injection ($r = 0.708$, $p = 0.001$) and IFA consumption ($r = 0.579$, $p = 0.012$), implying that the linkage evolved to be more towards preventive care integration rather than delivery-centric linkage. Overall, from a comparative analysis it appears that there is a shift from a delivery driven maternal health continuum in 2015-16 to a more segmental yet prevention-oriented service structure in 2019-21 dependent on evolving programme priorities, changes in behaviour, and potential disruptions in the institutional delivery-postnatal care linkage over time.

Spatio-temporal Differential Analysis

This section analyses the spatio-temporal changes through differential clustering by local Moran's I, which indicates that significant changes in spatial clustering have occurred between 2015-16 and 2019-2021. Figure 3 illustrates the differential LISA cluster analysis of the Maternal Healthcare Indicator (MHI) in West Bengal across two time-frames—2015-16 and 2019-21—using Local Moran's I. The purpose is to identify statistically significant spatial clusters where the MHI has either improved or declined, and to highlight local spatial auto-correlation patterns that have changed over time. Several clusters define different scenario, as mentioned below.

a. *High-High Cluster:* One district in north Bengal i.e. Dakshin Dinajpur forms a significant High-High cluster Fig. 4, indicating consistent high MHI performance in both time periods and strong positive spatial auto-correlation. This suggests the district and its neighbours have jointly improved or retained high standards of maternal healthcare.

b. *Low-Low Cluster:* A group of districts in south-western West Bengal i.e. Bankura and Paschim Medinipur displays Low-Low clustering, signifying spatial concentration of poor MHI outcomes over time. This implies persistent underperformance in maternal healthcare services with negative spatial reinforcement.

c. *Low-High Cluster:* The northernmost district, Darjiling falls under the Low-High category. This district has relatively poor MHI, but is adjacent to districts with better performance, pointing to possible spill over opportunities for targeted intervention and policy diffusion.

d. *Non-Significant and Not Considered*: Most districts fall into non-significant categories. Non-significant areas show no strong spatial autocorrelation, suggesting random patterns or mixed performance over time. Not Considered districts (Purba Bardhaman and Paschim Bardhaman) were excluded due to incomparable data between two periods.

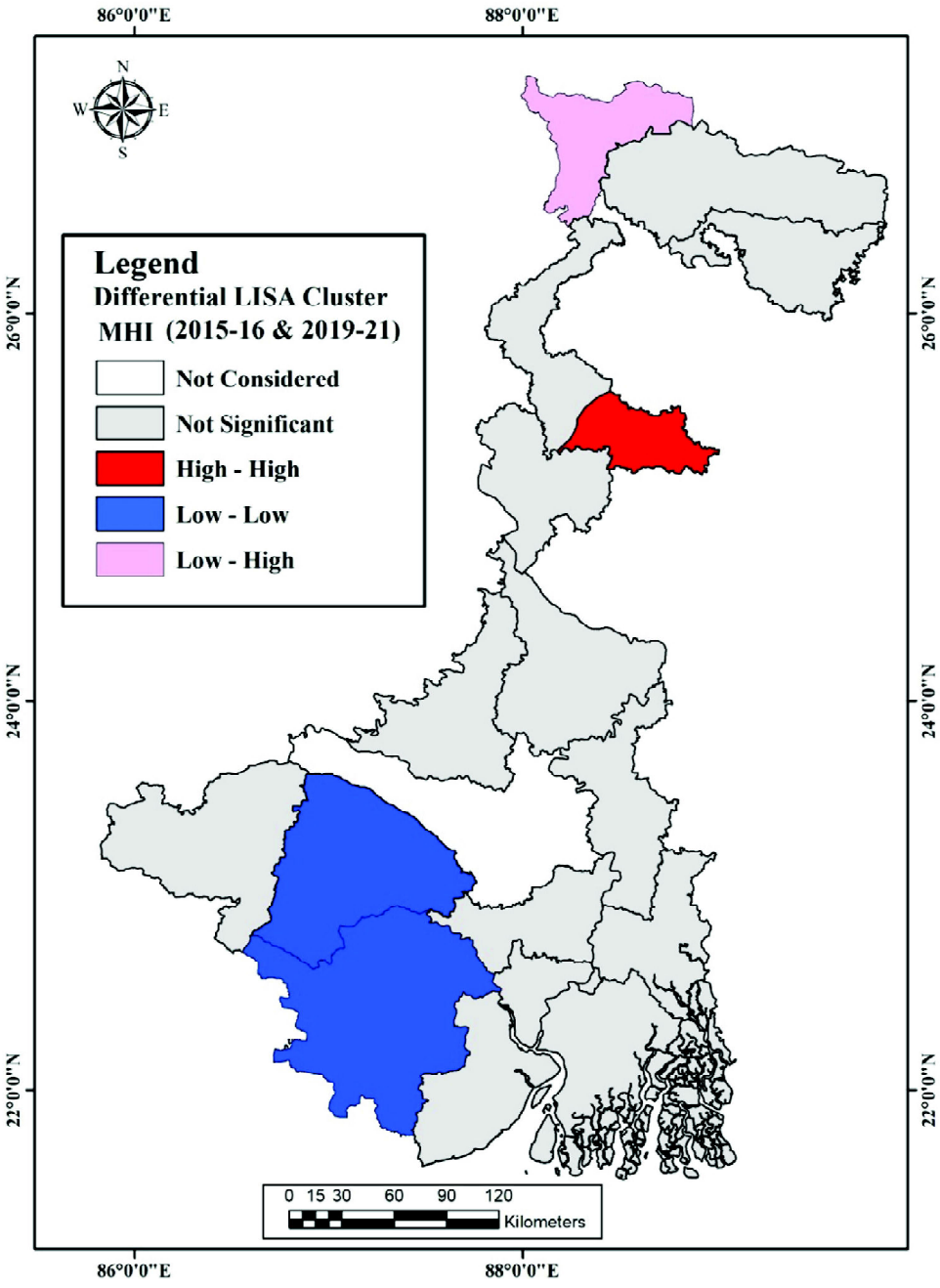

Fig. 4: Differential Spatial Clustering over the Period 2015-16 and 2019-21.

Discussion

The utilisation of maternal healthcare services is not the same across the districts of West Bengal and the inter-district differences in utilisation are likely due to differences in availability and accessibility of services among the districts (Sen et al., 2018). In the case of MHI of 2019-21, the high-ranking districts were predominantly from the northern part of the state, and quite understandably, from Kolkata and its surrounding areas. Examples include the first and second ranking districts of North Twenty-Four Parganas and Jalpaiguri respectively. Poor performers are mostly from the western and central parts of the state, for instance the last ranking district of Puruliya and Murshidabad holding the sixteenth rank. But the pattern of 2015-16 was of more mixed type. High scorers, such as Kolkata, Haora and Hugli, were mostly from the southern part. But the low scorers, like Puruliya, Maldah, Jalpaiguri and Dakshin Dinajpur, were mainly from western and northern parts. In fact, the study by Sinha and Basu, (2022) shows the presence of stark disparity between the northern and southern zones in maternal healthcare scenario. Additionally, Differential Local Moran's I analysis shows that the south-western districts (Bankura and Paschim Medinipur) belong to low-low spatial clusters, while high-high cluster is found in Dakshin Dinajpur in the north. Although many literatures discuss the poor status of ANC visits and their disparities as a major problem in maternal healthcare system of West Bengal (Ghosh and Mistri, 2015; Debsarma et al., 2022), the present study observes notable differences at the district level in indicators such as PNCs (range: 38.1 percent points in 2019-21), contraceptive use (range: 34.4 percent points in 2019-21) and TT injections (range: 31.6 percent points in 2019-21), along with ANC visits (range: 33.1 percent points in 2019-21), and to a lesser extent in case of IFA intake (range: 24.8 percent points in 2019-21) and delivery in health facilities (range: 21.5 percent points in 2019-21). On the whole, remarkable positive improvements in MHI are noted in Uttar Dinajpur, Jalpaiguri, Maldah, South Twenty-Four Parganas and North Twenty-Four Parganas, indicating enhanced maternal healthcare service utilisation and outcomes over the period. These improvements may reflect effective implementation of maternal healthcare programs and family planning interventions (e.g., Mission Parivar Vikas), increased health awareness, and better access to institutional services. In contrast, substantial decrease in MHI scores of Bankura, Purba Medinipur and Puruliya is particularly concerning, suggesting possible service delivery gaps, inadequate programme reach, or socio-economic vulnerabilities affecting maternal health status. Longchar et al. (2025) showed that the complete Continuum of Care utilization in India was 50% during NFHS 5, an 11.3%-point increase from NFHS-4. Dandona et al. (2024) notes that nationally the Human Opportunity Index indicates that there is a 34.6 per cent improvement in the equity of postnatal care. However, this does not hold true at the state level. Further analysis indicates that in spite of following the national trend of overall improvement there exist clustering pattern of development across West Bengal.

Such regional differences are noticed due to various geographical, cultural and socio-economic factors. First, both availability and quality of services differ widely. In the two neighbouring districts of Kolkata, namely North Twenty-Four Parganas and South Twenty-Four Parganas where

primary healthcare infrastructure (PHCs and sub-centres) is well available, while in south-western districts such as Bankura and Puruliya, there is a shortage of staff and poor-quality facilities at, which limit service uptake (Debsarma et al., 2022; Bango & Ghosh, 2022). Geographical barriers accentuate these problems. In both the hilly northern district of Darjiling and the remote tribal areas of the south-western region, rugged terrain or remoteness increases the distance of the target population from facilities and delays timely access to ANC or PNC (Chakraborty & Jana, 2025; Hiwale & Das, 2022; Tripathi et al., 2024). Another contributing factor is cultural norms. The traditional beliefs and distrust of institutional delivery among a high proportion of the tribal population in Puruliya and Bankura result in low uptake of institutional delivery and TT (Ali & Chauhan, 2020). These are reflective of national trends, with 30-40% inequalities in maternal care accounted for by rural-urban and wealth-related differentials (Ali & Chauhan, 2020; Guilmoto & Dumont, 2019). Conditional cash transfers of Janani Suraksha Yojana (JSY) increased institutional deliveries in rural-remote areas and low-performing regions (Debsarma et al., 2022; Lim et al., 2010). In the same way, Janani Shishu Suraksha Karyakaram (JSSK) and Pradhan Mantri Matru Vandana Yojana (PMMVY) eased financial burden on antenatal and postnatal care (Chakraborty & Jana, 2025). However, many south-western districts might be facing implementation bottlenecks and several vulnerabilities and outreach is not strong enough.

Limitation of the Study

The key source of this analysis is the NFHS-4 (2015-16) and NFHS-5 (2019-21). The use of secondary data imposes certain limitations on the district-level analysis of the maternal healthcare gap in West Bengal. While the NFHS data is valuable, there is little insight about the current quality of services, the condition of health facilities, the district-level challenges in implementing the programmes, and other contextual information that influence the decision to avail maternal healthcare services, among others. The survey data are likely to be affected by recall biases and social desirability biases, especially in the case of self-indicators. While the NFHS data does offer district-level estimates that are nationally representative, the sample sizes in these districts are small, which restricts their precision, especially for rare events and small population sub-groups. In addition, some NFHS-4 districts were bifurcated to create new districts, which posed comparability issues. This further led to the exclusion of a few NFHS-4 districts from NFHS-5 versus NFHS-4 comparisons. The NFHS design likewise does not permit triangulation of findings with complementary sources like records available at health facilities (HMIS), direct observation of the facility, assessment of inventory records, qualitative data from field visits or findings from focused.

Conclusion

Analysis of district-wise maternal healthcare in West Bengal based on NFHS-4 (2015-16) and NFHS-5 (2019-21) data shows an improvement at the state level but widening inter-district gap. For instance, institutional delivery which has increased to about 92 per cent. In contrast, the other aspects of comprehensive antenatal care, namely the supplementation of iron-folic acid

(IFA) for 100 days and early postnatal check-up, have either stagnated or increased in few districts. The maternal care data for 2015-16 is more 'integrated' and represents full antenatal and postnatal care. In contrast, the data for 2019-21 is more fragmented and more 'prevention-oriented', with contraceptive use becoming totally disconnected from the rest of the services. From a spatial standpoint, several northern districts of West Bengal, including Jalpaiguri, Dakshin Dinajpur, and Koch Bihar, along with the districts surrounding the Kolkata metropolitan area, have witnessed an upgradation from negative to positive. The inter-district differences that have been highlighted above are mainly related to the availability of infrastructure, literacy, media exposure and robustness of schemes linked with National Health Mission, level of socio-economic development, caste and tribal backwardness etc. These correlate with recent evidence from smaller studies and aggregate state level findings from NFHS-5 (national) that show overall improvements that are considerably uniform with SDG-related policies but wide divergence at sub-state levels (intra-state inequalities). For revamping primary and secondary healthcare for maternal and child through strengthening of infrastructure, mobile health services, behavioural change, initiatives sensitive to cultural belief and practices, stronger continuum of care, context-specific multi-sectoral strategies especially in high-focus districts, research to identify implementation bottlenecks and equity focussed monitoring using continuum of care and spatially disaggregated real-time data are important. Therefore, there is a need to have a decentralized and district focused evidence driven and equity focused strategy. Such attempts may set the platform ready for the SDG 3 (Health and Wellbeing) targets.

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