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# Time-Series Analysis of Maternal and Child Health Indicators Using HMIS Data: Application of Moving Averages to Assess Health System Performance in West Bengal

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**Abstract**
*Background: To achieve progress towards the Sustainable Development Goals (SDGs), regular interventions and monitoring of maternal and child health indicators are crucial. However, any shift in the data about the Health Management Information System (HMIS) can be distortionary. The moving average technique is applied in the analysis of time-series data in this research to assess the performance of the health system.*
*Methods: Data from HMIS on the following key indicators of MCH services were analysed: antenatal care (ANC), Institutional delivery, postnatal care (PNC), immunisation, caesarean section rate and inpatient mortality were analysed through a retrospective time-series analysis using HMIS data. The variability over shorter periods was removed by applying a moving average over the previous 3 years, indicating the longer-term trends. The indicators have been analysed in the relation to the trend and in relation to the phases of change and also aligned with the SDG targets.*
*Results: There were three distinct stages; fluctuation, growth and plateau. There has been good stabilization of immunization and almost universal coverage in institutional deliveries. Progress of ANC and PNC was gradual. Caesarean section rates were still not optimal. There were fluctuating but somewhat decreasing inpatient mortality rates. Improvements were continued over time as shown by moving averages.*
*Conclusion: While there is a progress in access to MCH services, there is a need to pay more attention to service quality and rational use of medical interventions, especially because of low trends in some indicators and high caesarean section rates. Routine data can be analysed by moving averages to inform evidence-based policy decision-making.*

**Keywords: HMIS, Maternal Health, Child Health, Moving Average, Time- Series Analysis, SDG 3, Health System, West Bengal**


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## 1. Introduction

Maternal and child health (MCH) is still a key public health agenda item within the Sustainable Development Goals (SDGs), especially when it comes to maternal and child mortality. The adoption of various interventions under the National Health Mission (NHM) in India has led to significant improvements in key indicators like institutional delivery, antenatal care (ANC) and immunization coverage in the past two decades (Singh et al., 2021). The widespread adoption of Health Management Information System (HMIS) has enhanced the monitoring of health services on a routine basis, although there have been inconsistencies in reporting, seasonal variations and administrative shuffling affecting HMIS data (Bala, 2016). These fluctuations can be addressed using statistical methods including using moving averages to effectively dampen the short-term fluctuations and uncover the longer-term trends in the performance of a health system (Hyndman & Athanasopoulos, 2021).

As per the National survey, India has made significant strides in maternal and child health care service delivery with the help of various initiatives such as Janani Suraksha Yojana and Mission Indradhanush and the NFHS-4 and NFHS-5. These programmes have led to a rise in institutional delivery and coverage of vaccination, especially for children and vulnerable groups (Kiran et al., 2022). Yet, there are questions of inequities, quality of care and the "over-medicalisation" of this. Although there has been improvement in maternal and neonatal outcomes with higher institutional deliveries, there has been no commensurate improvement in all aspects of the quality and continuity of care (Singh et al., 2021). Furthermore, increased c-section rates, particularly in the private health sector, have become an issue, as medically unnecessary caesarean may indicate commercialization and poor oversight of maternal health services (Betrán et al., 2018).

Maternal and child health (MCH) indicators show a high degree of regional variation in India which is significant with respect to West Bengal. While the state has relatively good performance in some MCH indicators, research shows that these aggregate results mask significant inequities between districts and between socioeconomic groups in accessing MCH services (Chakraborty & Jana, 2025; Ghosh et al., 2016). Differences in antenatal care, institutional delivery and Caesarean section rates reflect differences in access, quality, and continuity of health services, especially between urban-private and rural underserved areas. Although maternal and neonatal deaths are common in the postnatal period, postnatal care is still relatively weak, even in the face of improvements in the quality of antenatal and delivery care. Existing studies also underscore that low quality referral system, poor follow up and lack of counselling leads to less effective post natal care in India.

Although a lot of literature has been published on maternal and child health in India, the majority of them use cross sectional survey data like NFHS which cannot detect the short term changes and temporal trends. Unfortunately, limited research exist which focuses on using longitudinal HMIS data and newer time-series techniques (like moving averages) to analyze temporal trends in health system performance.

## 2. Problem Definition

Despite the marked improvement in these indicators of maternal and child health in India, there are high regional inequalities, poor quality

of healthcare and also increasing medicalisation, especially in West Bengal. The studies done so far mostly use cross-sectional survey data, which are low in describing changes over time and trends. The Health Management Information System (HMIS) generates routine health information on series of events, but the use of the potential of time-series analysis is underutilized. Thus, maternal and child health trends analysis by applying HMIS data and moving average methods should be done to understand the performance and health progress of the health systems in order to achieve the SDG targets.

## 3. Study Objective

To analyze time-series trends in maternal and child health indicators using HMIS data, apply moving average techniques to identify underlying patterns, and assess progress in relation to SDG targets.

## 4. Material and Methods

### 4.1 Study Design

A retrospective analytical study was conducted using secondary data from HMIS over a multi-year period.

### 4.2 Data Source

Data were obtained from the national HMIS database, which captures routine service delivery information from both facility based and community based services across India. The indicators that were chosen for analysis were:

- First trimester ANC registration
- Institutional delivery
- Safe delivery
- Postnatal care (PNC)
- Early breastfeeding
- BCG
- Measles
- Full immunization
- Immunization session planned vs Held
- Caesarean section rate
- Inpatient mortality rate

The indicators used in this study were chosen to comprehensively cover the continuum of maternal and child health and reflect health system performance. Access to and use of maternal services during pregnancy and childbirth are measured through maternal indicators, including: antenatal care in the first trimester, institutional delivery, and safe delivery. Postnatal care within 48 hours, early breastfeeding, birth weight and immunization (BCG, measles, and full immunization) are indicators of both immediate newborn care and child survival interventions. To measure service delivery capacity and quality of care, health system indicators, including sessions held, in-patient deaths and caesarean section rate, were included. These indicators support SDG 3 priorities and national health programmes, allowing for an integrated assessment of service coverage, quality and outcomes.

### 4.3 Data Analysis

**Time-Series Analysis**

Annual trends were analyzed for each indicator to assess direction (increase, decrease, or stable) and pattern.

**Moving Average**

A 3-year moving average was applied to smooth short-term fluctuations and highlight long-term trends. This approach reduces the influence of irregular variations and improves interpretability.

**Analytical Framework**

Indicators were analyzed based on:

- Trend direction
- Phases (fluctuation, growth, plateau)
- Variability (smooth vs fluctuating)
- Alignment with SDG 3 targets

### 4.4 Ethical Considerations

The study used publicly available secondary data and did not involve human subjects; therefore, ethical approval was not required.

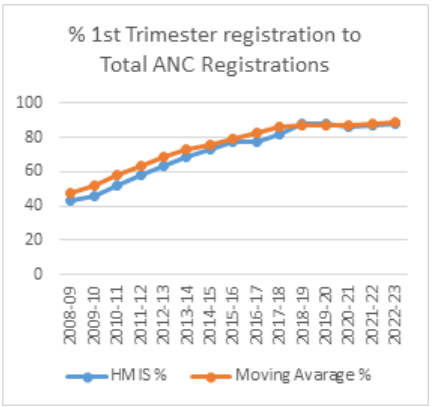
## 5. Results

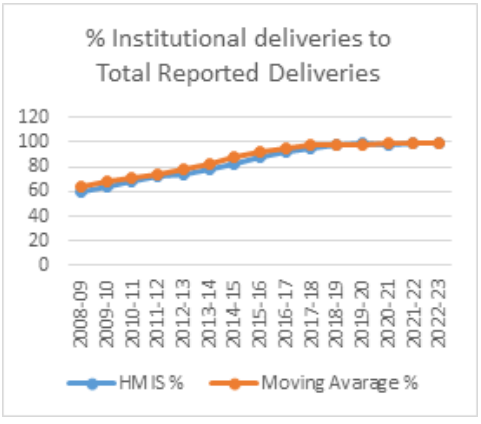
The time-series analysis revealed distinct patterns across indicators.

**Table 1**

| Indicator (HMIS) | Aligned SDG Indicator | Trend & Phase | Interpretation | Programmatic Linkage | Time Series Nature |
|---|---|---|---|---|---|
| 1st Trimester ANC Registration | SDG 3.1 (Maternal health) | Increasing; fluctuation → growth → plateau | Improved early contact with health system; better risk identification | National Health Mission outreach, ASHA mobilization | Moderately fluctuating |
| Institutional Delivery | SDG 3.1.2 (Skilled birth attendance proxy) | Strong increase; growth → plateau | High facility-based delivery coverage achieved | Janani Suraksha Yojana | Smooth |
| Safe Delivery | SDG 3.1 | Increasing; growth → plateau | Improved skilled care at birth | SBA training, facility strengthening | Smooth |
| Postnatal Care (PNC) | SDG 3.2 (Neonatal survival) | Gradual increase | Strengthening continuum of care after delivery | HBNC under NHM | Moderately fluctuating |
| Early Breastfeeding | SDG 3.2 | Increasing; plateau | Improved essential newborn care practices | Facility counselling, SNCU | Smooth |
| Full Immunization | SDG 3.2.1 (Child survival) | Increasing → plateau | Near-universal immunization coverage | Mission Indradhanush | Smooth |
| C-section Rate | SDG 3.1 (quality of maternal care) | Increasing (above optimal levels) | Possible over-medicalization; not always clinically justified | Emergency obstetric care expansion under NHM | Smooth rising |
| Inpatient Death Rate | SDG 3.1 & 3.2 (mortality outcomes) | Fluctuating; slight decline | Reflects variability in quality of care and case severity | Quality improvement initiatives | Highly fluctuating |

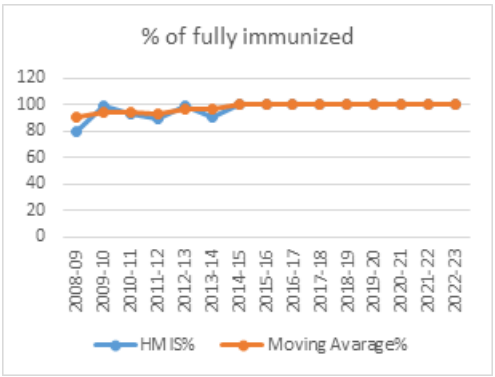
### 5.1 Maternal Health Indicators

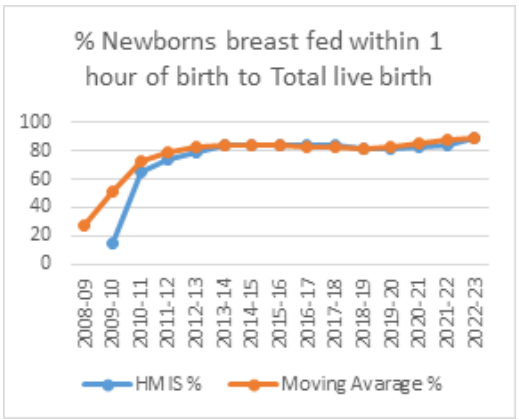


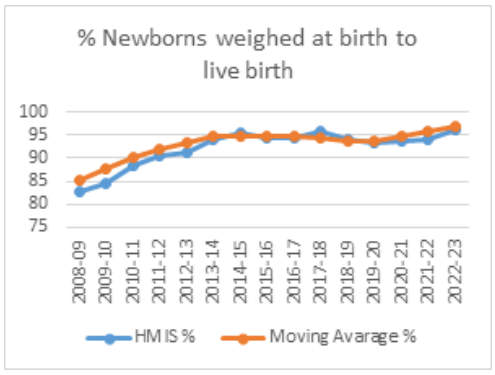



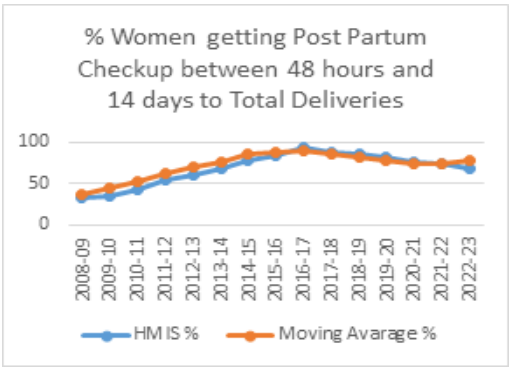
First trimester ANC registration showed a gradual increase over time, with initial fluctuations followed by stabilization. Institutional delivery demonstrated a strong upward trend, eventually reaching a plateau, indicating near-universal coverage. Safe delivery followed a similar pattern.

### 5.2 Child Health Indicators



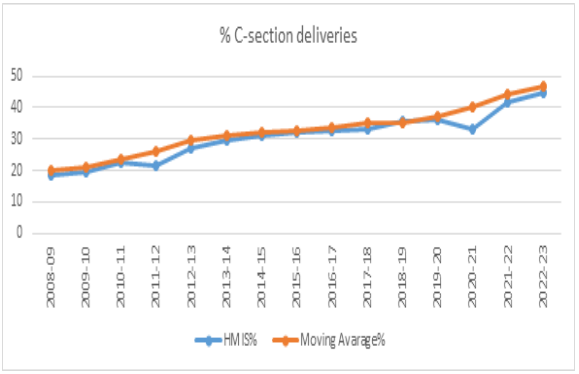



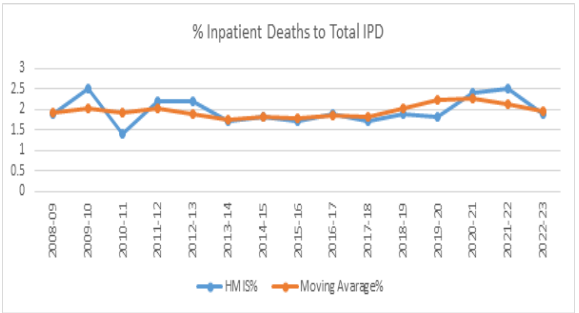

Immunization coverage increased steadily and plateaued at high levels. Early breastfeeding practices also improved, reflecting better adherence to newborn care protocols. Postnatal care showed gradual improvement but remained relatively variable.

### 5.3 Caesarean Section Rate




The caesarean section rate showed a consistent upward trend across the study period. Unlike other indicators, it did not plateau, suggesting continued increase beyond optimal levels.

### 5.4 Inpatient Mortality



Inpatient mortality exhibited fluctuations throughout the period, with a slight overall decline. Moving averages indicated underlying improvement, but variability remained high.

### 5.5 Moving Average Insights

**Table -2**

| Pattern Observed | Interpretation | Example Indicator |
|---|---|---|
| Raw fluctuates, MA smooth increases | True improvement despite variability | ANC, PNC |
| Both raw & MA increase | Strong program impact | Institutional delivery |
| MA plateaus | Saturation reached | Immunizatio n |
| MA increases steadily (undesirable indicator) | Systemic issue | C-section rate |
| Raw fluctuates, MA flat | No real improvement | Mortality |

The application of moving averages revealed that:

- Improvements in service coverage were sustained
- Early fluctuations were largely smoothed out
- Plateauing trends became more evident

## 6. Discussion

This study presents a detailed time-series analysis of maternal and child health (MCH) indicators, and applies the moving averages to better illustrate the underlying trends in the data, based on routine data from the Health Management Information System (HMIS). The results indicated a clear epidemiological and health system transition, with three phases of fluctuation, consolidation and plateauing of the epidemiological indicators of key services. This pathway is similar to what has been seen in other nations with limited resources, or low- and middle-income countries (LMICs), especially in the context of large-scale public health programs for delivering maternal and child health services.

This study's important methodological features include the adoption of the moving average technique to reduce the influence of short-term trends and detect long-term trends in indicators of child and maternal health. The seasonality of health data, reporting inconsistencies, and administrative changes make it difficult to interpret the programme progress. The study used moving averages to differentiate between random variation and ongoing improvement, following recommendations for the interpretation of routine health information systems in LMICs (WHO, 2016).

The results indicated a significant variation in indicators like ANC, PNC and newborn care practices at an early stage, which may be attributed to poor reporting systems, and poor programme implementation. As the major public health programmes under the National Health Mission were scaled up, such as Janani Suraksha Yojana (JSY), Janani Shishu Suraksha Karyakram (JSSK) and Mission Indradhanush, most indicators showed gradual improvement over the years.

The analysis also found that the extent of near-universal immunization coverage in the data from the HMIS was contrastingly lower in NFHS data, implying administrative underreporting because of errors with the target population or data duplication. During the latter phase, several indicators indicated signs of levelling off, indicating possible saturation in coverages. This underscores the shift from increasing access to enhancing quality, equity and sustainability of health care services in accordance with SDG 3 goals.

The present study reveals that rates of caesarean section (C-section) have been steadily rising over time as one of the most critical observations.The most crucial results of the present study are the sustained rise in the rates of caesarean section (C-section) over time. Although some rise in C-section rate is desired and accepted as services improve in access to emergency obstetric service, the steady increase beyond recommended rates is a matter of concern. World Health Organisation (2015) has indicated that population level rates of C-section greater than 10-15% are not linked to further decreases in maternal and newborn mortality. High rates of C-sections could be a sign of over-medicalization of childbirth, influenced by provider preference, incentives to the institutions, medico-legal concerns, and patient demand.

The data also shows that rates of C-section deliveries in India have increased dramatically and some states and private sector hospitals have higher rates of C-section deliveries (International Institute for Population Sciences, 2021).The results of this overall national trend were similar to that of the present study, which emphasizes that the rate of cesarean section births must be considered a measure of quality of care, rather than a measure of the availability of services. Increased pressure on health system resources and unnecessary health risks to women and newborns are among the potential harms that may occur with a rising cesarean section rate, which calls for a robust clinical governance, treatment guidelines, and monitoring of obstetric practices. Overall, the service coverage indicators for both the M&E period and the moving average analysis indicated stable improvement; however, the trends for inpatient mortality were mixed, indicating that the level of mortality is highly dependent on quality of services, referral systems and cases severity. The evidence points to a need for high-quality care during childbirth and the postnatal period as well as high coverage for improvements in maternal and child survival across the globe (WHO 2020).

The study found that there were differences between access-related indicators and continuity-of-care indicators. The institutional delivery and immunization indicators recorded consistent progress, while indicators of early breastfeeding and postnatal care exhibited more variation, thus reflecting the existence of gaps in the delivery continuum of care. The results indicate that while access to basic services has improved, quality, equity and continuity of care are new challenges for health systems.

The application of the Health Management Information System (HMIS) data along with the moving average approach was found to be effective in detecting the underlying trend of the routine health information as it helped in removing the short-term fluctuations in the health information. Due to the potential of the limitations in reporting, however, it is advisable to use survey-based evidence like NFHS in addition to HMIS data.

**Conclusion**

The study has overall shown a significant improvement on mother and child health service coverage, as well as new issues like increasing caesarean sections, quality of service variations and some indicators showing a lack of progress. The results point to the importance of moving towards quality, equity, rational use of health care interventions, and performance improvements to attain SDG and UHC and not only towards coverage expansion.

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