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Factors Enabling Data-Based Management in Healthcare: Insights from Case Studies of Eye Hospitals

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Abstract

Hospitals are complex systems that function most effectively when operations are coordinated and supported by real-time information and feedback loops. Sustained growth, quality improvement, and financial viability increasingly rely on data-based management (DBM), yet adoption and use vary widely across healthcare institutions. This study examined the enabling and hindering factors influencing DBM, with the aim of generating insights to strengthen data use and improve management of eye hospitals. A qualitative multiple case study design was employed in six purposefully selected eye hospitals in India, varying in size and baseline capacity for DBM. At each site, five to six key personnel were interviewed. Data collection involved audio-recorded interviews, transcripts, and field notes, and analysis followed a grounded theory approach using open and axial coding to identify themes, relationships, and develop a conceptual framework. Findings reaffirmed the core enablers—leadership commitment, data availability, and technology adoption. Additional drivers included operational adaptability, regulatory demands, systematic improvement practices, daily reporting, information policies, and the use of communication platforms such as WhatsApp. Key barriers were incomplete data entry, software limitations, inadequate analytical reporting, and inconsistent adherence to processes. Overall, effective DBM requires both foundational enablers and contextual drivers, while addressing barriers to institutionalizing data use and improving outcomes.

Keywords: data-based management (DBM); eye hospitals; healthcare operations; feedback loops; leadership and data use; continuous improvement; qualitative case study

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1. Introduction

Hospitals function as complex systems requiring seamless coordination across departments while simultaneously managing unpredictable patient conditions, fluctuating demand, and variable service times. Striking a balance between operational efficiency and quality care is essential, alongside strict adherence to legal and ethical standards. Integrating human-centered approaches with advanced technologies plays a pivotal role in optimizing patient outcomes and ensuring the sustainability of healthcare delivery [1,2]

The structure and design of an organization are central to its ability to function effectively. According to Galbraith [3], dividing tasks into specialized units can improve performance—but only if these units are well integrated through effective coordination.

In hospital operations, this principle is exemplified by closed-loop systems, which rely on feedback mechanisms and continuous monitoring to dynamically adjust workflows, resource allocation, and patient care processes. Closed-loop systems, unlike open-loop systems, are much more capable of converting uncontrollable factors into controllable ones [4]. Developing and managing closed-loop organizations and supply chains, on the one hand, and practicing evidence-based management and decision-making using data, on the other, are two sides of the same coin. These data-driven approaches help reduce inefficiencies, prevent delays, and improve quality by enabling proactive, real-time decision-making [5]. In essence, they are foundational to achieving operational excellence.

As healthcare systems strive for operational excellence, numerous quality frameworks have emerged, emphasizing core elements such as leadership, strategy, customer focus, human resources, operations, and results [6,7]. Across these frameworks, data-based management—referred to variously as decision-making with measurement, information analysis, or knowledge management—serves as a foundational pillar. Studies have shown that performance improvement tools such as benchmarking, closed-loop feedback [5], and continuous improvement are most effective when integrated with robust data practices [8].

Recent years have seen the rapid emergence of healthcare technologies such as electronic medical records (EMRs), mobile health (m-health), telemedicine, computerized physician order entry (CPOE), assistive digital services, and clinical decision support systems (CDSSs) [9,10]. These tools enhance decision-making by improving data accessibility, increasing processing speed, and enabling real-time analytics closer to the point of care [11]. The adoption of these digital innovations has been driven not only by practical benefits—such as improved diagnostics, patient monitoring, and efficiency—but also by institutional prestige and the pressure to remain competitive [12].

Despite these developments, many data initiatives fall short of transforming organizational decision-making. Surveys of large corporations have revealed that even with significant investments in big data and AI, challenges remain in treating data as a core business asset and achieving true data-driven cultures [13]. In healthcare, similar challenges persist—particularly in translating internal data into actionable insights and effectively utilizing them to inform day-to-day management and long-term strategic planning.

While existing literature highlights facilitators and barriers to data-driven decision-making, much of the research focuses on formal scientific evidence or external data [14,15]. Yet in practice, managing complex healthcare systems also requires the effective use of internally generated data—such as real-time information, performance indicators, service utilization patterns, and operational metrics—to drive continuous improvement. As stated earlier, data-based management and the development of closed-loop systems go hand in hand. However, possessing vast amounts of data without a closed-loop systems perspective can lead to information overload and limited utility. Without structured feedback mechanisms and responsive processes, data may accumulate without being translated into actionable insights. Healthcare organizations must therefore design controlled systems that can internalize and effectively respond to external factors—particularly those that introduce disturbances. Achieving this requires a deliberate strategy to manage uncertainty, enabling the organization to remain adaptive, resilient, and capable of making informed, real-time decisions.

Over the past decade, healthcare institutions have increasingly adopted digital technologies and expanded their capacity for data processing and management. However, the effective use of these tools—particularly at the managerial level—varies both across and within organizations.

This study aimed to explore the enabling factors that drive data-based management in eye hospitals, how these practices are implemented in day-to-day operations and management decision-making, and the key challenges hindering their effective implementation.

2. Methods

2.1. Ethics Approval and Consent to Participate

The study was conducted in accordance with the principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the institutional ethics committee (Reference No: RES2023007OR). Oral consent was obtained and recorded from all participants prior to the interviews. Participants were informed about the purpose of the study, assured of data confidentiality, and given the opportunity to ask questions before providing their consent.

2.2. Design

We conducted a qualitative case study to examine how internally generated data are utilized in management decision-making within eye hospitals. The study specifically focused on identifying key enabling factors and practices that drive data-based management, as well as the challenges encountered during its implementation. Given the exploratory nature of the research and the presence of several unknowns, a grounded theory approach was deemed appropriate. Grounded theory supports an open-minded, inductive exploration of emerging patterns, allowing new and unbiased concepts to surface organically from the data [16,17].

Ganesh Babu B. Subburaman, the principal investigator of this research, has a background in healthcare management and experience working with eye hospitals in a consulting capacity, particularly focused on improving performance, outcomes, and enabling data-based management capacity through training and implementation of IT solutions. The current study is part of the researcher's doctoral work on *Evidence-Based Management: Enablers, Challenges, and Outcomes*, and draws upon both academic inquiry and practical experience in the field to explore how healthcare organizations can adopt evidence-driven approaches to decision-making and continuous improvement.

At the same time, being familiar with the settings required paying careful attention to potential bias. To manage this, the researcher engaged in reflective journaling and held regular discussions with peers to question assumptions and interpretations. Data were collected from multiple sources using interviews, observations, and internal documents to ensure that the findings reflected a range of perspectives.

To reduce the influence of prior professional relationships, the researcher took care to maintain a neutral and open approach during interviews. These steps helped strengthen the credibility, reliability, and objectivity of the research.

2.3. Context

This study was conducted in six eye hospitals operating across India. These hospitals vary in size and service volume but share a common mission of delivering high-quality, affordable eye care. All participating hospitals have adopted information technology systems to support patient care and hospital operations. Four hospitals have recently implemented electronic medical records (EMRs), while the remaining two are transitioning from their existing EMR to new EMR platforms (See Supplementary Material Table S1).

2.4. Sampling Strategy

Six eye hospitals were purposively selected based on the presence of key enablers of data-based management, including leadership commitment, functional IT systems,

and organizational size. On-site visits to the selected hospitals were conducted between 15 December 2024 and 30 December 2024. Staff categories—such as Chief Executive Officer, Chief Medical Officer, Senior Ophthalmologist, Chief Operating Officer, Administrator, Manager, Outpatient Coordinator, Inpatient Coordinator, Counsellor, and Outreach Manager—were identified with the head of each hospital, who nominated suitable participants. In each hospital, at least five staff members from different departments were interviewed to ensure a diverse range of perspectives and assess the presence of data-based management practices across organizational levels.

2.5. Questionnaire Development

To explore how hospital staff use information in managing core areas that influence performance and outcomes, a semi-structured interview guide was developed. The guide was designed to elicit detailed, practice-oriented responses regarding the role of data in decision-making, operational management, and quality improvement.

The interview questions focused on core management areas influencing performance and outcomes (Table 1).

Table 1. Core management areas and sub-areas studied.

Area #	Core Management Areas	Details of the Sub-Areas
1	Service Demand	I. Improving walk-in outpatient and surgical performance metrics II. Achieving target surgical volume from outreach programs
2	Compliance	III. Compliance with surgery or treatment advice IV. Patient return for follow-up examination after cataract surgery V. Adherence to scheduled surgery or treatment appointments
3	Operational Efficiency	VI. Managing variation in daily outpatient load VII. Ensuring timely examination of outpatients VIII. Ensuring availability of essential supplies for surgeries and treatments
4	Quality and Patient Safety	IX. Achieving desired outcomes in cataract surgeries X. Patient safety incidents XI. Collecting and utilizing patient feedback
5	Financial Management	XII. Managing recurring expenses through patient service revenue

To ensure consistency while allowing for in-depth exploration, the following guiding questions were used across all topic areas:

a. Is this an area of concern or challenge in your hospital?
b. If yes, how significant is the problem?
c. How are you prepared to pre-empt or manage the problem?
d. What types of data do you use?
e. How is this data used in practice?
f. What challenges do you face in accessing or using data?

g. Do you think any additional information would help improve performance in this area?

This structure enabled the collection of rich, context-specific insights while aligning responses to key areas of hospital performance and management.

2.6. Pilot Study

The questionnaire was piloted in one eye hospital to assess its feasibility and relevance. The pilot helped verify the availability of required data, confirm that the appropriate staff were being identified for interviews, estimate the time required for each interview, and check the availability of relevant documents for comparison. Insights gained from the pilot study informed the development of a detailed plan for conducting on-site visits to the study hospitals.

2.7. Data Collection Methods

We focused on capturing real-time practices related to various hospital functions, allowing respondents to narrate their experiences and decision-making processes in their own words rather than choosing from predefined options. The interviews were designed to be flexible, enabling participants to share information they considered important. We developed forms to facilitate this open-ended approach and encourage comprehensive responses.

Performance data on the reporting profiles of the study hospitals were collected during the manuscript preparation period (March–April 2025), and data from three hospitals were subsequently updated during the manuscript revision period in October 2025 to enable comparisons between hospitals for a common timeframe.

2.8. Data Collection Instruments

Semi-structured interviews were conducted using a standardized template for each core management area, comprising seven guiding questions, with space to record bullet-point responses. These prompts encouraged deeper, context-specific discussions.

All interviews were voice-recorded using a mobile application on an Android phone with manual notes. The same questionnaire and recording method were used consistently across all interviews. Each participant responded to the same set of questions, enabling the researcher to identify differences in responses during the interviews and seek clarification during the sessions. Each interview lasted between 45 and 90 min.

In addition to interviews, direct observations of workflows, details of data captured, real-time use of data, and reports generated were conducted across all core management areas included in the study. Manual notes captured specific points that required clarification, as well as statements or arguments that interviewees emphasized as important or worthy of inclusion in the report—such as quotes or critical reflections. Supporting documents—such as internal dashboards, performance summaries, patient registers, and process tracking sheets—were also collected to enable the triangulation of findings across interviews, observations, and documentary evidence, thereby strengthening the validity of the data [18].

Memos capturing specific thoughts and observations during interviews, direct observations, data collection, processing, and coding were systematically documented and consistently referred to throughout all stages of analysis to inform the findings.

2.9. Data Processing

All recorded interviews were replayed to develop a descriptive report for each core management area. For each hospital, an initial report was drafted based on the first

interviewee's responses, and then iteratively updated by incorporating new insights from the remaining interviews and manual notes. This approach enabled a comprehensive and layered documentation of perspectives from multiple staff members.

2.10. Data Analysis

According to grounded theory, coding qualitative data involves reducing large volumes of information into smaller, more abstract categories while preserving the original meaning. Key terms used in the processes are the following:

Data collected were processed and analyzed through the following stages:

2.10.1. Initial Coding

Following the principles of Grounded Theory, initial coding was performed manually within each hospital's report, developed from formatted transcripts of interview audio recordings. Key concepts were highlighted and annotated throughout the transcripts, which were further enriched with insights from real-time observations of patient flow and operational activities. (See the initial coding in Supplementary Materials S1–S6 for the coding details)

Subsequently, NVivo 15 (trial version) software was used to organize, refine, and analyze the coding systematically across cases. Initial coding was carried out for each core management area within individual hospitals. The data from all six hospitals were then consolidated by merging the content of each core area into a unified dataset, resulting in one set of consolidated initial codes for each of the 12 sub-areas.

2.10.2. Axial Codes

Initial codes were then further analyzed to identify patterns and relational meanings, enabling cross-hospital comparisons, leading to the development of axial coding structured for each subarea. Two or three related subareas were combined under a core area, as outlined in Table 1, and axial coding was performed. This process involved iterative refinement and the use of analytic memos to trace emerging connections and strengthen conceptual clarity.

The detailed axial coding for each theme is presented in Supplementary Material File S7.

2.10.3. Selective Codes

Finally, the axial codes were used to generate selective coding (core categories), which informed the development of a conceptual framework for understanding data-based management practices in eye hospitals. Selective coding was conducted to develop the core theme of data-based management.

Figure 1 describes the details of data management, starting from data collection to building common themes to derive the conceptual framework.

To refine code descriptions, clarify thematic labels, and explore alternative interpretations or labelling, ChatGPT (Open AI 2024) [19] was utilized as a support tool during the axial and selective analysis process. The grouped initial codes were entered with the prompt, "Can you please do the axial and selective coding for the following initial coding? The focus is to identify what drives an organization to be data-based management". Throughout the research, all coding decisions, thematic constructions, and interpretations were made by the researcher, in strict accordance with the principles of Grounded Theory

and the standards of qualitative rigor. The use of this tool is acknowledged here to maintain transparency in the analytic process. Further details of the procedures are presented in Supplementary Material Section S1.

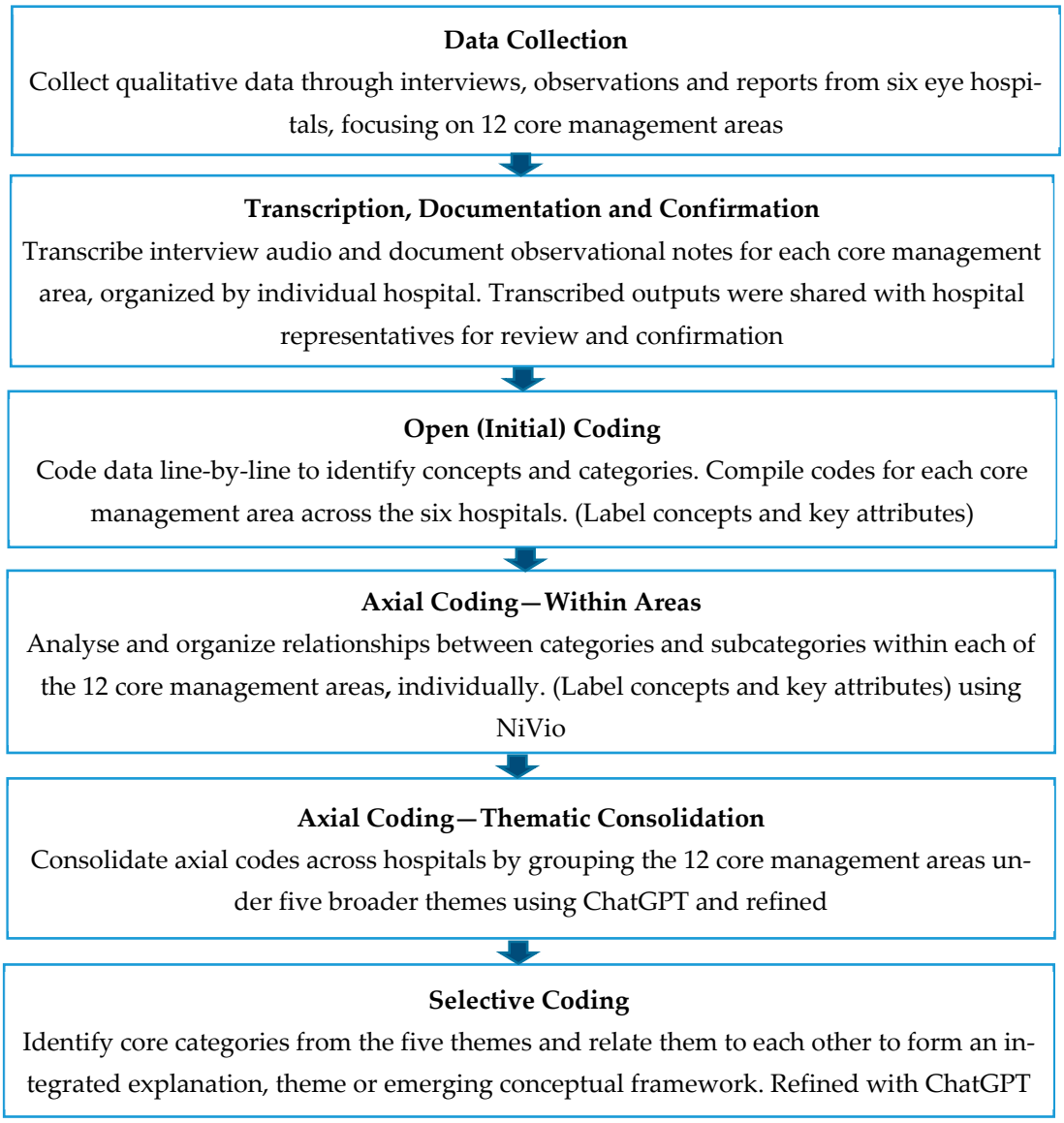

Figure 1. Data analysis stages and output at each level of processing.

2.11. Trustworthiness

Interviews using the same questionnaire for all the interviewees within a hospital ensured the reliability and trustworthiness of the data. The difference in responses between the interviewees was specifically reviewed and cross-checked, verified, and confirmed with the concerned interviewees. Additionally, a consolidated descriptive summary of the interviews was shared with one of the senior staff members in the hospital to review and confirm the findings.

Additionally, interview responses were compared with the observations of functions of managing each sub-area, as well as with the documents and reports maintained, to triangulate the findings and confirm trustworthiness.

We adhered to the Standards for Reporting Qualitative Research (SRQR) throughout this research.

3. Results

The key performance data of the six study hospitals are presented in Table 2. These hospitals were established between 1926 and 2004 and are spread across six regions of India. While all hospitals provide tertiary eye care services, the proportion of cataract surgeries among total surgeries is notably higher in H1 and H2 compared to the others.

Table 2. Profile of study hospitals.

	H1	H2	H3	H4	H5	H6
Year of establishment	1995	1984	1993	1926	2004	1994
Region	Bihar	Tamil Nadu	Andhra Pradesh	Uttar Pradesh	Chhattisgarh	Maharashtra
Period	2024–25	2024–25	2024–25	2024–25	2024	2024–25
Key Performance						
Outpatients Examined	1,359,439	94,311	90,581	276,275	72,432	35,877
Cataract surgeries	112,078	10,838	9021	30,905	10,664	16,602
All surgeries, lasers and Injection	145,553	11,933	11,642	36,545	14,586	20,887
Spectacles dispensed	150,426	5449	14,670	39,510	6006	3930
Manpower						
Total staff	1240	147	226	281	225	165
Ophthalmologists	50	15	20	20	12	11
Paramedical staff	360	37	54	36	55	19
Others	830	95	152	225	129	129

3.1. Selective Coding and Arriving at a Theme

The results of selective coding derived from the axial coding of all five thematic areas are presented in Table 3. To identify the overarching factors driving data-based management in eye hospitals, core categories were consolidated across themes. Thematic descriptions and relevant data practices are provided for each selective code, illustrating how various data practices support operational effectiveness and strategic decision-making.

Table 3. Consolidated selective coding.

Selective Code	Integrated Themes	Core Idea/Description
Goal-Oriented Planning and Execution	Demand, Operations	Hospitals set clear goals (e.g., patient targets, outreach targets, target outpatient turnaround time, Target compliance, target visual outcome post-cataract surgery) and align operations (e.g., staff, camp planning, triaging) with those using data for planning and performance tracking.
Real-Time Operational Adaptability	Demand, Operations, Compliance	Use of real-time data (e.g., patient volume, waiting time, compliance status) enables dynamic adjustments to staffing, scheduling, and service delivery to manage variability and maintain flow.
Integrated Resource Optimization	Demand, Operations, Finance	Data support optimal use of physical and human resources with appropriate planning and scheduling—balancing constraints with efficiency goals to meet service demand and ensure sustainability.
Feedback-Driven Improvement Loops	Demand, Compliance, Quality and Safety	Continuous review mechanisms (e.g., meetings, WhatsApp updates, satisfaction surveys) create loops that enable quick responses, learning, and operational refinement. Real-time synchronization of demand-capacity and both downstream and upstream feedback.

Table 3. *Cont.*

Selective Code	Integrated Themes	Core Idea/Description
Data-Enabled Compliance Management	Compliance, Quality and Safety	Structured tracking systems (EMR, Excel, reports) are used to ensure follow-up, reduce no-shows, and monitor adherence to care protocols, especially for surgeries, patients' feedback, and safety checklist.
Culture of Safety and Accountability	Quality and Safety	Systems of incident reporting, surgical audits, CAPA, and NABH * protocols support a proactive, error-reducing culture focused on improving patient outcomes.
Strategic Use of Outcome Data	Quality and Safety, Compliance	Data on clinical outcomes (e.g., VA, complications), compliance, and patient feedback are leveraged—where systems allow—to improve care and patient experience.
Financial Intelligence for Sustainability	Finance	Monitoring income, cost recovery, generating reserves during peak seasons to compensate for off-season shortfalls, and effective budget allocations help hospitals navigate funding challenges, plan efficiently, and optimize financial performance.
Adherence to Standards	Operations, Compliance, Quality	NABH drives to follow standard practices and set minimum standards for outcomes, like time taken to first examination, overall time taken for examination, repeat visits, readmissions, complication/infection rate, rate of effective outcome etc.
Technology adoption	All Themes	Implementation information and communication technologies enable effective delivery of care with optimized workflow, real-time information synchronizing service points, captures and process data for generating necessary information, reaching the remote population, awareness communication, reminders to enhance compliance, control cost of care etc.
Data Gaps and Structural Limitations	All Themes	Many hospitals face challenges like unstructured reporting, underused feedback, and poor data integration—limiting the impact of data-based decision-making.

* NABH: National Accreditation Board for Hospitals and Healthcare Providers—A Constituent Board of Quality Council of India.

3.2. Conceptual Framework

In Figure 2, the core categories identified through selective coding are systematically arranged to illustrate their relationships and to propose a context-specific conceptual framework. The framework presented here explores the key drivers of data-based management that facilitate data infrastructure establishment and systematic data collection. These enablers, in turn, support data processing and utilization, ultimately leading to improved operational efficiency and clinical outcomes.

A detailed explanation of the driving factors is provided below.

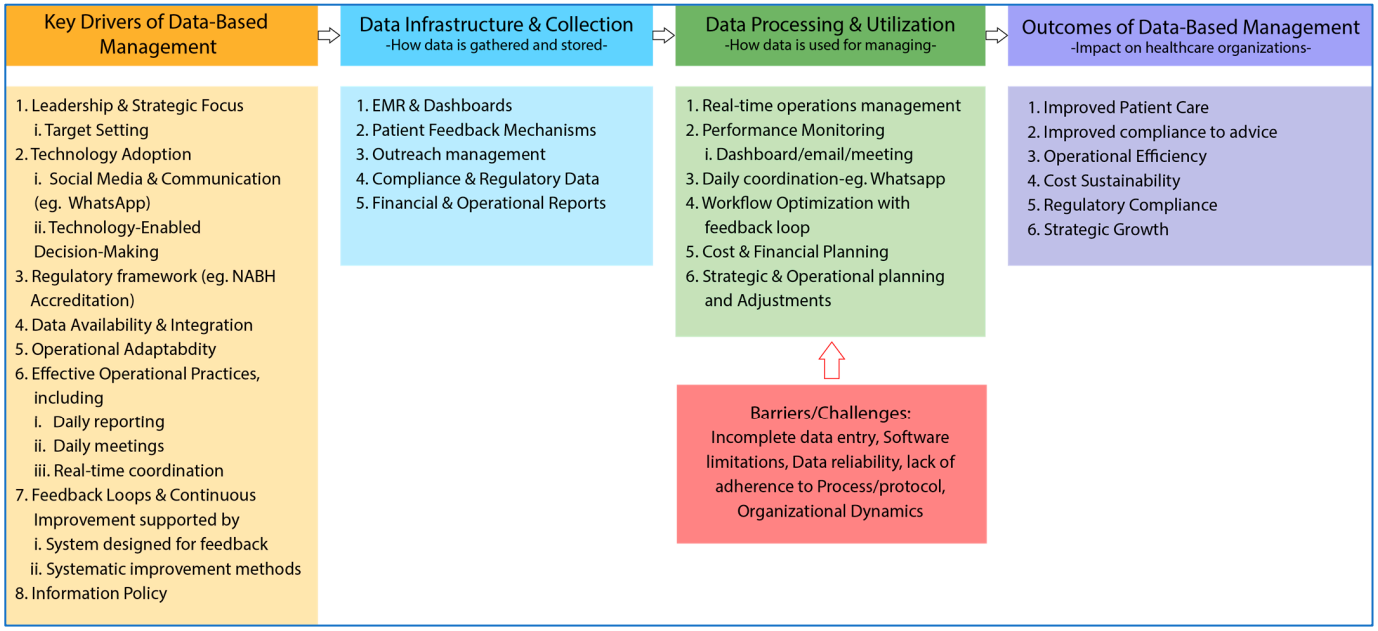

Figure 2. Conceptual framework showing how key drivers enable data infrastructure and its utilization through effective operations, leading to improved outcomes.

3.2.1. Key Drivers of Data-Based Management

Enabling factors identified in the left-most box of Figure 2 collectively drive the development and institutionalization of a structured platform for data collection and utilization.

Leadership

All hospitals demonstrated a strong commitment to leadership in enabling data-based management practices. This was reflected in actions such as implementing IT systems, setting goals and targets, ensuring access to necessary data, and actively participating in periodic review meetings to guide teams, build data literacy by educating staff on data interpretation, and drive performance.

Role of Target Setting

All hospitals emphasized the role of target setting in aligning teams and driving performance. A commonly expressed sentiment was "*Setting the targets helps us to drive and align the team towards the goal*." This was reflected in concrete examples such as setting annual outreach program targets, establishing standard turnaround times for outpatient examinations, and defining clinical benchmarks like "90% of cataract surgery patients should achieve effective visual outcome."

Influence of Regulatory Framework

Regulatory frameworks, particularly those linked to NABH accreditation, emerged as strong enablers of structured practices. Hospitals uniformly acknowledged "*Collecting patient feedback is a new initiative driven by NABH requirements*" and referenced process standards such as "Examining patients within 120 min." These external requirements were seen as catalysts for systematizing care and management processes. Although Hospital 4 (H4) had not yet received accreditation, it proactively implemented regulatory-compliant practices as part of its preparation for the accreditation application.

Technology Adoption and IT Implementation

The importance and expectations of technology adoption and IT solutions were also widely recognized. One hospital (H1) reflected on its transitional phase by stating, "*We*

still rely on some manual processes for data, but this will improve once we implement the new software." Another (H3) expressed cautious optimism, "*We expect the new electronic medical record system to deliver more accurate and timely reports; otherwise, we would have continued with the manual system, which was effective*."

Data Availability and Integration

Ensuring data availability and integration is a critical enabler of data-based management, typically achieved through the implementation of appropriate IT systems. Integration allows data to flow seamlessly across departments, minimizing the duplication of efforts and enabling real-time monitoring and feedback. This interconnected system supports cross-functional collaboration, improves operational efficiency, and enhances the quality of decision-making. Four of the study hospitals already have a well-established system, while the other two are in the phase of migrating or introducing a new system.

Operational Adaptability

Real-time adjustment to ensure efficiency in operation, dependent on real-time feedback, and also the availability and accessibility of the resources. Additionally, assigning patients to the correct station with minimal waiting and utilizing the appropriate resources helps avoid repetition of examinations. All hospitals in the study either use real-time information or have a patient care coordinator physically manage the patient flow.

Practice of Continuous Process Improvement

Continuous process improvement is increasingly being adopted across the hospitals studied. Hospitals reported leveraging structured methodologies such as PDCA (Plan-Do-Check-Act) and Kaizen to enhance operational performance and promote data-driven decision-making. For example, one hospital (H2) noted, "*The practice of using PDCA in our recent improvement project to increase patient volume in satellite centers has significantly helped us realize the importance of data and led us to review more data than we typically do*."

Making Improvements Using Systematic Approaches

Similarly, another hospital (H1) emphasized the role of Kaizen in streamlining processes: "*We expect to reduce the turnaround time for our outpatients with our current Kaizen initiatives*." These efforts reflect a growing organizational culture of using data not only for monitoring but also for driving incremental and continuous improvements.

Hospitals aiming to sustain efficiency rely on effective operational practices that support day-to-day functioning and resource optimization. These include daily planning meetings to review and organize activities, ensuring resource availability, coordinating with relevant departments, sharing daily performance updates, and facilitating real-time coordination through the use of data and on-ground observations. Regular observational visits to key service points help identify gaps and enable immediate adjustments in resource allocation. All study hospitals reported implementing these practices as appropriate, supported by the availability, accessibility, and timeliness of data.

3.2.2. Data Infrastructure and Collection

These key drivers facilitate the creation of systems and processes that govern how data are gathered from diverse sources across the organization. This includes data from electronic medical records (EMRs), patient feedback systems, compliance metrics, financial reports, and operational dashboards. Together, these elements form a comprehensive data infrastructure that supports evidence-based decision-making and continuous performance improvement.

Electronic Medical Record and Hospital Management Systems

Four of the six hospitals in the study have already implemented electronic medical record (EMR) systems, reflecting leadership interest in improving data collection and storage. While the success of implementation varies, these hospitals have been actively capturing data for over six months. One hospital recently introduced an EMR system, with staff currently undergoing training. Another hospital is in the process of exploring EMR solutions integrated with other systems, indicating a holistic and comprehensive understanding of organizational data requirements. Hospital 1 (H1), which is seeking a comprehensive and integrated system, reported that "*a business intelligence dashboard for clinical and financial data is needed to enhance decision-making*"—a capability that would become feasible with the implementation of an EMR system.

Patient Feedback Mechanism

All hospitals collect some form of patient feedback, primarily driven by NABH requirements. However, all the hospitals indicated that this feedback is not effectively utilized for driving improvements. Hospital 2 (H2) reported that they review individual feedback, take necessary actions, and inform patients about the steps taken.

Compliance and Regulatory Data

NABH regulations provide guidelines for monitoring key performance indicators (KPIs), specifying the data required and ensuring its quality. These indicators reflect both processes and outcomes. For example, patients should be attended to within 30 min of entry, medical prescriptions should be written in block letters, and readmissions should occur within defined time frames. All of this valuable data are collected to comply with NABH guidelines and ensure high standards of care.

Financial and Operational Reports

The need for various reports for daily and periodic reviews is driven by leadership, regulatory requirements, effective operational practices, data availability, and integration, among other factors. The leaders of Hospital 3 (H3) expressed that the new EMR system has yet to provide reliable and comprehensive reports and are currently working with the EMR vendor. They aim to develop dashboards for real-time monitoring of key parameters, such as doctor performance, complication rates, and patient outcomes, in order to overcome current reporting limitations and enhance decision-making.

3.2.3. Data Processing and Utilization

Building on the established data infrastructure, several practical approaches were identified to process and utilize collected data, driving operational improvements and informing management decision-making. These include acting on real-time feedback to address operational issues, implementing effective operational practices, conducting regular review meetings, establishing dedicated communication platforms (e.g., WhatsApp groups), and institutionalizing structured review mechanisms. A strong commitment to continuous monitoring and improvement was also evident. Together, these practices enable timely interventions, support strategic planning, and foster a culture of accountability and continuous improvement—reinforcing the role of data as a central asset in healthcare management.

Real-Time Feedback for Operations

The importance of real-time data from Electronic Medical Record (EMR) systems in optimizing patient flow and resource allocation was consistently emphasized by all four hospitals (H2, H3, H4, and H5) that have been using EMR for some years and months.

These systems provide immediate visibility into patient queues and staff availability, allowing for dynamic decision-making during daily operations. One respondent from H5 explained, "*We go by the guided information from the Electronic Medical Record system that gives real-time information on patients waiting in each station and currently logged-in resources, to drive the patient flow efficiently*." Similarly, a participant from H3 noted the role of EMR data in patient triage: "*Real-time information from the previous station is used for triaging the patients to the respective clinic*."

Operational Practices That Support a Feedback Loop

Effective operational practices—such as daily coordination, performance monitoring, workflow optimization, strategic and operational planning, and real-time management—enable the meaningful use of data. These practices ensure that collected data are translated into actionable insights, ultimately contributing to improved outcomes in patient care, regulatory compliance, operational efficiency, cost sustainability, and strategic growth.

Meetings and Communication Platform

Daily meetings were highlighted as an important mechanism for planning and coordination. As noted by one respondent from H1, "*Daily meetings help to plan for the activities of the next day*." All hospitals reported the use of performance reporting through email and WhatsApp groups, which enabled timely information sharing among stakeholders and supported operational coordination; H5 noted "*Use of floor coordinator helps to manage the patient flow using real-time information*".

Structured Review Mechanism

Hospitals also conducted several types of meetings and committee reviews to support ongoing management and improvement. These included intra-departmental meetings—used primarily for daily planning—and inter-departmental meetings, which served to address shared challenges and promote synchronization between functions. Committee meetings were convened to review specific thematic areas such as quality, safety, or outreach.

Committed to Review and Continuous Improvement

H4 noted that an emphasis on continuous improvement contributed to workflow optimization: "*Focusing on continuous improvement helped to optimize the workflow*." All hospitals had systems in place to monitor and review performance at defined intervals, reflecting an institutional commitment to performance oversight and iterative enhancement.

3.2.4. Outcomes of Data-Based Management

Cumulative Impact of Key Drivers

Overall, the key drivers identified in this study collectively contribute to creating an environment that enables the systematic processing and utilization of data. This enabled environment supports healthcare organizations in achieving enhanced outcomes, including improved patient care, better compliance, greater operational efficiency, cost sustainability, regulatory adherence, and strategic growth.

The impact of data-based management was evident across multiple case hospitals, with several reporting measurable improvements linked to structured data utilization. For instance, Hospital 6 illustrated a tangible outcome: "*Data-based actions combined with effective operational practices helped to improve our cataract surgery acceptance rate from 40% to 61%*," underscoring how structured data use can drive patient uptake. Hospital 1 demonstrated the application of the Kaizen approach, bringing teams together to reduce outpatient cycle time. Hospital 2 reported *steady growth in patient volume at primary eye care centers, along with*

revenue increases that helped match operational expenditures over six months. Similarly, Hospital 5 emphasized how data utilization enabled a *strategic focus on sub-specialty volume growth and facilitated the planning of targeted interventions*. Meanwhile, Hospital 4 highlighted *how reviewing cataract surgery outcomes led to strengthened post-operative follow-up mechanisms and ongoing efforts to enhance surgical outcomes*. These examples collectively reflect the transformative potential of data-based management in driving operational, financial, and clinical improvements.

3.2.5. Barriers and Challenges

However, challenges persist, offering opportunities for further improvement. These include the following:

1. Incomplete adoption or underutilization of new software systems,
2. Inconsistent or incomplete data entry,
3. Software limitations in generating actionable reports,
4. Concerns about data reliability,
5. Lack of adherence to clinical or operational protocols leading to practice variation, and
6. Organizational dynamics that affect consistent implementation

Several hospitals highlighted challenges that hinder the effective use of data for management decision-making. Hospital 3 (H3) noted that "*although data are being captured through the electronic medical record (EMR) system, it has yet to be fully utilized to generate timely and insightful reports*." Hospital 4 (H4) raised concerns about data reliability, suggesting that "*inconsistencies in vision outcome records may result from errors in the examination process or incorrect data entry*." Similarly, Hospital 2 (H2) expressed disappointment with the new software system, which lacked some of the key performance indicators previously monitored using the older system. Additionally, Hospital 6 (H6) pointed out "*limited involvement of clinical leadership, noting that their role is largely confined to reviewing clinical outcomes, with minimal engagement in evaluating overall performance and service quality*". These challenges reflect systemic and operational limitations that must be addressed to strengthen data-based management practices.

4. Discussion

Information technology (IT) is pervasive in healthcare, underpinning a wide range of clinical, administrative, and operational processes essential for modern care delivery and management [20–24]. Although the healthcare industry began integrating these technologies later than sectors such as manufacturing and engineering, their applications have significantly evolved over the past two decades. The adoption of IT is largely driven by the information processing needs of an organization. While earlier theories [3] emphasized the role of information technology in meeting increasing demands for data processing, its current utility extends well beyond that function. Given the favorable cost-benefit ratio, information technology is no longer a luxury but a necessity, becoming integral to healthcare organizations across various levels [22,25,26]. Today, every hospital possesses some capacity for data processing; however, the extent and effectiveness of data utilization vary based on several contextual factors [14,15,27]. This study investigated the enabling factors that allow hospitals to effectively utilize internally generated data—from both clinical care and administrative processes—for continuous improvement and informed decision-making.

4.1. Interpretation of the Conceptual Framework

The research identified several critical factors that contribute to the successful practice of data-based management in hospitals. The conceptual framework (Figure 2), developed

through grounded theory analysis, illustrates how data-based management in eye hospitals is influenced by a set of interrelated factors. Together, these enabling elements contribute to the development of robust data infrastructure and foster the systematic capture and utilization of data. Improved clinical and operational outcomes emerge when these practices are embedded into daily operations through mechanisms such as target setting, real-time monitoring, continuous improvement, and coordinated efforts. This framework offers practical guidance for hospital administrators aiming to institutionalize data-based management as an integral part of organizational practice.

4.2. Key Enablers of Data-Based Management

The study reaffirmed well-recognized enablers such as leadership commitment, data availability, and technology adoption, while also identifying context-specific drivers. These include target setting as a strategic alignment tool, regulatory compliance as a catalyst for structured practices, and the use of social media platforms (e.g., WhatsApp) for information dissemination and coordination. Additionally, the study highlighted the importance of practicing systematic improvement methodologies, the design of closed-loop systems for real-time monitoring and feedback, and the implementation of effective operational practices—such as operational planning, real-time operations management, daily coordination, and daily reporting. Addressing barriers to data capture, engaging teams across departments, and continuously improving IT systems are also essential to ensure that data-based management is sustainable and impactful. Taken together, these elements form a comprehensive ecosystem that supports the dynamic use of data for decision-making and continuous improvement in hospital settings.

Leadership is identified as a key variable that can shape the process of implementing evidence-based practice, for example, by acting as a role model for staff, enabling access to evidence, and creating a culture that encourages and supports innovation and changes in practice [28]. Having the right understanding at the leadership level helps drive the entire team toward data-based management [29]. The Chief Medical Officer (CMO) of Hospital 4 (H4) commented, "*We cannot manage every individual, but we can manage effectively through information*," while the Chief Executive Officer (CEO) of Hospital 3 (H3) emphasized the importance of using evidence, stating, "*We must understand that using information is for our own goodness and growth*." A strong understanding of the scope for improvement based on evidence enables leaders to initiate appropriate interventions. The CMO of Hospital 5 (H5) noted, "*We are seeing growth in volume, yet our existing resources remain underutilized*." One of the organizational values at Hospital 1 (H1) is "*It is okay to fail, rather than not even attempting*," with the leader adding that evidence helps validate whether a problem is real and needs to be addressed. Similarly, the CEO of H5 pointed to financial insights derived from data: "*Our outreach expenses are high—we are currently spending more per patient than the aid we receive*." Recognizing gaps in the system also demonstrates an awareness of key focus areas. Comments such as "*Feedback collection is inconsistent, leading to missed opportunities for structured improvement plans*" and "*Strengthening follow-up could significantly enhance patient outcomes*" reflect this awareness. Altogether, these insights illustrate both the presence and the need for effective leadership and a culture of using data for assessment and monitoring. These statements support the view that leadership behaviors play a significant role in shaping the climate for data-based management practice [30,31].

Building a team that is aligned with department goals and in line with broader organizational goals requires operationalizing strategies so that everyone understands the purpose behind their work. Target setting acts as a conduit for transmitting strategic priorities from leadership to staff, helping teams understand what they are expected to achieve and how to get there [4].

Regulatory compliance serves as a driver for adopting standard protocols and effective operational practices, while simultaneously creating opportunities to practice data-based management by requiring the collection of relevant data, ensuring data privacy and security, and defining how data should be stored and utilized—aligning with the principles of information policy [32]. While none of the hospitals in this study had a formalized information policy, key elements of such a policy—such as what data to collect, who is responsible, what reports to generate, and who should receive them—were found to be embedded within their systems and routines. Regulatory frameworks also require the establishment of committees and the use of structured review processes to investigate root causes of issues and assess performance and outcomes regularly.

System design plays a pivotal role in enabling closed-loop operations, allowing synchronization within and across departments and facilitating continuous improvement through upstream and downstream feedback. It is crucial to incorporate closed-loop elements thoughtfully—by providing easy access to data or integrating them into workflows—to ensure efficient transaction execution. For example, a patient may be assigned to a particular clinic based on the current waiting load, and subsequent movement to the next station depends on the number of patients waiting across various stations. Similarly, any errors or incomplete examinations must be communicated back to the preceding stations for correction. Such coordination is possible only when there is effective upstream and downstream flow of information within the system. The development of a well-established closed-loop system can be attributed to leadership's emphasis on continuous process improvement, consistent with the principles articulated by Ohno (1988) [33] in the Toyota Production System. Such systems secure both efficiency and quality, ensuring reliable outcomes at each station and across the organization through real-time feedback.

Practicing systematic improvement ensures that processes are transparent and understandable to stakeholders, enabling them to adopt similar practices within their own areas. Four of the study hospitals currently rely on internally developed improvement processes, while three are experimenting with formal methodologies such as Kaizen (H1) and PDCA (H2, H4). Additionally, four hospitals recently participated in the "LEAP" program, conducted by the Lions Aravind Institute of Community Ophthalmology (LAICO), which focused on addressing specific problems to drive improvements. The LEAP initiatives targeted key themes such as enhancing performance in primary eye care centers (H2, H3), closing the loop on patient compliance (H1, H6), and improving cataract surgical outcomes (H4). These efforts helped teams collect high-quality data and more effectively monitor both performance and outcomes.

Information dissemination tools, particularly WhatsApp, played a vital role in keeping teams updated and coordinated, possibly due to its widespread adoption and usage by all stakeholders. For example, sharing the next day's surgery schedule by the Operation Theatre (OT) group enabled the team to prepare accordingly, ensuring supplies and the posted surgeon were well-prepared to complete the surgeries. Similarly, information about outreach activities and the number of patients expected to be brought to the base hospital was shared in advance, enabling the wards to prepare beds, dietary departments to plan meals, and teams to make real-time adjustments based on updates from the outreach sites. While some of these details could be automatically generated from the system, others required manual input. Nevertheless, the use of such platforms proved highly effective in delivering information instantaneously to the appropriate person or team. Effective operational practices were found to be crucial in translating available resources into improved outcomes.

All hospitals practiced daily meetings to plan the following day, confirm resource availability, and monitor patient flow using dashboards. Real-time adjustments and triaging

were informed by data. While real-time adjustment of resources was possible in all the study hospitals, it may not be practically feasible in settings with resource constraints. However, the insights gained can facilitate improved resource planning over time. Periodic performance review meetings, with data as a central agenda item, reinforced a culture of data use across the teams and also helped to build data literacy among the staff. Managers used data to identify deviations, while gaps and opportunities for improvement were more likely to gain acceptance among professionals. This approach fosters objective dialogue, aligns teams, and encourages broader participation in action plans. In the case of Indian eye hospitals, the use of clinical and operational data created a shared platform for constructive engagement between managers, clinicians, and staff, strengthening collaboration and team cohesion [30,31]. Such meetings also help to develop data literacy, enable effective use of data, and enhance data quality; as emphasized in the literature, data quality improves through active use, where errors and gaps are detected and corrected in practice [34].

4.3. Strengths and Limitations

This study was conducted in six eye hospitals, with five to six participants from each institution responding to a common questionnaire. This approach facilitated the collection of rich qualitative data and allowed for in-depth confirmation of findings. Real-time observation and data verification helped triangulate the information, enhancing the validity and reliability of the results. The use of a grounded theory approach enabled the identification of key factors at a comprehensive level, leading to the consolidation of patterns and relationships, and ultimately the development of the conceptual framework.

The study was conducted in settings where the basic prerequisites for practicing data-based management—identified in previous research—were already in place. Although this may be viewed as a limitation, it was an intentional decision to ensure a foundational baseline from which new and context-specific factors could be identified. The findings stem from eye hospitals where IT systems for data-based management were already implemented. It is also important to recognize that hospitals without established IT systems may perform equally well—or even better—since they might address information-processing challenges through alternative organizational mechanisms (as posited by Galbraith) or rely on limited yet well-integrated IT solutions. Leadership did not emerge as a distinct category—this represents a weakness of the study. Future research should ensure that interview protocols and analytical frameworks explicitly capture the role and influence of leadership in shaping data-based management practices. The findings, derived from eye hospitals in India, may not fully generalize to other hospital types or health systems; however, the organizational characteristics and system-level enablers highlighted are broadly relevant across healthcare contexts. Furthermore, the six hospitals were purposefully selected to reflect a range of performance levels, which added diversity and depth to the responses, strengthening the robustness of the findings.

5. Conclusions

In a hospital setting, data-based management (DBM) should be an integral component of the organizational system to ensure sustained efficiency and effectiveness. Yet many hospitals face challenges in utilizing the vast amounts of data they generate to drive continuous improvement. This study shows that DBM in hospitals is enabled through an interlinked practice rather than any single intervention. Although leadership did not emerge as a distinct category in this study, its influence is implicit in shaping priorities, allocating resources, and fostering a culture that values evidence and accountability. Through goal setting, leaders align teams toward a shared direction, while regulatory compliance ensures consistency and accountability. These elements interact with closed-loop system

designs and systematic improvement methods, creating a feedback mechanism that embeds evidence use into ongoing cycles of problem-solving and learning.

Context-specific practices, such as the widespread adoption and usage of WhatsApp for rapid communication and coordination, exemplify how local operational realities influence DBM. In eye hospitals in India, where high patient volumes and dispersed care teams are common, these tools facilitate timely information sharing—enabled by the widespread adoption and familiarity of the platform among staff. Daily reporting, regular review meetings, and further reinforcing these routines, ensuring that data are not only collected but actively used to guide decision-making.

Together, these interlinked factors create a reinforcing system in which leadership guides practices, operational routines leverage data, and technological tools enhance information flow, collectively fostering continuous learning, improved performance, and sustainable quality of care. These findings are synthesized into a conceptual framework illustrating how these factors collectively create an enabling environment for practicing DBM, ultimately driving targeted outcomes. Depending on their specific context, hospitals can adopt a combination of these approaches to cultivate a data-driven management culture—and foster continuous learning, enhance performance, and strengthen the quality and sustainability of care delivery.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/hospitals2040025/s1: File S1: Hospital 1 Management practices, File S2: Hospital 2 Management practices, File S3: Hospital 3 Management practices, File S4: Hospital 4 Management practices, File S5: Hospital 5 Management practices, File S6: Hospital 6 Management practices, File S7: Open and Axial Coding of 12 Core Management Areas into Five Thematic Domains, Section S1: Analytical Transparency: Use of ChatGPT during Coding. Table S1: Implementation status of hospital management system and electronic medical record modules across study hospitals.

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