Green Healthcare Operations: Sustainable Resource Allocation via Data Analytics in Hospital Management

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Abstract

In this study it has been shown that, data analytics provides hospitals with an enhanced way to allocate limited resources in as sustainable manner as possible while at the same time addressing environmental challenges as well. Data Analytics enhances operational efficiency through systematic literature reviews using both empirical and conceptual studies on 15 different articles. In addition to real-time analytics methods, analytical and predictive planning methods, digital integration methods were also studied and profiled. Data analytics-based approaches help hospitals to optimise their resource use, while at the same time reducing waste, emissions, and support green healthcare initiatives through insights, thus advancing the knowledge base on methods to achieve environmentally sustainable management of hospitals by providing the decision maker with practical information.

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1. Introduction

As pressure continues to increase on healthcare organisations to provide better patient care, healthcare organisations also have sustainability challenges. Hospitals use large amounts of resources, and by using data analytics, healthcare organisations have an opportunity to create a more efficient and environmentally friendly operational decision process (Benzidia *et al.,* 2024).

Over the past few decades, most of the hospitals have continued to operate using traditional resources and resource management practices. Restaurants are complex, requiring different kinds of resources, which, when managed properly, use up fewer resources than if not managed properly (Magrizos *et al.,* 2023). These kinds of resources would include items like Food, Linen, Surgical Instruments and Equipment, Pharmaceuticals, and least serviced beds. The result is often the improper use of resources, increased costs, and increased pollution. The current state demonstrates the need for utilising analytics-driven solutions.

This paper will demonstrate how data analysis can improve the allocation of resources to support Sustainable Hospital Management by equipping decision-makers with practical examples and enhancing the Academic Community's understanding of Green Health Care operations.

This research aims to investigate how Data Analytics can provide support for Sustainable Resource Allocations in the Management of Hospitals by analysing current practices of resource allocation. It examines how Analytics enables the development of Green Operations, as well as how Analytics-based decisions impact a hospital's environmental footprint.

According to Alban *et al.* (2022), this research investigates how hospitals allocate and manage important resources and whether their existing allocation methods promote sustainable and optimal use of scarce resources. On the contrary, Allahham *et al.* (2023), also investigate the application of data analysis as a tool for hospital management and how the use of data analytic tools help hospitals make use of environmentally responsible methods for delivering care. In contrast, Darach *et al.* (2025), investigated and showed how the use of data analytics-based decision-making contributes to mitigate the negative environmental impact of hospitals, such as decreasing the amount of waste generated, increasing energy efficiency, and reducing the amount of carbon emissions produced by hospitals.

2. Methods

This specific study adheres to the "Systematic literature review" and the "Meta-Analysis (PRISMA) reporting in elucidating the research topic.

Data Collection

The systematic literature review was used to collect data from the 15 identified articles, and studies relevant to the topic of green healthcare operations, sustainable resource allocation, and healthcare analytics. The number of included studies amounted to both empirical and conceptual ones, including surveys, semi-structured interviews, real-time analytics, business analytics models, literature reviews, and case studies (Allahham *et al.,* 2023; Benzidia *et al.,* 2024; Machireddy, 2023; Ojika *et al.,* 2024; Dion *et al.,* 2023; Ajoud and Ibrahim, 2024; Karimov and Sattorova, 2024). The methodology, analytics tools, sustainability practices and application in resource allocation, energy efficiency and reduction of environmental impact were identified after the data extraction.

Table 1: List of Keyword Combinations

Keyword Combinations	
Sustainable resource allocation in hospitals	Hospital operations efficiency
	Energy-efficient hospital management
	Resource optimization
	Predictive resource planning
Data analytics for green healthcare operations	Big data in healthcare
	Artificial Intelligence (AI)
	Digital transformation
	Eco-efficient hospital management
Environmental impact reduction	Environmental impact reduction
	Carbon footprint reduction
	Eco-friendly hospital practices
	Sustainable healthcare operations

The 15 reviewed articles bring out three themes of green healthcare operations that relate to each other. Hospitals are based on the allocation of resources with the focus on efficiency, energy management, and predictive planning in a sustainable manner. Data Analytics driven green healthcare operations concentrates on eco-efficient processes, big data, eco-friendly transformation, and AI. The environmental impact reduction is a response to carbon footprint, eco-friendly practices, as well as sustainable healthcare operation, and it proves that the strategies with focus on analytics can improve operational and environmental sustainability in hospitals.

Data Analysis

The thematic data analysis implemented in this paper assumes the systematic examination of the 15 chosen publications to determine the common patterns, ideas, and knowledge in the area of Green Healthcare Operations. Important themes identified include sustainable allocation of resources, green operations made possible through analytics, and reduction of environmental impacts. Further, the identification of subthemes was conducted in order to focus on certain strategies such as real-time analytics, predictive planning, energy efficiency, and eco-friendly practices.

The use of Meta-Analysis and PRISMA reporting will help to provide a transparent, replicable, and systematic review of the 15 articles about green healthcare operations. PRISMA supports the clear description of the search strategy, inclusion/exclusion criteria, and data extraction process, which are expected to minimize bias and enhance reliability. Meta-analysis enables quantitative synthesis where feasible, and the results of studies in terms of resource optimization, energy efficiency, and reduction of environmental impact are compared.

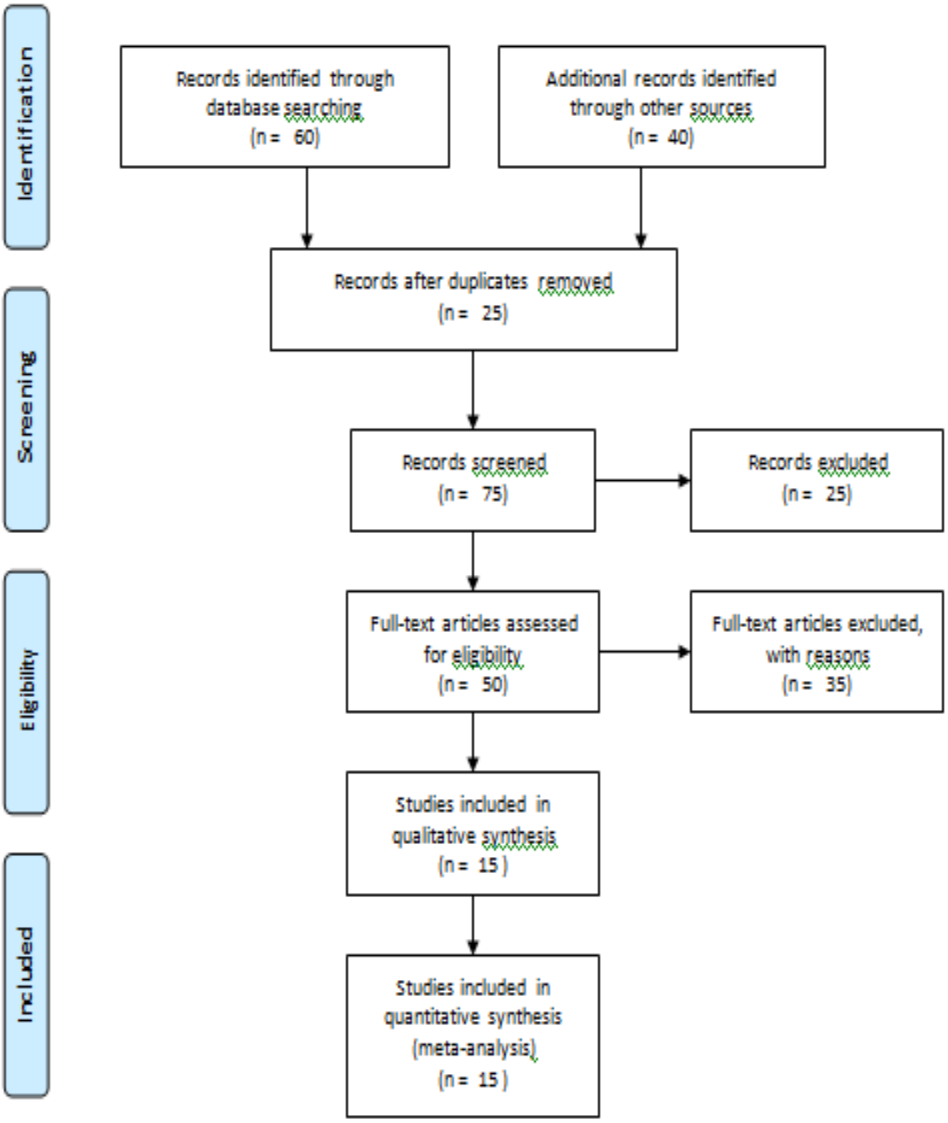

Figure 1: Prisma Chart

(Source: Self-created)

3. Results

Table 2: Systematic Literature Review Table

Author	Data Collection Method	Context	Theory
Hu *et al.,* (2022)	Conceptual article	Healthcare sustainability problems and practices.	Triple Bottom Line
Allahham *et al.,* (2023)	Survey	Hospital supply chain sustainability via BDA and AI.	Resource-Based View (RBV)
Machireddy, (2023)	Conceptual Article	Real-time analytics model for optimizing hospital resources.	Dynamic Capability Theory
Dion *et al.,* (2023)	Semi-Structured Interview and Case Study	Transformative initiatives for energy efficiency and sustainability in hospitals.	
Azadi *et al.,* (2023)	Quantitative modelling	Sustainable healthcare supply chains in the time of COVID-19.	Network Data Envelopment Analysis (NDEA)
Kaur, (2024)	Conceptual Article	Sustainable integration of energy, smart cities, and green healthcare.	Socio-Technical Systems Theory
Ojika *et al.*, (2024)	Conceptual Article	Analytics model optimizes healthcare supply chains during epidemics.	Dynamic Capability Theory
Ajoud & Ibrahim, (2024)	Survey	Sustainability practices impact Saudi public healthcare institutions.	
Karimov & Sattorova (2024)	Systematic review	New technologies in the policies of sustainable healthcare.	Institutional Theory
Arowoogun *et al.* (2024)	Conceptual review	Big data analytics of healthcare management.	Resource-Based View
Arega & Sharma (2024)	Case study	Cloud-based medical information systems Ethiopia.	Technology Acceptance Model
Gates *et al.,* (2024)	Analytical modelling	Healthcare predictive big data analytics.	
Shittu *et al.,* (2024)	Conceptual review	Healthcare operation business intelligence.	Decision Support Theory, Information Systems Success Theory
Benzidia *et al.,* (2024)	Survey	Healthcare operations, green innovation, big data drives sustainability.	Resource-Based View (RBV)
Sharma *et al.,* (2025)	Literature review	Healthcare waste management transformation in digital.	Circular Economy, Technology Acceptance Model (TAM)

The reviewed studies have employed variant methodologies, which throughout show that data analytics is the core of making the process of allocating resources sustainable and adopting green healthcare procedures in the management of the hospital. Empirical studies based on quantitative surveys (Allahham *et al.,* 2023; Benzidia *et al.,* 2024; Ajoud and Ibrahim, 2024) prove that big data analytics potential, AI tools, and sustainability practices strongly contribute in integrating green supply chains, promoting the efficiency of operations, and improving environmental performance in hospitals through evidence-based decision-making and optimum utilization of resources. As demonstrated by conceptual and model-driven studies (Machireddy, 2023; Ojika *et al.,* 2024), real-time analytics and business analytics systems are the most efficient in the allocation of healthcare resources, minimizing expenses, and responsiveness in the normal functioning of operations and in case of crisis such as epidemic outbreaks. As per qualitative data of semi-structured interviews and case studies (Dion *et al.,* 2023), the key to attain long-term energy efficiency and environmental sustainability in healthcare organizations is transformative management initiatives, which are facilitated by business analytics and performance monitoring. Lastly, Kaur (2024), conceptual synthesis explains that as the data-enabled structures of energy management systems are integrated with infrastructures of smart cities, green

healthcare results become stronger on an overall system scale. As a whole, the methodologies all conclude that analytics-based strategies help to achieve efficient, resilient, and environmentally sustainable operations of hospitals by harmonizing technological capacity, managerial decision-making, and green strategic goals.

Figure 2: Circular Economy Theory
(Source: circularinnovation.ca., 2026)

Table 3: Themes and Subthemes

Theme	**Subtheme**
Data-Driven Sustainable Resource Allocation in Hospitals	Real-time Analytics for Resource Optimization
	Analytics-Based Cost and Efficiency Management
Data Analytics Enabling Green Healthcare Operations	Analytics-Enabled Green Process Innovation
	Digital Integration for Sustainable Operations
Environmental Impact Reduction Through Hospital Analytics	Analytics-Driven Energy Efficiency Improvements
	Data-based Environmental Performance Monitoring

Real-time analytics are used to optimize the allocation of medical resources, staff, and equipment according to the needs to make hospitals respond dynamically to demand and achieve operational efficiency and minimize waste (Machireddy, 2023; Ojika *et al.,* 2024). At the same time, cost and efficiency management with the assistance of analytics rely on data insights to reduce the cost of operations and achieve the targeted quality of care and sustainability (Allahham *et al.,* 2023; Benzidia *et al.*, 2024). All these subthemes show that economic and environmental sustainability is achieved through the use of data in managing hospital resources, which meet green healthcare goals.
The innovation of green processes that is enabled by analytics enables hospitals to redesign their operations and supply chains to ensure sustainability, using AI and big data to reduce the environmental impact (Allahham *et al.,* 2023; Benzidia *et al.,* 2024). Sustainable operations coupled with Digital integration connects the healthcare management systems, energy monitoring, and intelligent infrastructure, ensuring coordinated and eco-efficient hospitals (Kaur, 2024; Allahham *et al.,* 2023). Amalgamation of these subthemes show that the use of data analytics can lead to increase operational efficiency, as well as systemic environmental sustainability within healthcare facilities.
Intelligent energy efficiency can be improved through analytics to help hospitals track and streamline their energy usage, minimize expenses, and carbon emissions (Dion *et al.,* 2023; Kaur, 2024). Monitoring environmental performance based on data enables the constant monitoring of the sustainability indicators and enables evidence-based

decision-making to reduce ecological footprint (Ajoud and Ibrahim, 2024; Allahham *et al.,* 2023). A combination of these subthemes demonstrates that hospital analytics not only improves the efficiency of operations but also contributes greatly to environmental sustainability, which puts green operational practices in line with effective healthcare practices.

Table 4: Theoretical insights based on findings achieved

Theory	**Application in resource allocation**
Resource-Based View (RBV) Theory	A number of studies of green healthcare operations and sustainable resource allocation have used various theoretical frameworks to call for the decision-making based on analytics. One of the most popular ones is the Resource-Based View (RBV) that is used to explain the role of big data, AI and analytics and their capabilities as strategic resources that are used to optimize the operation of a hospital, enhance efficiency, and facilitate sustainable supply chains (Allahham *et al.,* 2023; Benzidia *et al.,* 2024; Gates *et al.,* 2024).
Dynamic Capability Theory	Dynamic Capability Theory is the basis of such studies of Machireddy (2023), and Ojika *et al*., (2024), and their studies are designed to focus on the capacity of the hospital to change the distribution of resources in real time on the basis of predictive and business analytics, in particular, in the situation of crisis such as epidemics.
Socio-Technical Systems Theory	The Socio-Technical Systems Theory (Kaur, 2024; Arega and Sharma, 2024), emphasizes the combination of the digital systems, smart infrastructure, and human processes to obtain energy-efficient and sustainable healthcare services.
Network Data Envelopment Analysis (NDEA)	Network Data Envelopment Analysis (NDEA) is used by Azabi *et al.,* (2023) in order to measure the efficiency and resilience of healthcare supply chains during fluctuation of demands in a quantitative manner.
Information Systems Success Theory and Technology Acceptance Model (TAM)	Adoption of analytics and cloud-based systems is explained using Information Systems Success Theory (Shittu *et al.,* 2024) and Technology Acceptance Model (TAM) (Sharma *et al.,* 2025) to improve the decision-making process regarding the allocation of resources by providing data-driven insights on inventory, staffing, and energy use. Altogether, these theories indicate that the systematic implementation of analytics frameworks could promote the efficiency of the working of a hospital, its sustainability, and evidence-based distribution of resources.

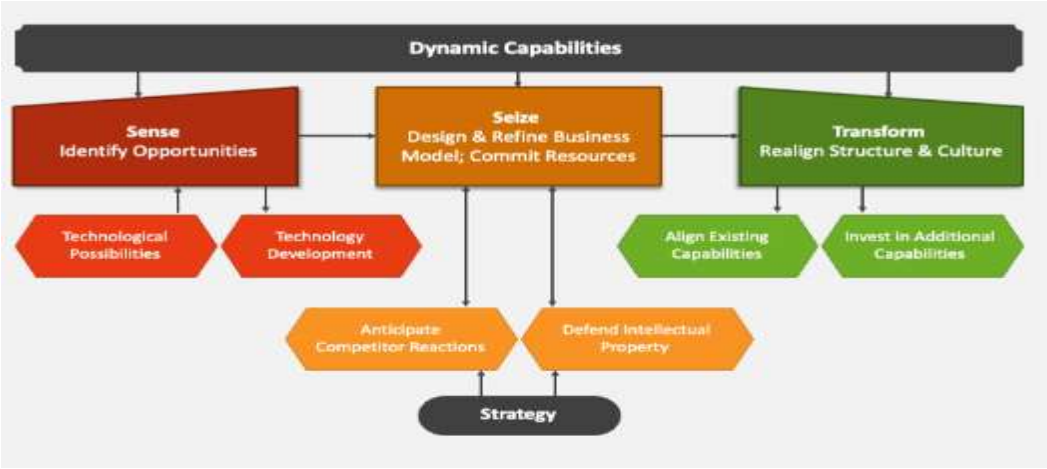

Figure 3: Dynamic Capability Theory

(Source: collidu.com., 2026)

4. Discussion

Data-based resource allocation creates hospitals' long-term ability to sustainably allocate scarce resources as per requirement. Real-time analytics provide hospitals with accurate information to make adaptive decisions regarding bed management, staffing, and inventory management, eliminating waste and unnecessary costs. By providing the

ability to use analytics, hospitals have developed a *Resource-Based View* that provides them with the capacity to operate more efficiently, be more competitive in a complex environment and maintain high-quality service levels.

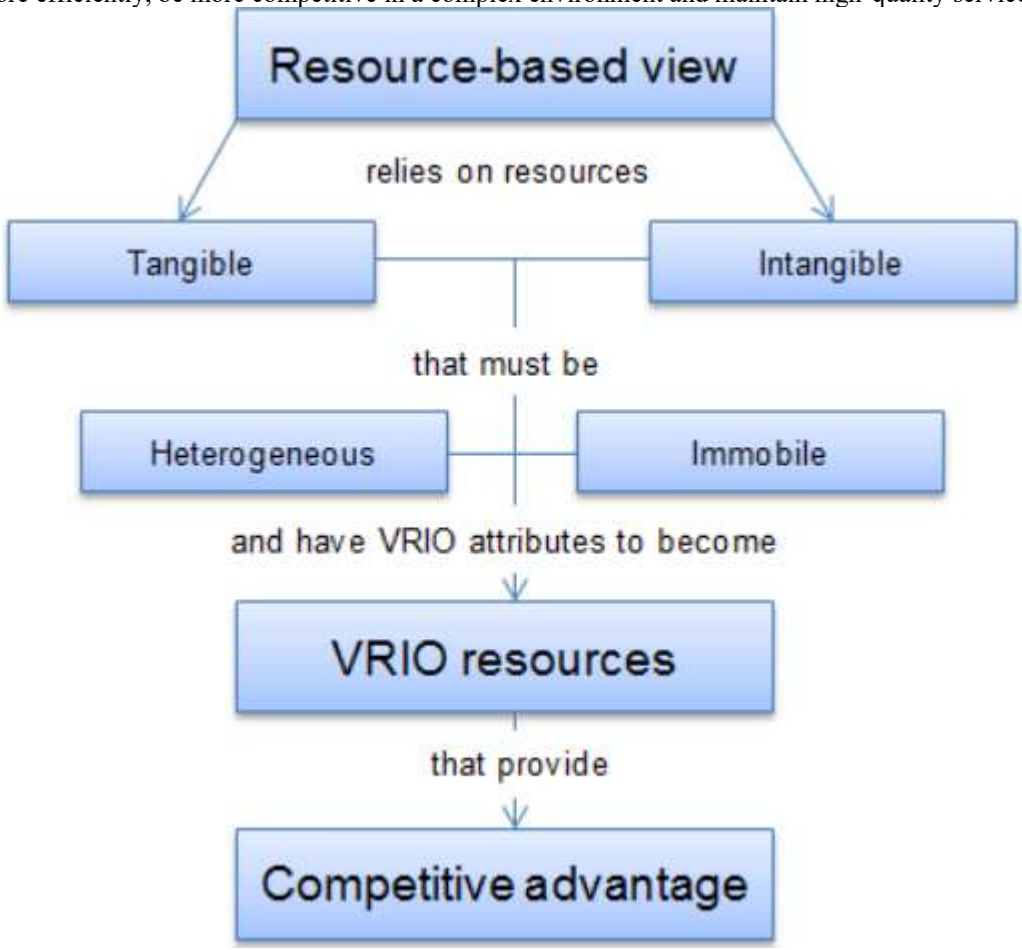

Figure 4: Resource-Based View
(Source: strategicmanagementinsight.com, 2023)

Additionally, healthcare analytics allow a hospital's green healthcare initiative to develop process innovations and digitally integrated systems. Through the ability to use analytics, hospitals can gain new insights regarding their workflows and how to create more streamlined purchasing and improved communications between clinical and business units. All of these processes increase operational efficiency while fulfilling the goals of the *Triple Bottom Line theory*, which balances economic, social and environmental issues while improving overall performance.

Figure 5: Triple Bottom Line theory
(Source: wisconsin.edu, 2022)

Increased Environmental Responsibility through analytics and monitoring Energy Management, utilizing data-driven tools to monitor energy consumption, emissions and waste at any given time, will help hospitals achieve targeted improvements in efficiency. Continuous Environmental Monitoring and Reporting further increases accountability and assists hospitals in tracking their performance for the best possible outcomes. In addition to enhance the ability to make data-based decisions about the sustainability of their initiatives, providing the opportunity to achieve multiple benefits: enhancing ecological success; providing cost savings; and developing more resilient organizations also become of paramount importance.

Table 5: Value proposition of resource allocation via data analytics

Dimension	Components
Data-Driven Resource Allocation	● Predictive analytics–based assignment of hospital beds, staff, and medical supplies to optimize resource utilization and patient care
Operational Efficiency	● Real-time analytics enhancing control of costs and efficiency of the services (Machireddy *et al.,* 2023).
Green Process Innovation	● Redesign processes with data in order to minimize waste.
Digital Integration	● Digital platforms to deliver sustainable operations. (Chan *et al.,* 2023)
Energy Efficiency Management	● Hospital energy consumption optimisation based on analytics.
Environmental Performance Monitoring	● Continuous data-driven monitoring of emissions and resource usage to improve sustainability, efficiency, and operational performance.

These analytics enable hospitals to make better use of their resources by enabling them to allocate those resources more effectively through better knowledge, improve their funding processes, and being continuously monitored by their environment. Operations that have been improved through the use of analytics, enable hospitals to achieve their operational goals (Balogun *et al.,* 2024) while also reducing resource waste and energy consumption which ultimately provides better care to patients and improves the performance of the organisation as a whole.

5. Conclusion

The findings of this research suggest that the use of data analytics can significantly enhance the efficiency with which hospitals manage their limited environmental resources, enabling them to achieve operational excellence while reducing their overall ecological footprint.

Theoretical Contributions

The research confirms that there is a constant need to apply Resource-Based View, Dynamic Capability and Socio-Technical Systems Theory through care delivery data analysis; demonstrating the ability to utilize data, digital systems information technologies and management capabilities to allocate human, financial and natural resources optimally, support sustainable care delivery practices and provide support for evidence-based decisions in care delivery systems of hospitals utilized in this study.

Implications

The findings of this research provide evidence for healthcare managers to adopt analytics as a monitoring tool for effectively managing energy consumption, optimizing staffing and supply utilization, implementing sustainable operational practices, and developing policies that improve patient care quality while promoting environmental sustainability and cost-effectiveness.

Limitations

While this study was conducted with a comprehensive analysis of 15 reviewed articles, it is limited in its establishment of a systematic approach to address all environments in which emerging technologies will be developed and implemented. The differences among published research methodologies and the differences in environments in which these articles were written can limit the degree to which the findings can be generalized; therefore, further empirical validation is needed to determine the applicability of this study in varying environments, hospitals, and locations across the globe.

Future Research

Future research may also assess the ability to utilize predictive analytics solutions in conjunction with intelligent hospital infrastructure in actual hospital settings and perform longitudinal studies with cross-national data on the sustainable management of hospitals and the impacts of creating hospitals that are operated with analytics-engendered approaches.

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