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RESEARCH ARTICLE

Assessing the Dynamic Capabilities and Sustainable Performance in Public Hospital Supply Chains Management

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ABSTRACT

In the volatility, uncertainty, complexity, and ambiguity (VUCA) era, unexpected disasters are rising. The Coronavirus disease 2019 (COVID-19) pandemic severely disrupted healthcare supply chains, with resource shortages significantly impacting the sustainable provision of public healthcare services. This highlighted the importance of supply chain management for public healthcare sustainability operations. An online survey was conducted among 127 public hospital employees and managers, adopting the SEM-PLS method to identify critical dynamic capabilities of supply chain management capabilities and their effect on sustainable development. The results indicate that strategic formulation capabilities, leadership, and digital technology competence significantly enhance the sustainable performance of public hospitals. This finding enriches the literature on sustainable supply chain management in the healthcare sector and provides policymakers and healthcare administrators with decision-making support.

Contribution/Originality: This study contributed to the current research on public hospital sustainable performance by establishing a comprehensive evaluation framework for the dynamic capability of supply chain management and providing a new perspective on the study of the impact mechanism of sustainable development in Chinese public hospitals.

1. Introduction

Public hospitals are the pillar of the national healthcare system and are closely related to public health rights. The hospital expenditures constitute approximately 40 percent of total healthcare costs, with supply chain expenditures comprising 30 to 40 percent (OECD, 2023). In recent years, some businesses have prioritized profit maximization in pursuing competitive advantage, often at the expense of sustainable growth. The concern has permeated the public healthcare system, rendering the viability of public hospitals a pivotal issue (Sarkis et al., 2011). As intricate entities within the public sector, public hospitals are pressured by various stakeholders to implement sustainability and multifaceted strategies that encompass social, economic, and environmental dimensions (Chatterjee et al., 2023). Supply chain management is a crucial component for ensuring operational sustainability and serves as the foundation for the sustainable development of public hospitals. The sustainable performance of public hospitals is used to assess their capacity to provide healthcare services while reconciling Environmental, Social, and Governance (ESG) goals. Before the Coronavirus Disease 2019 (COVID-19) pandemic, Chinese public hospitals optimized healthcare expenditures and resource use via inventory management. Nevertheless, abrupt supply chain disruptions induced by the pandemic led to inadequate healthcare resources, encompassing equipment and pharmaceuticals. These disruptions significantly impacted the provision of public healthcare services. They directly jeopardized patient safety. Driven by governmental regulations and public health catastrophes, supply chain management during crises has emerged as a critical field of study in the quest for sustainable development.

Dynamic capabilities theory suggests that an organization's ability to integrate, build, and reorganize internal and external resources enables it to cope with rapidly changing environments (Bogers et al., 2019). In supply chain management, dynamic capabilities have become an innovative theoretical perspective for addressing disruptive challenges (Wang & Gunasekaran, 2017). However, the mechanisms by which supply chain dynamic management capabilities influence the sustainable performance of public hospitals require further research.

Recent research has extended the focus from organization-level supply chain resilience to the broader socio-ecological system, enabling organizations to restore supply continuity through adherence, adaptation, and transformation (Reuter et al., 2010). Optimizing supplier management processes reduces risk and improves operational sustainability in the chemical industry. Wang and Gunasekaran (2017) used a nonlinear mathematical model to demonstrate that dynamic supply chain management capabilities significantly impact environmental expenditures and profitability. Revealed the significant impact of dynamic supply chain integration capabilities on organizational performance in the computer industry. However, there is a lack of empirical studies using SEM-PLS in this area, especially in the context of healthcare systems in developing countries. Therefore, there is a need for a comprehensive framework to assess the impact of key supply chain dynamic management capabilities on the sustainable performance of public hospitals.

To address this gap, this study developed a model of dynamic supply chain capabilities based on dynamic capabilities theory. It empirically examined the impact of dynamic supply chain management capabilities on the sustainable performance of public hospitals using SEM-PLS. This is essential to maintain sustainable public healthcare service delivery in the era of VUCA.

2. Literature review

2.1. Dynamic Capability Theory

Dynamic capability refers to an organization's capacity to assimilate, develop, and reorganize internal and external resources to adapt to swiftly evolving surroundings (Teece, 2007). Dynamic Capability Theory (DCT) asserts that businesses must cultivate the capacity to identify risks, capitalize on opportunities, and reorganize resources to ensure operational continuity by leveraging existing resource strengths (Teece, 2007). Dynamic capability theory concepts advocate for incorporating unanticipated disruption prevention and sustainability considerations into organizational supply chain management (Kırcı & Seifert, 2015). Healthcare organizations can mitigate unplanned disruptions by implementing robust governance measures to identify and prevent supply chain risks. This includes recycling high-value consumables, employing dynamic inventory management, and contracting third-party logistics providers to establish staffing contingencies, thereby reducing hospital costs and ensuring a swift and effective response to fluctuations in community healthcare demand. In a swiftly evolving external environment, innovation in supply chain management capabilities is crucial for hospitals to navigate complex challenges and significantly contribute to advancing a sustainable healthcare system.

2.2. Supply chain management

Supply chains refer to the network and process by which organizations collaborate with stakeholders, such as suppliers, to integrate resources and transform them into products and services that are ultimately delivered to consumers. Supply chain management involves integrating and coordinating material, financial, and information flows between organizations to transform resources and stabilize the value chain. Therefore, it was considered a critical management approach to ensuring organizational resources' sustainability and service delivery. The complexity of the supply chain requires constant vigilance to identify potential weaknesses and develop dynamic capabilities to cope with unforeseen disruptions. Dynamic supply chain management strengthens integration (Gruchmann et al., 2024). It enables organizations to better coordinate with their supply chain partners to ensure the continued availability of healthcare services and the delivery of high-quality patient care, even during unforeseen disruptions.

2.3. Sustainable performance of public hospitals

Traditional supply chain assessment criteria focusing on static financial and operational metrics and supply chain management based on the Sustainable Development Goals (SDGs) require a comprehensive assessment of supply chain management's environmental, social, and economic impacts, especially in a volatile external environment. In order to meet a wide range of stakeholder needs, sustainability in public hospitals is reflected in the creation of redundancies and backups through resource recycling and the use of green energy (environmental), balancing the supply and consumption of resources, emphasizing social responsibility to staff and the community (social), and the development of sustainable governance capabilities (government) through measures that include, but are not limited to, supply chain management, interdepartmental collaboration, and the application of new technologies (Hu et al., 2023). Sustainable healthcare supply chain practices in the context of the COVID-19 pandemic incorporate circular economy principles, a focus on social well-being, and emergency response governance into healthcare delivery, balancing economic, environmental, and social outcomes. These practices enable organizations to manage risk, improve resource efficiency, and create long-term value.

3. Hypothesis

Effective strategies are critical for managing resources, anticipating demand, and responding to supply chain disruptions. The healthcare supply chain includes complex multi-stakeholders, e.g., patients, providers, and insurers. Coordination is one of the critical elements of strategic supply chain management, which emphasizes external integration and requires organizations to have the ability to manage cross-functional collaboration, establish long-term and stable relationships with suppliers, facilitate flexible deployment and recycling of medical equipment and high-value consumables, and build in flexible redundancies and backups while reducing inventory and staffing costs. This includes developing contingency plans, establishing policies and processes to manage the supply chain effectively, and standardizing policies and processes that contribute to procurement flexibility (Han & Um, 2024). Supply chain sustainability in public health emergencies emphasizes improving long-term governance and safeguarding communities and employees in a volatile environment. Therefore, the ability to develop a dynamic strategy for the supply chain is critical for hospitals to provide sustainable services, leading to the following hypothesis:

H1: The supply chain's strategy formulation capability has a positive and significant effect on the sustainable performance of public hospitals

Leadership is a critical dynamic capability that influences organizational culture, decision-making, and resource allocation. In sustainable management, management plays a critical role in creating dynamic resource redundancy and backups through encouraging recycling and recycling utilization so that supply chain value translates into sustainable healthcare service delivery. Supply chain management should be able to meet the high complexity of daily operations and emergency procurement under public emergencies, coordinating resources to respond to sharp fluctuations in supply and demand (Hussain & Papastathopoulos, 2022). This includes developing contingency plans, diversifying sources of supply, and improving stakeholder collaboration. Experienced leaders must establish and control supply chain priorities, foster team building, and establish appraisal criteria, all of which are essential for achieving management strategies. Effective leadership governance facilitates the amelioration of resource shortages and healthcare service disruptions and enhances community and public healthcare welfare. Therefore, the second hypothesis is developed:

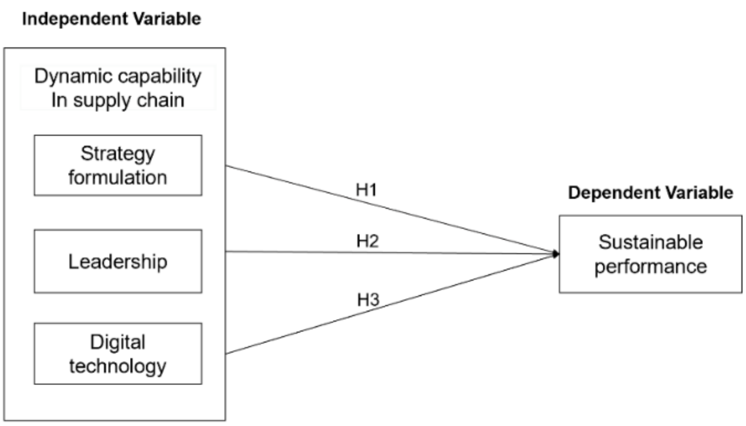
H2: Supply chain leadership has a positive and significant effect on the sustainable performance of public hospitals

Digital technology integration helps monitor resources in real time, improves communication, and enhances supply chain management efficiency (Hendijani & Norouzi, 2023). By promoting collaboration and information sharing with suppliers, digital technology can achieve real-time tracking of inventory levels, production plans, and transportation status (Wang et al., 2018). This, in turn, enhances the collaboration and decision-making capabilities of the supply chain, enabling it to better respond to unexpected resource disruptions and promote flexible resource allocation and recycling. Integrating medical equipment and material management systems, as well as digital technologies such as telemedicine, into healthcare can ensure timely and effective delivery of medical services, improve community and public health outcomes, and strengthen the governance of public hospitals in emergencies. This is particularly important for countries with limited resources during pandemics. Developing a digital supply chain in public hospitals can help manage disruptions more effectively and maintain sustainable performance. Therefore, a third hypothesis is proposed:

H3: The digitalization capability of the supply chain has a significant positive impact on the sustainable performance of public hospitals.

A research model was developed based on the assumed path relationship between variables, as shown in Figure 1.

Figure 1: The dynamic capability of supply chain effect on hospital sustainable performance



4. Methodology

This study employs quantitative methodology to investigate the relationships among selected variables systematically. This approach facilitates precise measurement and the application of statistical analysis to uncover potential causal relationships between the dynamic capabilities in supply chain management and sustainable performance of public hospitals, focusing on three critical, independent variables: strategic formulation capability, leadership, and digital technology capabilities. In order to achieve the research objectives, this study conducted the purposive sampling method, and the population included managers and staff of Chinese public hospitals (including tertiary hospitals, secondary hospitals, and preliminary community hospitals). During the COVID-19 pandemic, Chinese public hospitals were the pillars of the public healthcare system, experiencing supply chain disruptions and shortages of healthcare resources and eventually recovering from the crisis. Therefore, their viewpoint about this area will be representative.

To determine the appropriate sample size, we used the G*Power statistical software, which recommends a sample size of at least 85 respondents to obtain sufficient statistical power (α = 0.05, Erol = 0.80, predictor = 3) to detect moderate to significant effects in Structural Equation Modeling (SEM) analyses. Ethical approval for this study was subsequently obtained from Universiti Teknologi MARA (UiTM) in July of 2024, and informed consent was obtained from all participants prior to participation to ensure compliance with ethical standards for research involving human subjects.

From July to September 2024, questionnaires were generated and distributed online to 320 potential participants via the “Questionnaire Star online survey platform” in China, with 127 respondents eventually completing the questionnaire for a response rate of

39.69%, which exceeded the minimum sample size derived from the G-Power Sample Calculator, thus enhancing the robustness and reliability of the analysis.

The structured questionnaire utilized for data collection was divided into two parts (A and B). Part A collected demographic information (e.g., gender, age, public hospital level, education, professional experience, and managerial roles) to ensure a representative understanding of the respondents' backgrounds. Part B focused on the fundamental concepts of this study: strategic formulation (Goldstein et al., 2002; Han & Um, 2024; Robinson, 2023; Yoshikuni et al., 2023), leadership (Sandhu & Al Naqbi, 2023; Trieu et al., 2024; Zahari et al., 2022), and digital technology capability (Liu & Qi, 2024; Zhang et al., 2021), as well as sustainable hospital performance as the dependent variable (Al-Khatib, 2023; Ziat et al., 2024; Zurynski et al., 2022). These variables were measured using items adapted from previously validated scales in the literature to increase conceptual validity and ensure relevance. Each item was scaled by a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Afterward, SPSSAU was utilized for demographic data analysis, while Smart PLS 4.1 was applied to evaluate questionnaire data.

5. Data analysis and discussion

As shown in Table 1, the respondent profile shows that 59.06% are male and 40.94% are female. The age distribution shows that 40.13% of the respondents are between 30 and 40 years old, while 50.41% are over 40. Most respondents (70.08%) hold management positions, and 80.31% are affiliated with second or higher-level public hospitals. In addition, educational qualifications show that 54.33% of respondents have a bachelor's degree, 18.11% have a master's degree, and 16.54% have a doctoral degree. Notably, 58.27% of the respondents have ten years or more of professional experience. This demographic feature indicates that the respondents possess the necessary professional knowledge, educational background, and perspectives related to the research focus.

Table 1: The Frequency analysis of demographic information

Items	Categories	N	Percent (%)	Cumulative Percent (%)
Age	Above 50	26	19.47	19.47
	41 - 50	52	30.94	50.41
	30-40	37	40.13	49.14
	Less 30	12	9.45	100.00
Education	PhD	21	16.54	16.54
	Master	23	18.11	34.65
	Bachelor	69	54.33	88.98
	College	14	11.02	100.00
Years	Above 20	24	18.90	18.90
	10-20	50	39.37	58.27
	1-10	48	37.80	96.06
	Less than1	5	3.94	100.00
Level	The tertiary	40	31.50	31.50
	The secondary	62	48.82	80.31
	The third	25	19.69	100.00
Gender	Male	75	59.06	59.06
	Female	52	40.94	100.00
Position	Dean	27	21.26	21.26
	Director	62	48.82	70.08
	Staff	38	29.92	100.00
Total		127	100.0	100.0

Next, this study used the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity to assess whether the data conformed to factor analysis. As shown in Table 2, the KMO values and Bartlett's test of sphericity were met as the KMO was 0.943, which is greater than 0.7 and less than 0.05 ($p < 0.05$) significant. These data indicate sufficient correlation between the variables to extract meaningful information.

Table 2: KMO and Bartlett's Test Analysis in EFA

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.943**
Bartlett's Test of Sphericity	Approx. Chi-Square	5796.277
	df	351
	Sig.	<.001

Figure 2: The measurement model

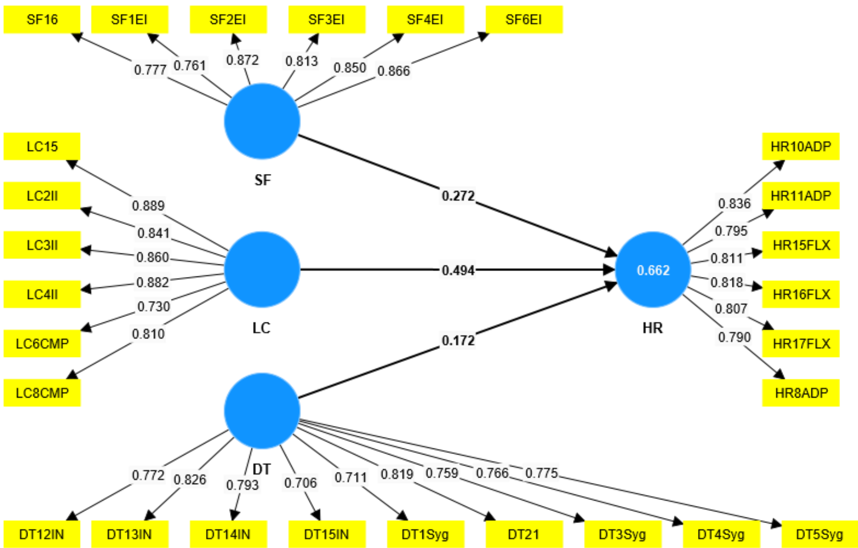


Table 3: The measurement test

	Outer loadings	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
SF	0.846	0.906	0.915	0.927	0.679
LC	0.872	0.914	0.921	0.933	0.700
DT	0.781	0.915	0.921	0.929	0.594
HR	0.813	0.895	0.897	0.919	0.656

Table 4 presents the model fit indices for the estimated model. The Standardized Root Means Square Residual (SRMR) values for both models are 0.082, below the threshold of 0.10, indicating an acceptable fit (Hu & Bentler, 1999). The unweighted least squares discrepancy (d_ULS) value for both models is 2.541, and the geodesic discrepancy (d_G) is 0.826, suggesting a satisfactory overall model fit (Schermelleh-Engel et al., 2003). The Normed Fit Index (NFI) is 0.779, approaching the acceptable threshold of 0.90, indicating that the model demonstrates a reasonable fit.

Table 4: The Model Fit

	Saturated model	Estimated model
SRMR	0.082	0.082
d_ULS	2.541	2.541
d_G	0.826	0.826
Chi-square	1327.939	1327.939
NFI	0.779	0.779

Table 5 provides the results of the structural model assessment. The R-Square value for HR is 0.662, with an adjusted R-Square of 0.658, indicating that the independent variables explain approximately 66.2% of the HR variance. The F-Square values suggest the effect sizes of the exogenous variables on HR, where SF contributes a moderate effect (0.113), LC demonstrates a significant effect (0.415), and DT has a negligible effect (0.049). The Q^2 value for HR is 0.380, which indicates the model's predictive relevance. Additionally, all VIF values are below 3.3, with SF at 1.935, LC at 1.733, and DT at 1.766, suggesting that multicollinearity is not a concern within the model (Hair et al., 2019).

Figure 3: The structure model

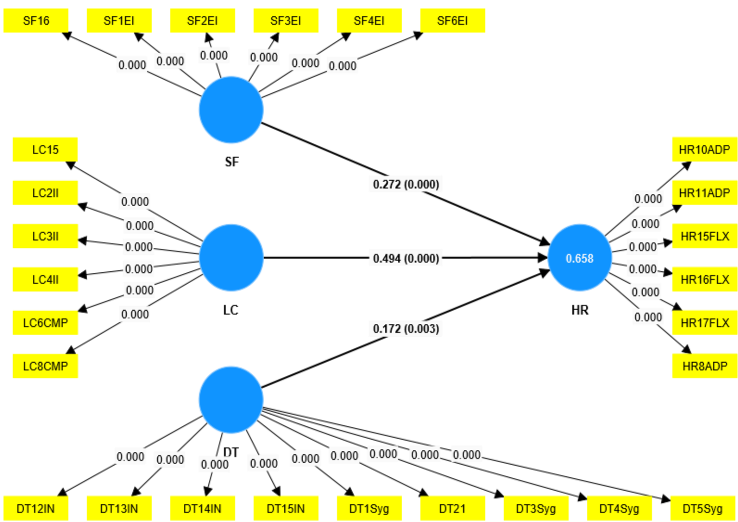


Table 5: The structure model test

	R-Square	R-Square Adjusted	F-Square	Q^2	VIF
HR	0.662	0.658		0.380	
SF -> HR			0.113		1.935
LC -> HR			0.415		1.733
DT -> HR			0.049		1.766

Table 6 reports the path coefficients of the structural model, providing insights into the relationships between the dynamic capability (strategic formulation capability, leadership capabilities, digital technology) and hospital sustainability.

The test result of H1, the relationship between strategic flexibility (SF) and hospital sustainable performance, is positive and significant (β = 0.272, T = 4.543, P = 0.000). This finding supports the previous hypothesis (Han & Um, 2024; Hasan et al., 2021; Liang et al., 2022), suggesting that strategic flexibility improves hospital sustainable performance.

The test result of H2 indicated that digital technology has a positive and insignificant effect on the hospital's sustainable performance (β = 0.172, T = 2.929, P = 0.003). This finding is consistent with previous research (Akpan & Ibidunni, 2023; Liu & Qi, 2024; Zhang et al., 2021), indicating that digital technology plays a statistically significant role in influencing hospital sustainability.

Table 6: The path coefficient

	β	Mean	SD	T statistics	P values
DT -> HR	0.172	0.173	0.059	2.929	0.003
LC -> HR	0.494	0.493	0.051	9.621	0.000
SF -> HR	0.272	0.272	0.060	4.543	0.000

The test result of H3 shows a positive and significant relationship between leadership capabilities and hospital sustainable performance (β = 0.494, T = 9.621, P = 0.000). The finding is consistent with previous research (Hussain et al., 2019; Sandhu & Al Naqbi, 2023; Trieu et al., 2024; Zahari et al., 2022). This test result signifies a positive and significant relationship, underscoring the critical importance of leadership capabilities in enhancing hospital sustainable performance.

The path coefficient results indicate that leadership capabilities substantially affect hospital sustainable performance, followed by strategic flexibility and digital technology. These relationships support the hypothesis that dynamic supply chain management capabilities positively influence hospital sustainable performance in complex and uncertain environments.

Table 7 shows the predictive power metrics of the structural model. The Q^2_predict values range from 0.324 to 0.507, indicating moderate predictive relevance (Sarstedt et al., 2014). The highest predictive power is observed for HR15FLX (Q^2_predict = 0.507), while HR11ADP has the lowest (Q^2_predict = 0.324). The test result of PLS-SEM shows a lower value of RMSE (the value from 1.192 to 1.515) and MAE (0.894-1.115) compared to LM_RMSE (1.235-1.584) and LM-MAE (0.928-1.194), which indicates better predictive power in this model. This supports PLS-SEM's suitability for analyzing the effect of dynamic supply chain management capabilities on sustainable performance.

Table 7: The predicted power

		PLS-SEM_RMSE	PLS-SEM_MAE	LM_RMSE	LM_MAE
HR10ADP	0.407	1.329	1.006	1.405	1.065
HR11ADP	0.324	1.515	1.115	1.584	1.194
HR15FLX	0.507	1.192	0.894	1.235	0.928
HR16FLX	0.430	1.380	1.042	1.423	1.055
HR17FLX	0.474	1.292	0.988	1.327	1.009
HR8ADP	0.38	1.351	1.008	1.433	1.075

6. Conclusion

This study utilized the SEM-PLS to investigate how dynamic supply chain management capabilities affect the sustainable performance of public hospitals in China. The findings suggest that strategy formulation capability, leadership capability, and digital technology capability in supply chain collaboration positively affect the sustainable performance of public hospitals.

This study fills in the theoretical gap between dynamic capabilities and long-term performance in the public hospital supply chain by proposing an assessment framework of sustainability based on the dynamic capability theory. The quantitative methods adopted by this study contribute to existing literature. This is one of the few studies investigating strategy formulation, leadership, and how digital technology influences sustainable performance. This study's primary contribution is finding the critical effect mechanism of the dynamic supply chain capabilities on the sustainable performance of public hospitals, which provides valuable insights for sustaining academic research and managerial decision-making in healthcare in developing countries.

However, this study has inherent limitations due to time and space constraints. Firstly, it used a cross-sectional design that captured hospital managers' perceptions of dynamic supply chain capabilities and their impact on sustainability at a single point in time. Second, with an R^2 value of 0.662, the results suggest that other unquantified factors influence hospital sustainability performance. Thirdly, as an organizational-level study, it only focused on the perceptions of internal managers and employees.

First, future research should address the above shortcomings by adopting a longitudinal approach to observe how sustainability performance evolves. Secondly, while dynamic capabilities significantly improve sustainability outcomes, challenges remain in balancing immediate economic performance with long-term sustainability goals, especially for traditional public healthcare organizations transitioning to more sustainable practices. Thirdly, as a public sector study, future research should incorporate a broader range of stakeholders, such as regulators, external providers, and patients, to deepen a more holistic understanding of the field. This will inform hospital management and decision-making.

Ethics Approval and Consent to Participate

This study was approved by the Universiti Teknologi MARA ethics committee (UiTM). We certify that the study was performed by the 1964 declaration of HELSINKI and later amendments. Written informed consent was obtained prior to this study's publication.

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Conflict of Interest

The authors reported no conflicts of interest in this work and declared no potential conflict concerning this article's research, authorship, or publication.

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