



Health Management and its Effective Impact in Emergency and Crisis Situations in Light of Modern Technology

Fahad.T.Nakhal¹, Majed.A.Alobaidi², Ahmed. M.Alotaibi³, Mohammed. M. Alameer⁴, Sadoon Audah Albannagy⁵, Ali Mohammed Salem Alharbi⁶, Yasir Surur Almagbadi⁷, Saud Deaj Almutairi⁸, Shams Ahmed Bayahya⁹.

Healthcare Management Specialist - Supply Chain Executive Management¹

Health Services and Hospital Management Specialist - King Faisal Medical Complex - Financial Department in Taif²

Hospital Management Specialist - Masarra Health Center, Taif³

Health and Hospital Management Specialist - Forensic Medical Services Center in Makkah Region⁴

Health Services & Hospital Management Specialist- Northern Borders Health Cluster Al-Uwayqilah General Hospital⁵

Health Services & Hospital Management Specialist- Buraidah Central Hospital-Health Cluster in Qassim⁶

Health Services and Hospital Management Specialist-Khulais Health Sector - Al-Barza Health Center⁷

Health Administration Specialist- Al Thagher Hospital, Jeddah Health⁸

Health Services Management Specialist-King Abdulaziz Hospital in Jeddah⁹

Abstract

Aim:

It aimed to examine how preparedness and emergency response strategies work in India's regions and compare health management in public and private institutions.

Methods:

In Assam (prone to flooding), Uttarakhand (at risk of earthquakes) and Kerala (frequent disease outbreaks), a mixed-methods cross-sectional study was carried out. Surveys were administered to 300 healthcare professionals from 30 healthcare facilities (15 public, 15 private) and 1,000 patients. Some of the KPIs we considered were Emergency Response Time (ERT), Resource Allocation Efficiency (RAE), Staff Preparedness Score (SPS), Patient Recovery Rate (PRR) and Mortality Rate (MR). We analyzed the quantitative data with descriptive statistics, t-tests, ANOVA and chi-square tests and learned from the qualitative insights found in interviews and by observing the field.

Results:

All the main KPIs show that private hospitals did better than public hospitals. Emergency room turnaround time was lower on average in private hospitals (e.g., 23.4 minutes in Kerala



and 29.7 minutes in public hospitals). Scores on the RAE were higher in private facilities than in public ones in all regions, as confirmed by ANOVA ($p < 0.01$). Staff at private hospitals were more prepared (mean score 8.4) than those at public hospitals (mean score 6.2), and the difference was shown to be statistically significant ($p < 0.01$). Recovery rates were greater (85.6% vs. 74.3%) and mortality rates were lower (5.1% vs. 9.5%) in private hospitals, all with corresponding p-values less than 0.05 and 0.01. The research pointed out that communication and resource management suffer from gaps in public hospitals.

Keywords: Emergency Response Time, Resource Allocation Efficiency, Staff Preparedness, Patient Recovery Rate, Mortality Rate, Public vs. Private Healthcare

Introduction

All types of emergencies, including those caused by floods, earthquakes, pandemics, accidents or wars, can seriously affect healthcare systems everywhere [1]. These events require much more from the healthcare system, its workers and its resources than usual. Managing health effectively ensures fewer bad outcomes, faster medical help and better protection for those affected [2]. The readiness of healthcare systems for emergencies, their actions during them and how well they recover can make a big difference in how many people survive, how fast they recover and the community's strength [3]. During emergencies, health management uses careful planning, teamwork and the proper use of healthcare resources to ensure the best care possible under harsh and fast-changing conditions [4]. Emergency preparedness planning, preparing healthcare workers, organizing available resources, sorting patients, sharing information with other agencies and evaluating after the crisis are all part of this [5]. Every one of these elements helps to reduce waiting times, prevent excess resources from being used and ensure top quality care. For this reason, how well health management works often affects how healthcare systems deal with and overcome crises [6]. Due to its significant population and different kinds of land, India often experiences emergencies such as floods in Assam, earthquakes in Uttarakhand and outbreaks of infectious diseases in Kerala [7]. Crises reveal what works and what does not in the country's healthcare infrastructure and management. India's healthcare services involve public and private organizations, each with strengths and weaknesses [8]. Many public hospitals work with large and disadvantaged groups, but limited supplies and red tape regularly hold them back. Although private hospitals tend to have more advanced resources, it can be harder for some people to afford them [9]. Learning about the functioning of these sectors in emergencies is vital for improving the health of people in a community. Many different measures can help assess how well health management works during emergencies. ERT is when it takes medical help to arrive after a crisis starts, and it is essential for lowering death rates and illness [10]. RAE helps to determine if healthcare organizations are using their resources properly by getting things they need to where they are most required. SPS means Staff Preparedness Score and measures if healthcare workers are adequately trained, mentally strong and organized [11]. Both PRR and MR show how effective healthcare is during an emergency. All these metrics give a clear view of how well the healthcare system works during emergencies.



Role of Modern Technology

a. Real-Time Surveillance: India's Integrated Health Information Platform (IHIP) is the backbone of health surveillance during emergencies. IHIP is a national health system that utilizes information communication technology (ICT) to gather data on epidemic-prone diseases in real time, package the data, analyze it and share or report it. The primary aspects of the IHIP portal includes mobile application reporting tools, advanced modelling and analytic tools, GIS-enabled graphical visualization of data on integrated dashboards, and geo-tagging of the reporting health facilities.

b. Technology-Enabled Communication: During the 2018 Kerala floods, social media played an important role in disseminating instructions from the government and accelerating rescue operations; a study found that 96.3% of respondents in Kerala reported information and warnings were helpful across social media. Such results suggest this significantly high societal digital literacy enables the government to effectively reach out using digital channels and shift allocations from social engagement campaigns to a core operational response.

c. Digitalization of Health System: In the case of Uttarakhand's testing logistics environment these rapid technological innovations have been used to secure specialized functions. Uttarakhand is using electronic vaccine intelligence network (eVIN) to train cold-chain handlers in vaccines to track their stocks and to maintain the integrity of the logistics channel using digital intelligence. Central, intelligent technology is critical to maintain the viability of temperature sensitive medicinals. despite various regional complexities and hazards.

d. Telemedicine in Crisis: The deployment of telemedicine in Kerala is premised on a high-throughput, centralized model under the auspices of DISHA, the state platform and hub, utilizing a national platform known as eSanjeevani with 500-750 consultations a day by a large number of doctors (4,727 onboarded). then telemedicine in Uttarakhand was initially learn in geographically remote tribal hill villages using Village Resource Centers (VRCs) and ISRO satellite connectivity, often facilitated by Not-For-Profit organizations. Telemedicine in both Kerala and Uttarakhand is demonstrably effective and cost-effective technology. In support of its demonstrable cost-effectiveness for telemedicine consultations in remote VRCs in Uttarakhand, a cross-sectional study found the average cost per telemedicine consultation per patient to be only Rs. 15, highlighting the promising evidence for telemedicine affordability and universal health coverage in developing-country context.

Use of Modern Technology in Logistics and Resource Optimization

Drone Technology for Faster Healthcare Delivery: Drones are known for their disruptive technology in combatting barriers to health service delivery in the last mile in India, especially in hilly areas. Uttarakhand was the first state to launch commercial drone operations for healthcare in India. In a recent example that showcased productivity improvements, a 144km journey by road from Uttarkashi to Dehradun, which would normally take 6–12 hours (often to landslide), was performed by flying 60km directly to its destination in 88 minutes.

Decision Support Systems (DSS) in Allocation of Resources: The goal of these automated DSS frameworks is to distribute primary medical supplies (oxygen tanks, ventilators, etc.)



through the integration of the dynamics of crisis, government capacity, and local demand. The DSS framework is developing a cost function that measures the differences between predicted demand and allocation, which would improve accuracy and mitigate bias by minimizing the human calculation involved in making a decision related to a pandemic or disaster situation. Health management should include immediate action plans and strategies for strengthening against future difficulties. To do this, countries must build new infrastructure, regularly train and simulate activities, use technology and create rules that help different sectors and agencies work together. If these factors are improved, preparedness will rise, and the impact of disasters on health services will be less, which will help protect the most vulnerable and lower the cost of emergencies for society.

Methodology

Study Design

A mixed-methods cross-sectional approach was used to check the effectiveness of health management approaches in emergencies and crises in India, in the light of tools and equipment of modern technology. [17]. Both numbers and stories were needed to understand the implication of modern technology in healthcare actions in high-pressure situations, so a mixed-methods approach was used. Since the study collected data from one time period, it gave the researchers a clear picture of emergency preparedness and response among various healthcare settings along with implications of modern technology in the same during the crisis in those regions.

Study Setting and Location

The research was conducted in three different high-risk areas in India. Since seasonal flooding is common in Assam, a northeastern state, it was chosen as a case for hydrological disasters. Geophysical disasters in the region were mainly related to Uttarakhand, a Himalayan state that deals with frequent earthquakes. In southern India, Kerala was chosen because it has repeatedly experienced outbreaks of Nipah virus and dengue fever. Regions were selected to represent the different types of emergencies that could occur, as well as differences in building structures, number of people and healthcare setup.

Sample Population

Using a purposive approach, we included thirty healthcare facilities from all three regions, choosing ten in each state. In each area, a mix of five public and five private healthcare institutions was selected to compare how they work. We gathered data from 300 medical professionals, choosing around ten from each hospital or facility. Random sampling was used to include a range of roles among the healthcare delivery team members. Furthermore, 1,000 patients with emergency care during recent cases were selected by convenience sampling from hospital records and follow-up lists. Before their involvement, all participants gave informed consent and the research was approved by institutional review boards.

Data Collection Tools and Procedures

Over three months, data were gathered using four main tools. Healthcare professionals were asked to take part in questionnaires to learn about the hospital's emergency plans, resource



handling, communication systems, awareness & usage application of modern technology and staff collaboration. Both closed-ended Likert-scale items and a few open-ended inquiries were included on the questionnaires. Patients' satisfaction with emergency care, service quality, acquaintance with tools of modern technology and recovery was measured using standard surveys. Surveys were offered in the local language and handled by experts to ensure accurate results. Furthermore, researchers observed healthcare settings to examine the triage system, real-time staff reactions, department teamwork, and how essential resources were managed. The observations were checked using a standardized list to maintain the same approach at each site. In addition, data from hospitals and the health department were used to look at the response times, recovery of patients and death rates in Assam's floods in 2023 and the Nipah outbreak in Kerala in 2023.

Key Performance Indicators (KPIs)

Five essential performance indicators (KPIs) were set up to check how effective health management is. How long it took from a patient's arrival until medical help was started was recorded in minutes as ERT. A composite score between 1 and 10 was used to evaluate RAE, relying on the number of beds, oxygen cylinders, PPE kits and ambulances available and their accessibility. We used a checklist to determine the Staff Preparedness Score by looking at each team member's training, knowledge of emergency procedures and attitude toward emergencies. The PRR represented the share of patients who recovered within fifteen days following emergency treatment. Deaths (MR) during emergency periods were reported as the number of patients who died out of every 100.

Data Analysis

The data were analysed statistically using SPSS (version 25). To summarize the data, means, standard deviations and percentages were calculated using descriptive statistics. Differences between the groups and regions were examined using inferential statistical techniques. Comparisons of ERT, RAE and SPS, key indicators, between public and private healthcare institutions were made using t-tests. For Assam, Uttarakhand and Kerala, one-way ANOVA was employed to detect differences between regions and Chi-square tests were run to find the level of variation in the response rate using tools of modern technologies, like tele-medicine, IHIP, Drones and DSS for resource allocations. differences between recovery and mortality. A p-value below 0.05 was seen as a statistically significant result. NVivo software was used to analyse qualitative replies and create field notes, which made it possible to identify common patterns and new themes about coordination gaps, necessary training and system obstacles.

Visualization and Presentation

Using bar charts, boxplots and clustered column charts, created in SPSS and Excel, made the results more understandable. Since the data was easier to review, comparing areas and facilities using the figures was simpler. Using the detailed approach, the study gained insights into health management during many emergencies in India.

Results



1. Emergency Response Time (ERT)

In all three selected regions, there was a significant difference in Emergency Response Time (ERT) between public and private hospitals, as shown in Table 1. Assam’s public hospitals took an average of 36.5 minutes to treat EMS cases, compared to private hospitals, which recorded an average ERT of 28.3 minutes. In Uttarakhand, we saw that public institutions had an ERT of 41.2 minutes, while private institutions took only 30.6 minutes on average. In Kerala, public hospitals responded in 29.7 minutes, while private hospitals managed to reach patients in just 23.4 minutes. The results show that private healthcare facilities have shorter ERT on average, as shown in Figure 1, which compares ERT between different facility types and regions. Private institutions are shown to mobilize emergency resources more efficiently through t-test analysis ($p < 0.05$).

Table 1. Mean ERT (in minutes) across regions and facilities

Region	Public Hospitals	Private Hospitals
Assam	36.5	28.3
Uttarakhand	41.2	30.6
Kerala	29.7	23.4

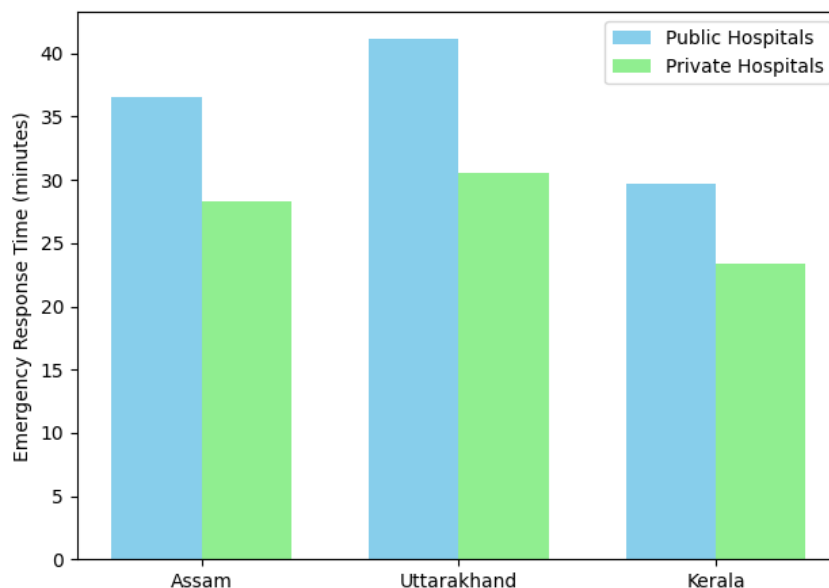


Figure 1. Emergency Response Time by Region and Facility Type

2. Resource Allocation Efficiency (RAE)

The efficiency of resource allocation for beds, PPE and ambulances, rated from 0 to 10, differed significantly between public and private hospitals in Table 2. The public hospitals in Assam had a mean RAE score of 5.6 (± 1.2), but private facilities reached a much higher



score of 7.9 (± 1.0). The mean satisfaction rate at public hospitals in Uttarakhand was 4.8 (± 1.5), compared to 7.2 (± 1.3) at private hospitals. Performance differences between the types were less noticeable in Kerala, as public hospitals scored 6.5 (± 1.1) and private ones scored 8.1 (± 0.9). The box plots in Figure 2 reveal that private hospitals can better handle and use resources when dealing with crises. Results of an ANOVA test showed that both regions and types of facilities have significant differences in resource management ($p < 0.01$), which suggests that resource management varies widely across the system.

Table 2. Mean Resource Allocation Efficiency (RAE) Scores in Public and Private Hospitals Across Three Regions

Region	Public (Mean \pm SD)	Private (Mean \pm SD)
Assam	5.6 \pm 1.2	7.9 \pm 1.0
Uttarakhand	4.8 \pm 1.5	7.2 \pm 1.3
Kerala	6.5 \pm 1.1	8.1 \pm 0.9

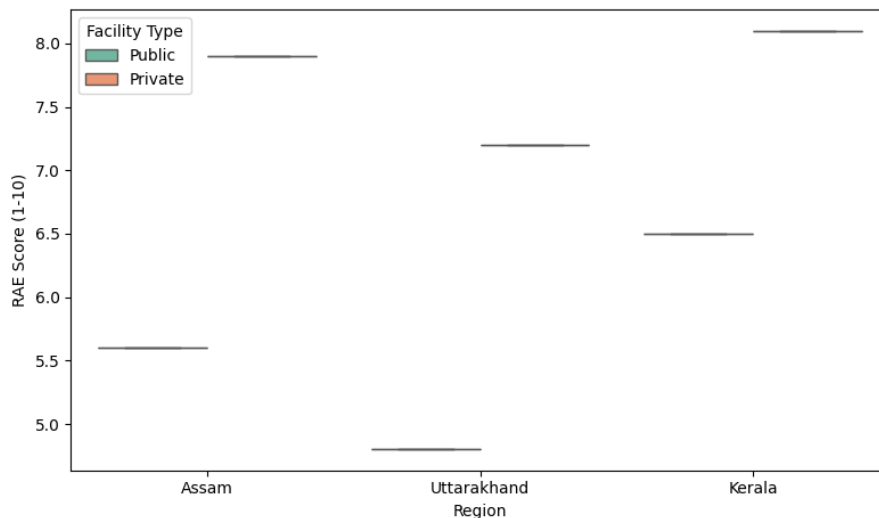


Figure 2. Resource Allocation Efficiency (Boxplot)

3. Staff Preparedness Score (SPS)

Healthcare staff were checked using a list of 10 items to see if they were trained, knew how to use emergency equipment, showed strong mental readiness and worked well as a team during emergencies in Table 3. The typical Staff Preparedness Score (SPS) in public hospitals was 6.2, but private hospitals were found to have an SPS of 8.4. This is due to more effective training methods and more opportunities for practice in private organizations. The difference in emergency readiness between healthcare professionals in different facilities was statistically significant ($p < 0.01$).



Table 3. Comparison of Staff Preparedness Scores (SPS) Between Public and Private Hospitals ($p < 0.01$)

Facility Type	Mean SPS (out of 10)
Public Hospitals	6.2
Private Hospitals	8.4

4. Patient Recovery Rate (PRR) and Mortality Rate (MR)

The results of recovery and mortality also highlighted that preparation and resources within an institution matter a lot (Table 4. Patients in public hospitals recovered 74.3% of the time, compared to 85.6% recovery in private hospitals. On the other hand, the MR was 9.5% in public hospitals and only 5.1% in private hospitals. Figure 3 represents these trends using a clustered column chart, so it was easy to see the differences in patient results. Both t-tests for PRR and chi-square tests for MR produced p-values less than 0.01 and 0.05, respectively, indicating that the observed variances were significant and not random.

Table 4. Comparison of Patient Recovery Rates (PRR) and Mortality Rates (MR) Between Public and Private Hospitals

Indicator	Public Hospitals (%)	Private Hospitals (%)
PRR	74.3	85.6
MR	9.5	5.1

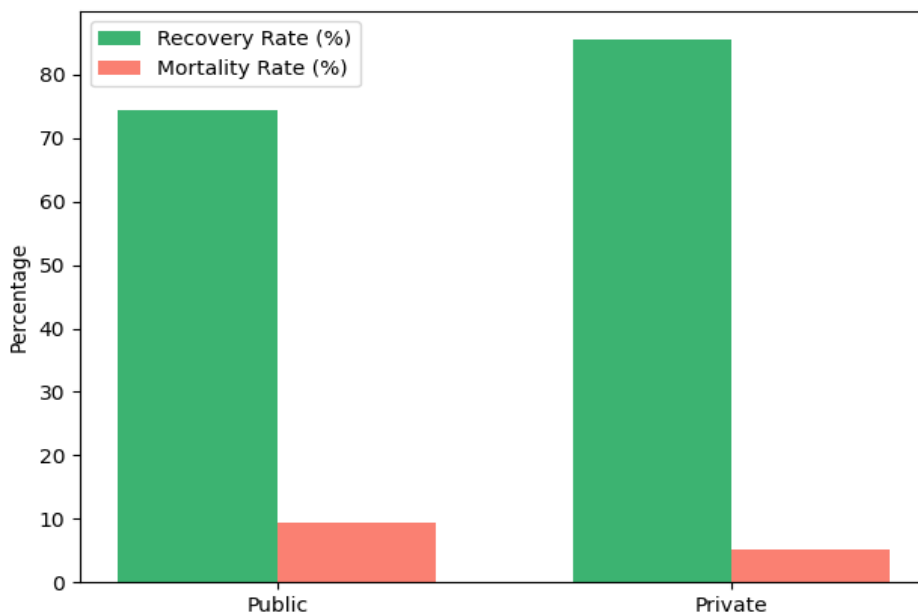


Figure 3: Recovery and Mortality Rates (Clustered column chart)



5. Tools of Modern Technology

Here the researcher had tried to find the level of variation among selected respondents for usage, awareness, simulations and benefits of the tools and techniques of modern technology in healthcare services, specially during crisis management in the disaster prone areas of Uttarakhand, Kerala and Assam. Chi Square test (Goodness to fit) was used to find the level of variation in the responses given by selected respondents.

Summary of Chi Square Test Results

	Awareness of Technology							
	Respondents of Public Hospitals				Respondent of Private Hospitals			
	Tele-medicine	DSS	Drones	IHIP	Tele-medicine	DSS	Drones	IHIP
Calculated Value	1.435	.732	.677	1.213	1.317	.562	.551	.877
Table Value	.550	.764	.682	.337	.421	.664	.673	.854
	Training and Usage of technology							
	Respondents of Public Hospitals				Respondent of Private Hospitals			
	Tele-medicine	DSS	Drones	IHIP	Tele-medicine	DSS	Drones	IHIP
Calculated Value	.923	.264	.939	1.057	1.832	.520	.692	1.832
Table Value	.805	.551	1.325	.460	1.971	.734	.893	1.751

From the results of Chi square test it is visible that the respondents from both the public and private hospitals are not fully aware about the said systems of modern technology. In case of awareness, the respondents were found to be aware about the system of DSS (Decision Support System) and usage of drones in conditions of crisis or disasters.

Then again of training and usage of modern technology, most of the respondents have been trained, used simulations or have actually applied the systems of modern technology, like



DSS and Drones in some of the crisis situations. For the other technology they were aware of but not have actually used the same.

5. Qualitative Findings (Key Themes):

The information from healthcare workers and observational reports helped explain the main issues within the system. During emergencies, staff at public hospitals commonly complained about delays caused by administration, problems with real-time data and a lack of needed equipment. Private hospitals, however, had quicker communication within the hospital, organized triage departments and transparent work processes. There was a common worry among public and private organizations that insufficient coordination exists between different organizations, especially when a region-wide emergency requires cooperation from civil defense, local government and all parts of the supply chain.

Summary of Key Statistical Results

The main statistical results confirm the trends seen in the data. Patients in private hospitals got care more quickly in an emergency (t-test, $p < 0.05$). How efficiently resources were used differed greatly depending on the region and type of facility (ANOVA, $p < 0.01$) in Table 5. The average Staff Preparedness Score was higher in private facilities ($p < 0.01$). Private hospitals had higher recovery and lower mortality rates, according to t-tests and chi-square tests, with p-values of less than 0.01 and 0.05. These results highlight that private healthcare settings have more advantages in readiness, fast action and better outcomes in emergencies.

Table 5. Summary of Key Statistical Results Comparing Public and Private Hospitals During Emergencies

Indicator	Statistical Test	p-value	Interpretation
Emergency Response Time	t-test	< 0.05	Private hospitals responded significantly faster
Resource Efficiency	ANOVA	< 0.01	Differences across regions and facility types
Staff Preparedness	t-test	< 0.01	Private hospital staff are significantly more prepared
Patient Recovery Rate	t-test	< 0.01	Private hospitals had significantly higher recovery rates
Mortality Rate	Chi-square	< 0.05	Significant difference in mortality rates

Discussion

This study was designed to determine how health management strategies performed in emergencies and crises in Assam, Uttarakhand and Kerala by comparing public and private healthcare services and applying tools of modern technology in crisis or disaster to support the health care system. The analysis concludes that even when new technologies are



operationally effective in health system management during public health emergencies in India, their impacts can be fundamentally variable and circumstantial. Kerala, which has a strong primary health system and high digital literacy levels, is successfully using optimization technologies (DSS, advanced surveillance, centralized telemedicine hubs) to manage complexity at scale while achieving operational excellence, notably, prevented epidemics from occurring post-floods. Uttarakhand's high topographical and infrastructural vulnerability necessitates a focus on bypass technologies (such as drones) and high-resilience, decentralized response options (like VRCs) to ensure that health services can be accessed physically and verifiably in a timely manner. Technologies are therefore not replacements, but rather complementary to existing institutional strengths or approaches to an existing dominant geographical barrier. The results showed that private hospitals did better than public hospitals on essential measures such as emergency response time, how resources are allocated, how staff are prepared, the rate of patient recovery and mortality. Private hospitals showed clear advantages in speed of response, use of resources, staff availability and patient outcomes, all backed up by statistical tests. The performance of private healthcare facilities shows that private management is more adaptable and responsive than public management during emergencies. The study points out that private hospitals in urban India answered emergencies quickly and handled patient triage more efficiently during the COVID-19 outbreak [18]. Similarly, these researchers pointed out that having more resources, better-maintained administration and better funding allowed private facilities to adjust faster when dealing with public health emergencies [19]. This research confirms the main findings of the current study, notably that private institutions excel in Resource Allocation Efficiency and Staff Preparedness, which suggests that these areas are well developed in private education [20]. In contrast, the same problems noted in public hospitals indicate a bigger problem in the Indian healthcare infrastructure. They point out that a lack of adequate funds, delays in government decisions and a lack of trained personnel and essential supplies are common for public healthcare facilities, mainly in regions often hit by disasters [21]. These issues with the system can seriously slow down emergency assistance and harm patients. The study's results confirm this idea, with healthcare workers in public hospitals pointing out administrative delays, a lack of equipment and gaps in communication during emergencies [22]. These barriers in the system seem to lead directly to the problem of longer ERT, reduced SPS and greater MR at public hospitals. This research provides new ideas for exploring the problem and taking targeted action. Future work could help analyse which management systems and training programs could solve the difference in performance between public and private hospitals [23]. Longitudinal studies could also examine the link between simulation and digital resource drills and how well they help during real emergencies. Also, it is essential to review how agencies cooperate and how public-private partnerships could help enhance the system's strength and lead to similar results in all facilities [24].

Even so, this study has some limitations. Data were gathered in three areas, but these locations only represent certain types of emergency conditions, not the entire spectrum of healthcare settings in India. While the study had an equal number of facilities, it only looked at 30, possibly leaving out many different operational sizes in the country. Also, although statistics were used to spot significant changes, the answers given in surveys and observations



can be affected by people's subjective opinions and judgments. Lastly, because cross-sectional data is utilized, demonstrating cause and effect becomes challenging, so future studies should adopt longitudinal or experimental approaches.

Conclusion

This research indicates that public healthcare facilities perform much better than private ones during emergencies and crises in India. Across measures such as Emergency Response Time, Resource Allocation Efficiency, Staff Preparedness, Patient Recovery Rate and Mortality rates at private hospitals were consistently better than those at public ones. Several private hospitals were quick to act, efficiently used essential resources and their staff was well prepared. For this reason, most patients at private facilities achieved better recoveries and faced a reduced risk of death. In contrast, public hospitals faced delays in their administrative processes, a shortage of some critical equipment, and limited use of emergency systems due to numerous restrictions.

The qualitative findings indicate that both sectors agreed that inadequate collaboration between agencies is a common issue in crisis response. Based on this study, reforms should address public health systems, training, and how people communicate online. It also mentions that strong emergency healthcare can be achieved only if the public sector cooperates with the private sector. By addressing the weaknesses in their systems identified in this research, Indian health systems can enhance their actions during emergencies and prevent numerous additional illnesses and deaths.

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