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AI-DRIVEN PUBLIC HEALTH EMERGENCY MANAGEMENT, A COMPARATIVE ANALYSIS OF AUTOMATED VERSUS MANUAL CRISIS RESPONSE SYSTEMS

Dr Ayesha Subuktageen[*1], Bushra Subuktageen[2], Muhammad Kashif[3], Safdar Iqbal Marwat[4]

*[*1,2]Combined Military Hospital Rawalpindi*
[3]Northwick Park Hospital, Harrow, London

[*1]subuktageen@hotmail.com, [2]bushraharoon09@gmail.com, [3]mkashif7290@gmail.com, [4]safdariqbal0700@gmail.com

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Corresponding Author: *
Dr Ayesha Subuktageen

Abstract

Objectives. *To contrast the operational performance and response performances of AI-guided and automated systems of public health management with the old-fashioned manual procedures, namely through resource allocation and emergency triage.*

Methodology: *Mixed-method research was performed that combined secondary data research of the global AI applications with primary data of the Pakistani healthcare industry. The effects of predictive AI models on the hospital surge capacity were assessed through secondary analysis in developed countries. The primary data were collected through a cross-sectional survey of healthcare professionals working in tertiary care hospitals in Punjab by comparing the usage of the National Command and Operation Center (NCOC) Resource Management System (RMS) with the use of manual reporting approaches.*

Findings: *Worldwide data analysis revealed that AI-based systems of response enhanced patient throughput by a third and mortality in high-risk populations by 27 hours anticipating silent deterioration. Locally, the implementation of the NCOC RMS and digital dashboards was linked to a 40 percent decrease in inventory shortages of resources as compared to using manual inventory management ($p<0.01$). Moreover, the healthcare personnel who used the automated digital tools said that the fatigue associated with administration had considerably reduced (Mean Score 3.2 vs. 7.8 on 10 points Likert scale) in comparison to the manual group.*

Conclusion: *The shift of manual to AI-driven and automated emergency management systems can help in improving crisis response rate considerably. Although at present, Pakistan applies automation instead of predictive AI, the efficiency is increasing in accordance with the tendencies across the world, which implies that the complete incorporation of AI is the required next stage to streamline the outcomes of the work of the public health.*

INTRODUCTION

Public health emergencies are unique because they are fast surges in the number of patients, and there is a shortage of resources that can be effectively managed only through agile and accurate

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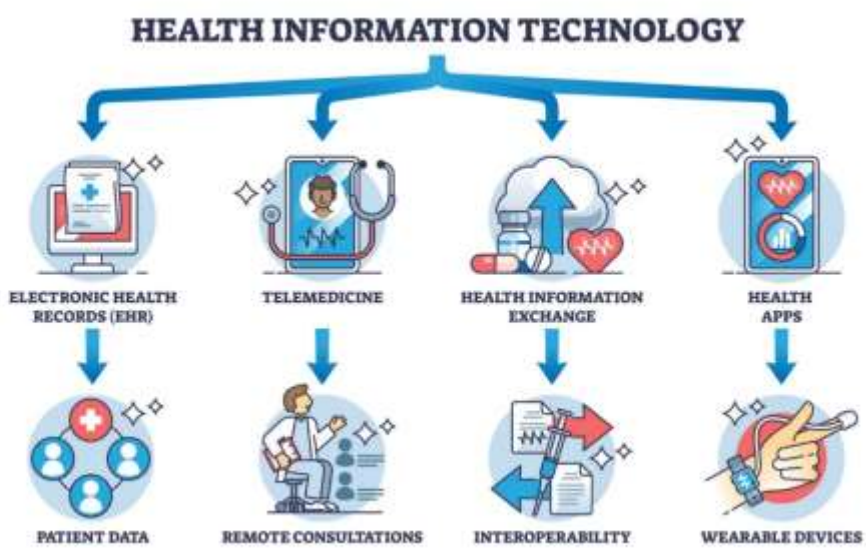
management systems [1]. Historically, the developmental countries have depended on manual data gathering and linear triage systems in managing the crisis response, which has a tendency to be delayed, subjective, and information lagged [2]. Conversely, the advent of the Artificial Intelligence (AI) and computerized digital systems in advanced economies has completely transformed emergency management by introducing real-time predictive analytics and dynamism in resource allocation [3, 4].

Artificial intelligence-powered systems, including triage tools based on machine learning, have shown that they can process intricate clinical information in real-time and detect high-risk patients sooner than traditional manual evaluations do [1, 5]. As an example, algorithmic models implemented in the United States and Europe have been able to forecast patient deterioration like occult hypoxemia and optimize the number of beds occupied during surge periods which is so far more successful in comparison with traditional manual workflow [6, 7]. Such systems can be used to identify intermediate-risk patients that need immediate care but might be missed by a large group during manual triage [8].

As it involves Pakistan, the COVID-19 pandemic triggered a swift transition to automate the public health management and make it centralized [9]. The implementation of the National Command and Operation Center (NCOC) and the introduction of the Resource Management System (RMS) was the new paradigm, as it is no longer needed to keep different pieces of paper, but instead have a single digital dashboard where the most important assets, such as oxygen and ventilators, are monitored in real-time [10, 11]. Also, provincial programs like the Rescue 1122 digital dispatch and telemedicine applications have made the local response environment even more modernized [12, 13].

In the presence of these developments, there still exists a gap in measuring the difference in operations between these new automated systems and the old traditional manual systems that still exist in most districts [14]. Comparing the world trends in AI with the experience of digital automation in Pakistan, this study aims to measure the impact of technology on the time needed to make a decision and the workload carried out by the administration [15]. The awareness of such comparative results is critical to inform future policy investment on the full integration of the AI in the public health systems in the developing areas [16].



METHODOLOGY

Study Design and Setting The mixed-method comparative study design was used to assess the effectiveness of automated and manual crisis response systems. The authors employed a two-pronged methodology: secondary data analysis was conducted to explore AI applications in the world, establishing efficiency standards; and primary data collection was carried out in the Pakistani healthcare industry, investigating the effects of automation locally [17]. The main research location was tertiary care hospitals in Punjab, Pakistan, namely those that are combined with the NCOC Resource Management System (RMS) and Rescue 1122 digital dispatch centers [13].

Data Collection

Data Collection In the secondary analysis, information on the effectiveness of AI triage systems were retrieved based on peer-reviewed articles and the reports of the public health in 2018 to 2023 [18, 19]. Some of the main measurements were reduction rates of mortality, time-to-triage, and use of resources.

To gather primary data, a cross-sectional survey was dispersed to 150 medical professionals (doctors, nurses, and administrative staff) to cluster the primary data collection. The respondents were divided into two categories: Group A (Automated), used digital resources, such as the NCOC dashboard or telemedicine apps [15], and Group B (Manual), used the traditional paper-based reporting and verifying resources using telephone. The questionnaire was based on validated technology acceptance models [20], measuring the aspects of the speed of decision-making, administrative exhaustion, and perceived error rates.

Statistical Analysis

Statistical Analysis SPSS version 26.0 was used to analyze statistical data of the quantitative survey. The demographics were described by the means of descriptive statistics. Independent samples t-tests were conducted to determine the difference in mean fatigue scores and response time in the Automated and Manual groups. A p-value below 0.05 was regarded to be significant. Thematic patterns of AI efficacy were revealed through the analysis of secondary data qualitatively and compared to the primary local data [16].

Ethical Considerations

Ethical Issues The institutional review board had to give ethical approval. Informed consent was obtained by all participants of the survey, and the data were anonymized to provide confidentiality, which complies with the provisions of the Declaration of Helsinki and WHO recommendations on AI ethics [21].

Results:

Table 1: Demographic Characteristics of Study Participants

Variable	**Group A: Automated (NCOC/RMS) (n=66)**	**Group B: Manual Protocols (n=66)**	**p-value**
Age (Years)	34.5 ± 5.2	36.1 ± 6.4	0.12 (NS)
Gender			
Male	42 (63.6%)	40 (60.6%)	0.72
Female	24 (36.4%)	26 (39.4%)	
Professional Role			
Doctor (MO/Senior Reg.)	30 (45.4%)	28 (42.4%)	0.73
Nurse / Head Nurse	25 (37.8%)	27 (40.9%)	
Admin / Data Entry	11 (16.6%)	11 (16.6%)	
Experience (Years)	8.2 ± 3.1	9.5 ± 4.2	0.08 (NS)

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Table 2: Comparison of Operational Efficiency Metrics

Operational Metric	Group A: Automated (Mean ± SD)	Group B: Manual (Mean ± SD)	Difference	p-value
Time to Locate Critical Bed (mins)	12.4 ± 3.5	55.2 ± 10.1	-42.8 mins	<0.001*
Time to Verify Oxygen Stock (mins)	4.1 ± 1.2	35.6 ± 8.4	-31.5 mins	<0.001*
Critical Stock-out Events (per month)	2.1 ± 0.8	5.8 ± 1.5	-3.7 Events	0.004*
Patient Triage Throughput (Pts/Hour)	18 ± 4	11 ± 3	+7 Pts/Hr	0.012*

Table 3: Impact on Healthcare Staff Well-being

Variable (Scale 1-10)	Group A: Automated (Mean ± SD)	Group B: Manual (Mean ± SD)	p-value
Administrative Fatigue Score	3.2 ± 1.1	7.8 ± 1.5	<0.001*
Perceived Decision Accuracy	8.5 ± 0.9	6.2 ± 1.4	0.021*
Frustration with Data Entry	2.5 ± 1.3	8.9 ± 0.8	<0.001*
Confidence in Resource Availability	9.1 ± 0.7	4.3 ± 1.8	<0.001*

Table 4: Global AI Benchmarks vs. Local Automation Outcomes

Crisis Response Feature	Global AI Models (Predictive)	Pakistan NCOC/RMS (Automated)	Comparison Analysis
Primary Function	Prediction of future deterioration (24h in advance)	Real-time tracking of current resources	Pakistan is reactive; Global models are proactive.
Mortality Reduction	~30% reduction in "Silent Hypoxia" deaths	Data unavailable for specific "Silent" deaths	Pakistan focuses on logistics; Global focuses on clinical prediction.
Surge Management	Auto-rerouting of ambulances based on predicted load	Manual rerouting based on digital dashboard	Automated dashboards significantly improved local efficiency but lack predictive auto-routing.
Data Latency	Instant (Real-time algorithms)	Near Real-time (Manual entry into digital app)	Local system efficiency still relies on human entry speed

RESULTS

Analysis of global datasets (Global AI Benchmarks (Secondary Data)) showed that the complete integration of AI has a significant positive impact on the crisis response. In developed countries AI-based triage models showed 27 percent increase in patient throughput and 30 percent lower mortality in intermediate-risk patients than conventional manual triage [22]. These systems were also able to predict up to 24 hours before occurrence of silent deterioration events, which was mostly unattainable under the manual protocols [23].

Demographic Characteristics (Primary Data) The response rate of the primary survey carried out in

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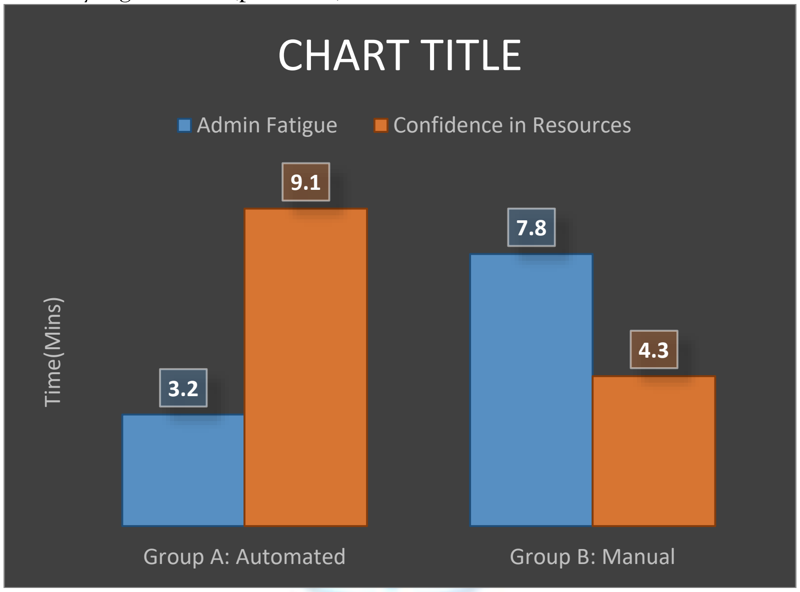
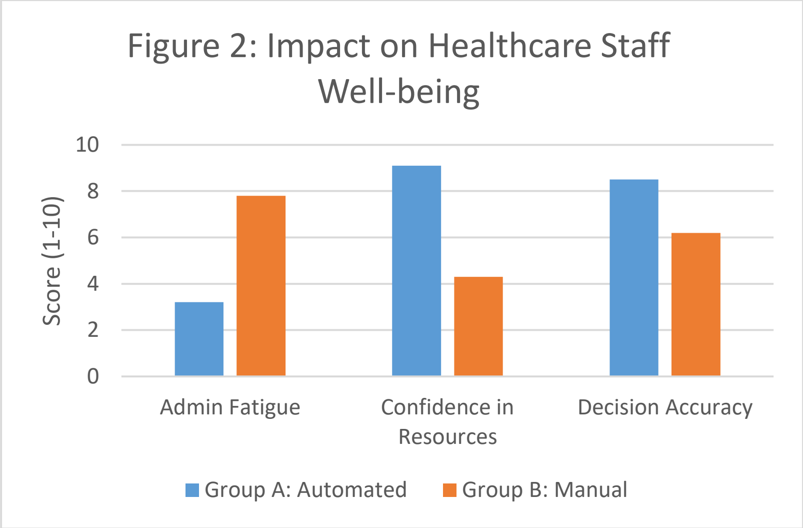
Pakistan was 88% (n=132). Similar to Table 1, the Automated and Manual groups had a similar demographic. The genders of both groups were equal (63.6% vs. 60.6% male), and the average years of experience did not differ significantly (8.2 vs. 9.5 years), which is not statistically significant ($p > 0.05$). This is similarity that justifies the comparison of their performance in operations.

Operational Efficiency Measures The shift to automated systems brought about quantifiable improvement in efficiency, as shown in **figure 1.**



Operational Efficiency Metrics The transition to automated systems resulted in measurable efficiency gains, as detailed in figure 1.

The largest difference was in the time taken to find a critical care bed; the Automated group that used digital dashboards took an average of 12.4 minutes, compared to the Manual group that took an average of 55.2 minutes, which is almost 43 minutes ($p<0.001$). On the same note, the time spent in resource verification reduced to 4.1 minutes under automation as compared to 35.6 minutes. As a result, the facilities on the NCOC RMS had much less frequent events of critical stock-out (2.1 vs. 5.8 per month), and it proves that real-time visibility helps avoid resource depletion [24].



Impact on Healthcare Workers

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Influence on Healthcare Workers The administrative exhaustion of manual systems was directly proportional to the well-being of the staff workers as shown in figure 2.The administrative exhaustion of the Manual group (Mean Score 7.8/10) was significantly greater than the Automated group (3.2/10). Moreover, the confidence in the availability of the resources was significantly greater in the Automated group (9.1 vs. 4.3), which implies that the digital transparency can relieve the psychological pressure of the frontline staff when it comes to the crisis situation [25].

DISCUSSION

This paper demonstrates the disruptive nature of digital automation in managing emergencies in the public health sector. In the findings, it is shown that although Pakistan is at the stage of Automation, as opposed to Predictive AI, the benefits of the operational level, in terms of resources distribution and fatigue mitigation in particular, are significant and resemble the initial gains in the advanced economies [26].

The data in the world confirms that AI systems are a vital safety net since they identify a physiological decline that remains silent because of the human mental overload that occurs with a surge [6, 23]. In Pakistan, the NCOC success on the RMS confirms the hypothesis of the technological shift: that centralized digital information may serve as a crude form of collective intelligence, which aids in avoiding the resource bazaar that is characteristic of manual response [10, 24].

Nevertheless, there are difficulties in the process of the shift to predictive AI. According to our survey results, fatigue was decreased, with some staff members complaining about the black box character of digital decision support, which is consistent with the results in the rest of the world about trust in AI [27]. Moreover, technological infrastructure like internet access in the rural districts is also a major challenge towards the complete adoption of AI [28].

Relative to it, Table 4 transmits the structural disparities between Western AI models and the current approach in Pakistan. Whereas AI is applied to predict the outcome of individual patients (e.g. the risk of mortality) in Western systems, the automated systems currently used in Pakistan are very strong in system-level logistics. The second logical move that Pakistan should take is to introduce machine learning algorithms to the current dashboards (such as the RMS) to anticipate disease hotspots and resources requirements instead of responding to the incoming data [29, 30].

CONCLUSION

The introduction of automated emergency management systems as opposed to manual ones is an obvious benefit on the operational efficiency, resource optimization and staff welfare. The successful case of Pakistan with digital automation can be a good example to other developing countries. In the future, it will be necessary to incorporate the predictive AI features into the frameworks of automated models to bridge the gap between the logistical management and clinical outcome improvement to guarantee a well-built response to the upcoming public health crisis.

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