

Challenges and Opportunities for Telemedicine Integration in Disaster Medicine: A Saudi Arabian Perspective

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Abstract

Aim: Telemedicine has become a crucial tool in disaster medicine, enabling remote consultations, diagnostics, and patient monitoring when traditional healthcare systems are disrupted. This study examines the perceptions of telemedicine among 100 disaster medicine and emergency management professionals in Saudi Arabia, highlighting its benefits, challenges, and areas for improvement.

Materials and Methods: A descriptive survey design was employed to assess telemedicine perceptions among staff at the National Health Emergency Operations Center. A structured questionnaire, utilizing validated tools such as the Telemedicine Satisfaction and Usefulness Questionnaire and the Technology Acceptance Model, was used to collect quantitative data on telemedicine's effectiveness, ease of use, and potential to replace in-person consultations during disasters. Regression analysis was conducted to identify the demographic and contextual factors that influenced the perceptions. The survey was administered electronically via WhatsApp over two weeks. Participation was voluntary, with informed consent obtained. The study was approved by the Institutional Review Board.

Results: A 75% response rate was achieved, with 75 participants completing the survey. Respondents reported that telemedicine significantly improved communication [mean=3.70, standard deviation (SD)=1.10] and enhanced patient care (mean=3.76, SD=1.08) during disasters. Confidence was moderate regarding telemedicine's ease of use (mean=3.41, SD=1.11), reliability (mean=3.44, SD=1.13), and ability to replace in-person consultations (mean=2.94, SD=1.24). Regression analysis revealed gender as a significant predictor of perceptions of telemedicine-improving communication ($p=0.035$), with male participants reporting lower agreement. Other factors, such as age, experience, and perceived barriers, were not significant predictors.

Conclusion: Telemedicine has substantial potential to enhance disaster response in Saudi Arabia, particularly in improving communication and care delivery during emergencies. Addressing technological and training challenges is critical for successful integration. These findings offer actionable insights for policymakers and practitioners seeking to optimize disaster preparedness and response strategies.

Keywords: Telemedicine, disaster medicine, emergency management, disaster response

Introduction

Telemedicine has become a vital tool in disaster medicine, particularly when traditional healthcare infrastructures are compromised during natural disasters or large-scale emergencies. By enabling remote consultations, diagnostics, and patient monitoring, telemedicine enhances the efficiency and effectiveness of disaster response efforts (1). Globally, the ability to maintain access to medical expertise under challenging conditions has made it an essential component of modern

disaster preparedness and response (2). In Saudi Arabia, the integration of telemedicine holds particular promise given the region's vulnerability to natural and man-made disasters, yet its adoption remains underexplored (3).

Previous studies have demonstrated that telemedicine improves patient outcomes, reduces the burden on healthcare facilities, and enhances coordination among emergency response teams (4). However, barriers such as lack of training, privacy concerns, and high technology costs continue to hinder adoption, particularly



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in Saudi Arabia (5,6). Research in Riyadh and the Eastern Province has highlighted low awareness and limited perceived benefits among healthcare professionals, underscoring the need for tailored strategies to overcome these challenges (7,8). The findings from a recent study on the Use of Technology in Disaster Medicine further emphasize the importance of aligning telemedicine solutions with local needs to maximize their potential impact (4).

This study uniquely explores the perceptions of telemedicine among disaster medicine professionals in Saudi Arabia, addressing an underexplored yet vital area. The survey included 100 professionals and identified key benefits, challenges, and opportunities for improving telemedicine integration in disaster response. The findings provide actionable recommendations to enhance telemedicine adoption, bridge gaps in the existing literature, and strengthen disaster preparedness and response efforts in the region.

Materials and Methods

This study employed a descriptive survey design to evaluate the perceptions and experiences of telemedicine in disaster medicine among the employees of the National Health Emergency Operations Center (NHEOC). The survey aimed to capture insights into key aspects of telemedicine, including its effectiveness, ease of use, and potential to substitute in-person consultations during disaster scenarios. A comprehensive approach was adopted by targeting all 100 employees at the NHEOC to ensure that the entire population of professionals with relevant expertise in emergency management and disaster response was included. Participants were purposefully selected based on their roles and experience to maximize the relevance and depth of the findings.

Survey Development and Validation

The survey instrument was specifically designed for this study, incorporating elements from established tools, such as the Telemedicine Satisfaction and Usefulness Questionnaire (9), the Technology Acceptance Model (10), and the Disaster Preparedness and Response Questionnaire (11). These instruments provide a robust foundation for evaluating telemedicine adoption, satisfaction, and perceived effectiveness in disaster medicine.

The questionnaire was divided into several sections to gather a wide range of data, including demographic information, experiences with telemedicine, perceived benefits and challenges, and overall effectiveness in disaster contexts. Responses were measured using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), allowing for detailed quantitative analysis. To ensure cultural and contextual relevance, the questionnaire was initially developed in English, translated into Arabic and

then back-translated into English. The survey was distributed electronically via WhatsApp, enabling convenient and efficient participation. Responses were collected over two weeks using Google Forms.

The survey instrument included a range of questions to capture the participants' perceptions and experiences with telemedicine in disaster medicine. Examples of the questions included "What is your role in emergency management?" (e.g., general director, specialist, administrative support) and "Have you used telemedicine in disaster response?" Participants were also asked to rate their agreement with statements such as "Telemedicine improves communication during disasters" on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Additionally, an open-ended question invited participants to provide recommendations for improving the implementation of telemedicine in disaster medicine. These questions ensured a comprehensive assessment of both quantitative and qualitative aspects relevant to the study objectives.

Statistical Analysis

Descriptive statistics were used to summarize the participants' demographic characteristics and responses to the survey items. The mean scores and standard deviations (SDs) were calculated for each item to assess the central tendency and variability of the responses. Correlation analysis was performed to identify significant relationships between different aspects of telemedicine in disaster medicine. To explore the factors influencing perceptions of telemedicine, a regression analysis was conducted. The dependent variable was the participants' agreement with the following statement: "Telemedicine improves communication during disasters" (rated on a Likert scale from 1 to 5). Independent variables included age, gender, years of experience, and key barriers such as technical issues, lack of training, resistance to change, privacy concerns, and costs. The analysis was performed using ordinary least squares regression, and the results were evaluated for statistical significance ($p < 0.05$).

Results

Participant Demographics

The survey included responses from 75 participants (75% response rate). The age distribution was primarily within three groups: 24-34 years (42 respondents), 35-44 years, and 45-54 years. The majority of respondents were male (52 respondents), with females making up the remainder. Participants' roles in emergency management varied, with 65 unique job titles reported, the most common being "administrative" roles (3 respondents). Experience in emergency management varied widely, with the most common experience bracket being 6-10 years (30 respondents).

Descriptive Analysis

Telemedicine Improves Communication During Disasters (Figure 1a)

Participants reported that telemedicine significantly improved communication during disasters, with a mean score of 3.70 and a SD of 1.10. The high mean score indicates a consensus among respondents about the effectiveness of telemedicine in enhancing communication. The low standard deviation suggests that most respondents had similar views about this aspect.

Telemedicine Enhances Patient Care During Disasters (Figure 1b)

The perception that telemedicine enhances patient care during disasters was assessed using a mean score of 3.76 with a standard deviation of 1.08. This finding highlights the confidence among participants that telemedicine can play a crucial role in improving patient care during disasters. The

relatively low standard deviation indicates consistent responses across participant groups.

Telemedicine is Easy to Use in Emergencies (Figure 1c)

The ease of use of telemedicine in emergencies was rated with a mean score of 3.41 and a standard deviation of 1.11. This score indicates moderate confidence in the usability of telemedicine technologies during emergencies. While most respondents found it easy to use, the slightly higher standard deviation indicates some variability in the responses.

Telemedicine Can Replace In-Person Consultations (Figure 1d)

The potential for telemedicine to replace in-person consultations during disasters was rated with a mean score of 2.94 and a standard deviation of 1.24. This lower mean score reflects respondents' skepticism or caution about the complete replacement of face-to-face consultations. The higher standard

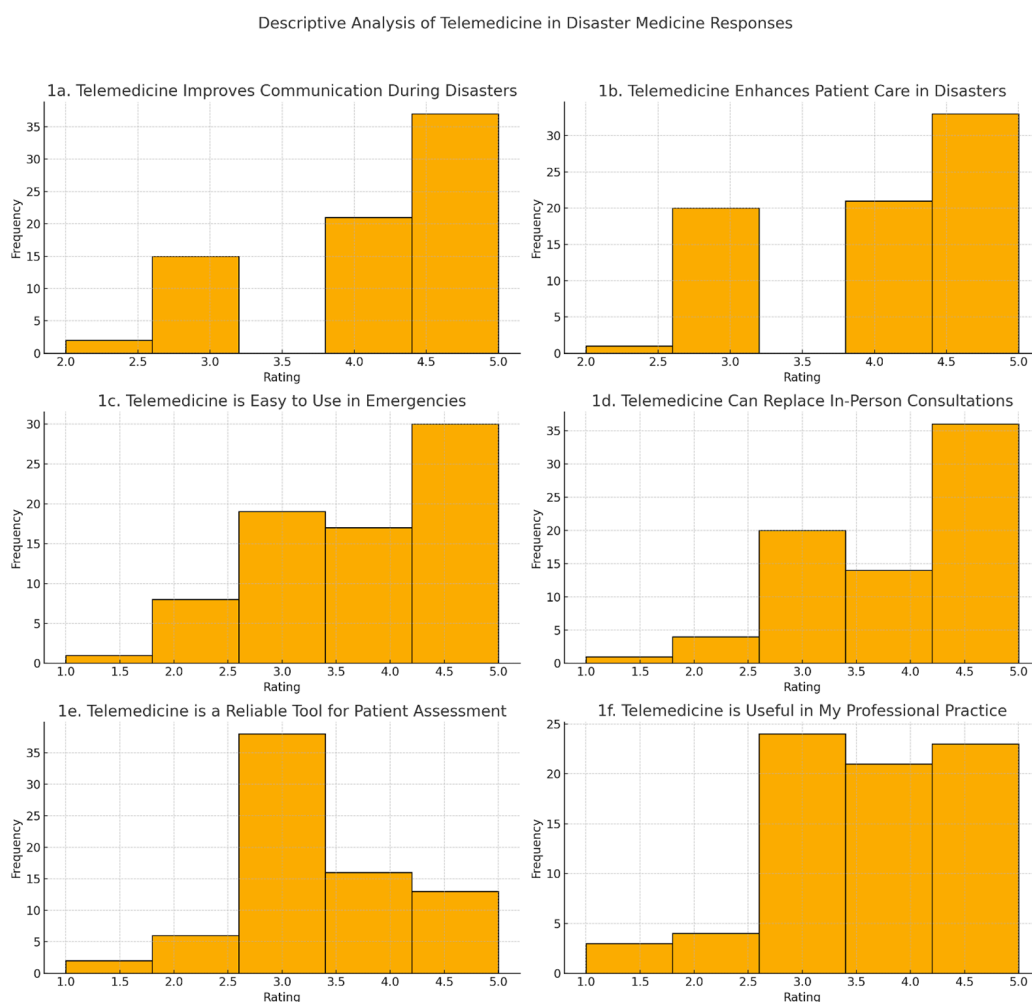


Figure 1. Descriptive analysis of telemedicine in disaster response

deviation suggests that there are diverse opinions on this matter.

Telemedicine as a Reliable Tool for Patient Assessment (Figure 1e)

The reliability of telemedicine as a tool for patient assessment had a mean score of 3.44 and a standard deviation of 1.13. Participants generally viewed telemedicine as a reliable assessment tool, although some variability was noted in their responses. This indicates room for improvement in ensuring consistent reliability of patient assessments via telemedicine.

Telemedicine is Useful in My Professional Practice (Figure 1f)

The usefulness of telemedicine in professional practice received a mean score of 3.76 with a standard deviation of 1.08. This high mean score reflects a positive perception of telemedicine’s role in professional settings. The low standard deviation indicates that the perception was widely shared among respondents.

Statistical Analysis

The correlation matrix (Figure 2) reveals several significant relationships between the survey variables. This matrix illustrates how different aspects of telemedicine in disaster management are interrelated.

Regression Analysis

The regression analysis revealed that gender was a significant predictor of perceptions regarding telemedicine’s ability to improve communication during disasters ($p=0.035$). Specifically, male participants were less likely to strongly agree with this statement than their female counterparts. Other factors, such as age, experience, and barriers, such as technical issues and costs, did not show statistically significant relationships with this perception. The model explained 30.2% of the variance in perceptions, although the adjusted R^2 was 2.3%, suggesting limited explanatory power (Table 1).

Recommendations for Improving Disaster Medicine Implementation of Telemedicine

Based on the findings from the survey, several recommendations have been proposed to enhance the implementation of telemedicine in disaster medicine. These recommendations address key areas such as technological infrastructure, training, software development, collaboration, and community awareness. Each recommendation targets specific aspects crucial for the successful integration of telemedicine, ensuring a comprehensive approach to improving disaster medicine practices (Table 2).

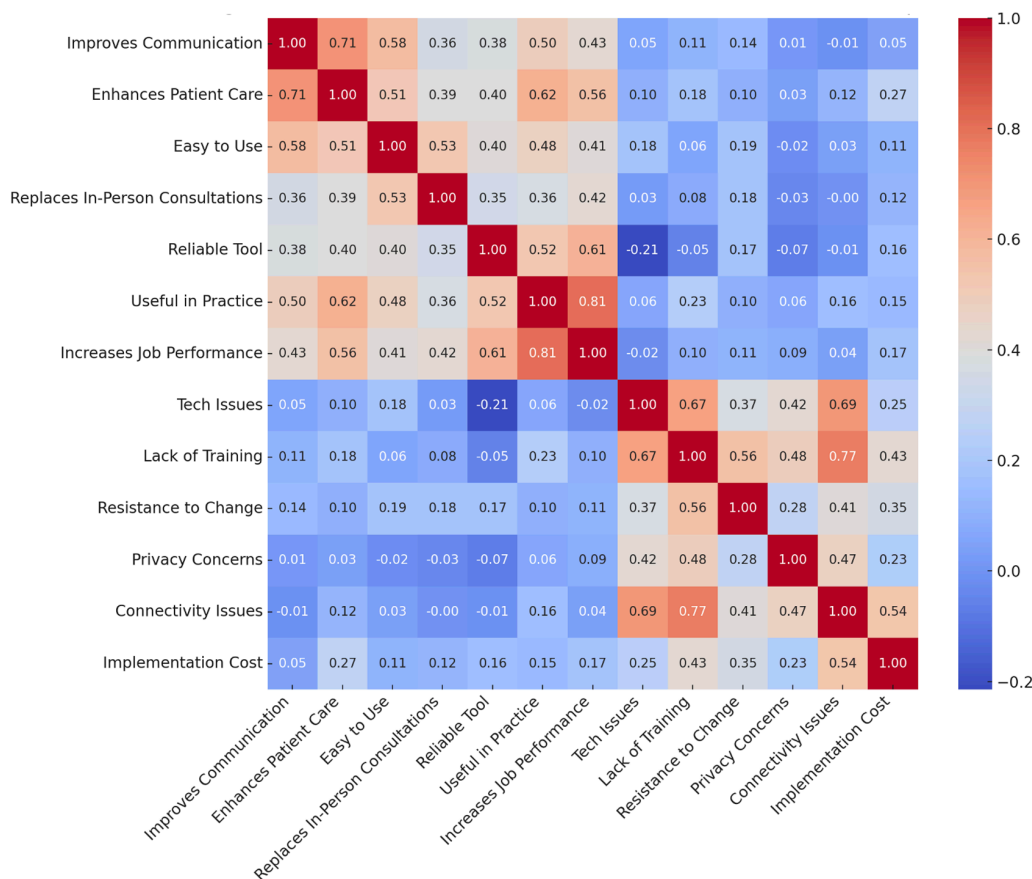


Figure 2. Descriptive analysis of telemedicine in disaster response

Discussion

The findings of this study indicate a generally positive attitude toward the use of telemedicine in disaster situations among healthcare professionals in Saudi Arabia. The high mean scores for perceived improvement in communication and patient care highlight telemedicine's potential to enhance disaster response efforts. These results are consistent with those of previous studies

demonstrating the effectiveness of telemedicine in improving communication and coordination during emergencies (3). The ability to deliver remote consultations and diagnostics plays a crucial role in bridging the gap between healthcare providers and patients during disasters (11).

A case study by Jamal et al. (12) illustrated how telemedicine effectively bridged healthcare gaps in emergency scenarios.

Table 1. Regression analysis of factors influencing perceptions of telemedicine-based communication improvement during disasters

Predictor	Coefficient (β)	Standard error	t value	p value	95% Confidence interval
Constant	1.922	1.528	1.258	0.223	[-1.265, 5.109]
Age	0.031	0.037	0.823	0.420	[-0.047, 0.109]
Gender (Male)	-0.778	0.344	-2.261	0.035*	[-1.496, -0.060]
Experience	0.014	0.043	0.317	0.754	[-0.076, 0.104]
Technical issues	0.249	0.247	1.010	0.324	[-0.266, 0.764]
Lack of training	0.047	0.215	0.217	0.831	[-0.402, 0.495]
Resistance to change	0.030	0.147	0.202	0.842	[-0.278, 0.337]
Privacy concerns	-0.018	0.148	-0.121	0.905	[-0.326, 0.290]
Cost	0.079	0.157	0.505	0.619	[-0.248, 0.406]

*Note: Adjusted $R^2=0.023$; F-statistic = 1.083, $p=0.413$, *Statistically significant at $p<0.05$

Table 2. Recommendations for improving the implementation of telemedicine in disaster medicine

Recommendation	Points
1. Improving technological infrastructures	1. Ensure strong and stable internet connectivity in remote areas. 2. Provide durable and portable devices for harsh environments.
2. Training and awareness	1. Training medical teams on using telemedicine technologies effectively. 2. Educate the community about the use of telemedicine during emergencies.
3. Development of software and applications	1. Develop specialized applications for disaster medicine with features like interactive maps and real-time reports. 2. Enhance cybersecurity to protect patient information.
4. Collaboration and coordination	1. Strengthen partnerships among governments, NGOs and international bodies to achieve unified disaster response. 2. Ensure integrated and comprehensive collaboration to improve efficiency and resource utilization.
5. Preparedness and field exercises	1. Organize field exercises simulating disasters to improve response. 2. Create and regularly update emergency plans, including telemedicine scenarios.
6. Funding and government support	1. Provide financial support for developing and improving telemedicine services. 2. Establish policies supporting telemedicine use during emergencies.
7. Research and development	1. Support research to study and improve telemedicine technologies in disaster medicine. 2. Continuously updating technologies based on research findings.
8. Enhancing partnerships	1. Promote strong cooperation among stakeholders to ensure effective telemedicine use during disasters. 2. Create strategic alliances to leverage shared expertise and resources.
9. Continuous training	1. Regular training programs to ensure medical teams are proficient in telemedicine technologies. 2. Provide ongoing education to ensure readiness and adaptability to disaster scenarios.
10. Community awareness	1. Increase public awareness of telemedicine's role in emergencies and how to access these services. 2. Educate communities about the benefits and use of telemedicine during disasters.
11. Improving communication and knowledge sharing	1. Enhance communication channels between field and telemedicine teams to improve task distribution. 2. Promote knowledge sharing and best practices to improve overall response capabilities.

Similarly, this study confirms telemedicine's ability to enhance communication and patient care during disasters. Innovative technologies such as Google Glass have also been explored in disaster telemedicine triage (13), demonstrating how wearable devices enhance situational awareness and real-time decision-making. Wearable health monitoring technologies, like wireless electrocardiography systems, further expand telemedicine applications by providing reliable, continuous patient monitoring in disaster settings (14).

The regression analysis further explored factors influencing perceptions of telemedicine. Gender was identified as a significant predictor, with male participants reporting lower agreement with the statement that telemedicine improves communication during disasters compared to their female counterparts ($p=0.035$). This finding underscores the potential role of demographic factors in shaping attitudes toward telemedicine. Other variables, such as age, experience, and barriers like technical issues and costs, did not show significant relationships in this study. The limited explanatory power of the model (adjusted $R^2=2.3\%$) suggests that additional factors, such as cultural attitudes and prior exposure to telemedicine, may be crucial in shaping perceptions.

Despite the positive perceptions, significant barriers to telemedicine adoption were identified. The relatively low mean score for telemedicine's potential to replace in-person consultations suggests cautious acceptance. This could stem from concerns about the reliability of remote consultations, a challenge noted in previous research as a critical factor influencing telemedicine adoption (4). Other barriers, such as lack of training, privacy concerns and high technology costs, mirror findings from studies conducted in Riyadh and other Middle Eastern regions, where infrastructural limitations, cultural considerations and policy gaps hinder progress (6,15).

The role of telemedicine has expanded significantly during the COVID-19 pandemic, as highlighted by Bains et al. (16), where it has become integral to managing emergency department patient care. This aligns with the current findings, demonstrating telemedicine's utility in delivering remote healthcare in disaster scenarios.

Moderate scores for the ease of using telemedicine technologies suggest that healthcare professionals recognize the benefits of telemedicine, but further training and familiarization are needed. Research in the Eastern Province has emphasized that awareness and training are essential for enhancing adoption (6). Ensuring healthcare professionals are proficient in telemedicine technologies is critical for successful integration into disaster response.

Correlation analysis revealed significant relationships between the key aspects of telemedicine. Enhancing technological infrastructure could improve reliability and ease of use, thereby increasing healthcare professionals' acceptance. Previous studies have emphasized that successful telemedicine initiatives in disaster settings require robust technological systems and clear protocols (8). The strong positive correlation between perceived ease of use and reliability suggests that hands-on experience with telemedicine technologies builds confidence in their reliability. Similarly, the perceived usefulness of telemedicine in professional practice was strongly correlated with its effectiveness in improving patient care. These insights underscore the need for targeted training and practical experience to strengthen telemedicine adoption (16).

Overall, the study highlights telemedicine's potential to enhance disaster response efforts in Saudi Arabia. However, addressing barriers such as technological infrastructure, training, privacy concerns, and costs is critical. Successful implementations in similar settings, like the California Valley Fire response, emphasize the importance of these strategies (17).

Study Limitations

This study has several limitations. First, the sample was drawn primarily from NHEOC professionals in Saudi Arabia, which may limit the generalizability of the findings to other healthcare settings or disaster management roles. Second, the reliance on self-reported data introduces the potential for social desirability and recall bias. Third, although regression analysis provided insights into factors influencing perceptions, the model's limited explanatory power suggests that additional variables, such as cultural attitudes and prior telemedicine experience, may also play significant roles. Finally, the cross-sectional design limits the ability to infer causal relationships, and longitudinal studies are valuable for capturing changes in perceptions over time. Participation in the survey was voluntary, and informed consent was obtained from all participants prior to their participation. The survey was designed to ensure the anonymity and confidentiality of the responses. Approval was obtained from Kingdom of Saudi Arabia Ministry Health of IRB GDRS the Institutional Review Board prior to the commencement of the study, ensuring the ethical conduct of the research (decision no: 24-55-M, date: 29.05.2024).

Conclusion

This study highlights a generally positive perception of telemedicine among healthcare professionals in Saudi Arabia. Telemedicine is recognized for its potential to enhance communication and patient care during disasters; however,

significant barriers remain, including technological challenges, lack of training, and privacy concerns. The regression analysis revealed that gender significantly influenced perceptions, with male participants reporting lower agreement on telemedicine's ability to improve communication. These findings underscore the need for targeted strategies to facilitate telemedicine adoption, such as improving infrastructure, providing training, and addressing privacy and cost concerns. Future research should explore additional factors, including cultural attitudes and prior telemedicine experience, to further enhance disaster preparedness and response efforts.

Ethics

Ethics Committee Approval: The survey was designed to ensure the anonymity and confidentiality of the responses. Approval was obtained from Kingdom of Saudi Arabia Ministry Health of IRB GDRS the Institutional Review Board prior to the commencement of the study, ensuring the ethical conduct of the research (decision no: 24-55-M, date: 29.05.2024).

Informed Consent: The survey was administered electronically via WhatsApp over two weeks. Participation was voluntary, with informed consent obtained. The study was approved by the Institutional Review Board.

Footnotes

Conflict of Interest: The author declare that they have no conflict of interest.

Financial Disclosure: The author declared that this study received no financial support.

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