Improving the management of Acute Myocardial Infarctions: Exploring the barriers and facilitators to implementing a Smartphone Application for physicians

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Table of Contents

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Abstract

Background: The delivery of timely and appropriate care is crucial for survival in patients experiencing ST-elevation myocardial infarction (STEMI). Efficient communication and exchange of test results between the referring emergency medicine (EM) physician or Emergency Medical Service (EMS) paramedic and the interventional cardiologist (IC) is essential to achieving timely care. In many communities, sharing of some information crucial to decision making, such as electrocardiograms (ECG), relies on using fax or text message. The SMART AMI App was developed to streamline communication and ensure that information is shared in a secure manner. The application is simple to use, privacy-compliant, and allows for rapid ECG sharing between healthcare providers, enabling timely decision-making.

Objective: This paper details the results of targeted pre-implementation surveys to establish the barriers and enablers of using a smartphone application to transmit ECG images among ICs, EM physicians and EMS paramedics to help tailor implementation interventions.

Methods: To assess the proposed acceptability and uptake of the application, pre-implementation surveys were disseminated to ICs, EM physicians and EMS paramedics in one region of Ontario, Canada. Questions were generated based on selected components of the Consolidated Framework for Implementation Research, results from a pilot study carried out at a regional hospital where the SMART-AMI App was previously implemented, and predicted barriers based on expert guidance. The pre-implementation surveys consisted of both 7-point Likert scale questions (1=strongly disagree and 7=strongly agree) and open-ended questions. Open-ended data was extracted verbatim and analyzed using an inductive qualitative approach, with transcripts coded into descriptive qualitative codes and then collapsed into themes.

Results: Uptake of the survey was acceptable, with 9 of the invited 10 ICs, 51 of the invited 223 EM physicians, and 93 of the invited 1138 EMS paramedics responding. Survey findings demonstrated a need for an App, as all groups recognized that current practices for sharing ECGs allowed room for improvement, accepting that fax can be inconvenient and text messages may not be secure. When asked whether there was a need for a smartphone application to transmit ECGs, ICs (M=6.67, SD=0.50), EM physicians (M=5.57, SD=1.30) and EMS paramedics (M=5.79, SD=1.45) consistently agreed. Commonly reported barriers were concerns over technological challenges, privacy issues, and cell phone reception strength. Through

identification of the barriers in each stakeholder group, implementation strategies were developed that facilitated the scale-up of this system-change intervention.

Conclusions: Results from the three online pre-implementation surveys to identify key barriers and enablers to implementation of the App helped inform the selection of tailored implementation strategies to support roll-out of the App across the health region. The surveys identified key barriers around technology, privacy concerns, and access to required WiFi that needed to be addressed during App implementation to facilitate uptake and use. Results from the surveys, and ongoing evaluation of effectiveness, are informing expansion of the App intervention to local ambulance services and other health regions. Clinical Trial: https://clinicaltrials.gov/study/NCT05290389

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Trial Registration: https://clinicaltrials.gov/study/NCT05290389

Keywords: ST-elevation myocardial infarction, digital health, mHealth, barriers and enablers

Introduction

Each year, approximately 7,000 people in Ontario experience ST-elevation myocardial infarctions (STEMIs) requiring timely reperfusion of the affected area of the heart to restore blood flow through the coronary arteries[1].Reperfusion can occur by a procedure called percutaneous coronary intervention (PCI) or with thrombolytic medications. When possible, PCI is preferrable, and guidelines recommend that a patient presenting to a centre that can perform PCI (PCI-capable centre) should have this procedure performed within 90 minutes of the patient presenting to the hospital. Those who present to a non-PCI-capable centre should be transferred to a centre that can perform this procedure within 120 minutes[2]. However, among the 270 health care institutions in Ontario, only 20 centres have PCI capabilities onsite[3]. Thus, achieving timely care can be challenging, particularly for patients who live in rural areas where access to a PCI-capable centre is limited. Where on-site PCI is not available, patients must be transferred to a partner PCI capable hospital. Patients receiving care above evidence based best practice time thresholds show increased risk of mortality, repeat myocardial infarction, congestive heart failure, and hospitalization[4–7].

STEMI is diagnosed based on an electrocardiogram (ECG) and care for patients with STEMI requires rapid coordination of several services, including Emergency Medical Services (EMS), emergency medicine (EM) physicians and staff, the interventional cardiologist (IC) and the PCI laboratory staff. This can range across several centres and/or jurisdictions that rarely share electronic medical records. Previous research shows that efficient coordination of these services through timely communication leads to improved outcomes for STEMI patients[2]. The current process for STEMI activation for many centres in Canada relies on a variety of technologies that are poorly integrated or inefficient. For example, STEMI activation at the Hamilton General Hospital (HGH), a high-volume quaternary cardiac care hospital in Ontario, Canada, utilized fax for electrocardiogram (ECG) transmission, which is secure but slow, inconvenient, and sometimes unavailable. To improve communication and efficiency in this pathway, a quick, easy-to-use, privacy-compliant smartphone application was developed, the Strategic Management of Acute Reperfusion and Therapies in Acute Myocardial Infarction (SMART-AMI) smartphone application (App), for rapid ECG sharing between healthcare providers, enabling timely decision-making.

The SMART AMI App has been pilot tested with ICs and select EM physicians since May 2020 for patients presenting to Niagara Health and requiring transfer to HGH for primary PCI. Although preliminary data shows promise [8], additional research is required to promote the technology more widely as an evidence-based innovation for care. Similar smartphone applications with capabilities of sending ECG images to ICs for decision-making have demonstrated STEMI patient outcome improvement and reduction in decision time[9–13]. However, limited evidence exists from the users' perspectives that assesses barriers and enablers to implementing such an App; perspectives that impact acceptability and sustained App use. To promote the App as the standard means to communicate ECGs in the setting of STEMI patients beyond the pilot sites in the Niagara region, we sought to gather an understanding of the perceived usefulness and acceptability of the technology in routine practice from prospective App users across a wider region (i.e., Southeastern Ontario)[14]. This paper details the findings from the pre-implementation surveys, which will be used to assist

with the potential scale-up and implementation of the App across other provincial STEMI systems in Ontario and beyond.

Methods

Study Design

Development and administration of the survey was led by a collaborative team consisting of medical professionals, public health researchers, and experts in implementation science. A multi-centre cross-sectional study was conducted to assess the need, usefulness, and acceptability of the SMART AMI App in practice through the development and distribution of online surveys to key stakeholders, including ICs, EM physicians, and EMS paramedics who care for patients presenting with STEMI within the HGH cardiac catheterization laboratory catchment area. The catchment area includes Hamilton, Niagara, Haldimand, and Brant regions, which cover an area of 6,473 km^2 and a population of 1.8 million people[15,16]. Figure 1 illustrates the partner hospitals from which EM physicians were sent survey invitations, as well as a geographical map depicting the locations where sampled EMS paramedics respond to emergency calls. Interventional cardiologists were sampled from the primary PCI hospital indicated on the map as Hamilton Health Sciences.

Survey Development

In 2021, three surveys were developed and tailored for each stakeholder group (interventional cardiologist, emergency medicine physicians, and EMS paramedics). These surveys were focused on gathering a better understanding of the barriers and facilitators that may impact the successful implementation of the SMART-AMI App intervention on a larger scale (see Supplementary File 1-3 for the surveys). Development of survey questions, analysis and interpretation were guided by results from the Niagara Health pilot study, predicted barriers based on expert guidance from study team members (including implementation science researchers, interventional cardiologists, EMS paramedics and EM physicians) and the Consolidated Framework for Implementation Research (CFIR)[17]. The CFIR is a determinant framework, with a list of 39 constructs organized across five major domains, and provides a practical structure to identify multi-level factors that can impact implementation[18]. CFIR is a widely used framework in implementation science, with great breadth in its application across study design, objectives, settings and outcome measures [19]. Through an iterative process involving input from research team members, questions were drafted and selected for inclusion in the surveys around the potential need for an App to transmit ECG images, the fit of an App into existing workflow processes, the potential for an App to improve patient care and reduce treatment times, and the overall comfort level of using an App in the treatment of suspected STEMI cases. The pre-implementation surveys consisted of both 7-point Likert scale questions and open-ended questions. Likert scales were utilized to identify participant opinions on App implementation and usefulness. We applied a 7-point scale (1=strongly disagree and 7=strongly agree), as this has been shown to reach the upper limits of the scale's reliability, in comparison to a 5-point scale [20]. The surveys developed for each group are fully presented in the Multimedia Appendix 1.

Sample Population

Our study targets the healthcare providers who use the STEMI activation system for a Quaternary Care Hospital to activate and respond to a STEMI. These include ICs, EM physicians and EMS paramedics. Additional questions on the usage of the STEMI activation system (known locally as the Heart Investigation Unit Hotline), were included, however, results from those questions will not be reported in this paper.

Survey Distribution

The pre-implementation surveys were hosted in REDCap and questionnaires were designed for anonymous completion. Senior leaders of each survey group utilized a list of physician and EMS paramedic contact details provided by administrative distribution lists to develop the survey sampling frame. Senior leaders were asked to distribute a survey invitation by e-mail to their staff, which included a summary of the evaluation project, a link to the survey, and details about consent; they were also encouraged to send out a reminder email to staff approximately 1 month after the initial invitation was sent.

Data Analysis

Quantitative data were analyzed using descriptive statistics of frequencies through Excel Microsoft 365 ©, with continuous variables presented as means and standard deviations. Open-ended data was extracted verbatim and analyzed using an inductive qualitative approach, with transcripts coded into descriptive qualitative codes and then collapsed into themes using qualitative data analysis software (NVivo 12, QSR International). Initial coding was completed independently by two researchers (KC and KM) and development of themes was done collaboratively by two researchers (KC and KM) with themes then validated by a third researcher (JC), to ensure rigor.

Ethics

Consent was obtained from participants through the use of a question at the beginning of each survey. As survey responses were anonymous, participants could not withdraw their data after submission, however, participants were notified that they could withdraw consent by exiting the survey without submitting any responses. This study was approved by the Hamilton Integrated Research Ethics Board (REB #7691). That approval did not include the ability to publish verbatim survey responses.

Results

Quantitative

Between the period of June and August 2021, senior leaders of each survey group sent out survey requests to physicians and EMS paramedic staff, with response rates varying among each of the stakeholder groups sampled. Of the 10 interventional cardiologists at the Hamilton General Hospital, nine (90%) completed the survey. 51 (23%) of the 223 invited EM physicians completed the survey, and 93 (8%) of the 1138 invited EMS paramedics completed the survey.

Of the 51 EM physicians, 96% reported that they currently submit ECGs to ICs. Nearly all (98%) did so through text message, while 39% also reported sending ECGs via fax. All nine ICs indicated that they received ECGs via text message, while 33% reported receiving ECGs also via fax. EMS paramedics reported that they rarely submitted pre-hospital ECGs to ICs (7.5%), and physical ECGs were typically exchanged in person at patient hand off.

Among all groups, there was recognition that current practices for sharing ECGs allowed room for improvement, accepting that fax can be inconvenient and text messages are not secure. When asked whether there was a need for a smartphone application to transmit ECGs, ICs (M=6.67, SD=0.50), EM physicians (M=5.57, SD=1.30) and EMS paramedics (M=5.79, SD=1.45) consistently agreed one was needed. Furthermore, among ICs, EM physicians and EMS paramedics, use of the App was believed to fit well into existing workflow processes, with mean Likert responses of 6.67 (SD=0.50), 5.65 (SD=1.31) and 5.56 (SD=1.77), respectively. Staff also noted feeling comfortable with using an App for ECG transmission and review, with mean Likert responses of 6.44 (SD=0.88), 5.51 (SD=1.92), and 5.22 (SD=2.05) reported. Figure 2 highlights viewpoints on the implementation of a smartphone application to transmit ECGs from each group.

Qualitative

Through inductive qualitative analysis, 24 codes were identified for ICs, 46 codes were identified for EM physicians, and 57 codes were identified for EMS paramedics (Table 1). The codes were grouped into four key themes, which housed both barriers and enablers to App implementation: 1) technological issues and constraints; 2) perceived capabilities, alternatives, and comparisons of the App; 3) attitudes and beliefs towards the App; 4) impact on current workflow and requirements for implementation (Table 2).

Commonly reported barriers to implementation were concerns over technological failures within the App. Given STEMI activation is a medical emergency, there were concerns that App updates could be required during urgent scenarios, making the App unusable and thus affect clinical care. EMS paramedic providers and physicians practicing at hospitals with unreliable internet signal also expressed concerns about their ability to reliably call and transmit ECGs using their smartphone. Another important barrier was the uncertainty about the proven risks and benefits of the App as this is a new technology without extensive real-world data. Privacy and security of the tool to transmit PHI was raised. There was concern that the App could take more time than the current clinical workflows thus worsening the process of STEMI activation. Respondents also expressed a desire to follow-up with referring or accepting physicians to discuss the case in future, which is a feature not offered via the App.

Discussion

Principal Results

Responses from the pre-implementation surveys allowed for the understanding of barriers and enablers to implementing an App that facilitates emergency cardiac communication. The primary use case is to securely transmit ECGs images and enable telephone calls directly via the

App in the case of suspected STEMI in a large health region in Ontario, Canada. While there have been results published from other studies on the diagnostic utility of sending ECG images through an App for STEMI care [11,21,22], this paper is the first to report on the barriers and enablers to implementing such an App from target users, allowing for tailored implementation strategies to be utilized in future to increase uptake. Overall, survey findings demonstrated agreement on the perceived need for an App, and consensus that the App would fit well within existing workflow processes, reduce time to STEMI treatment, and reduce inappropriate activation of the on-call IC team. Commonly reported barriers were concerns over technological challenges, privacy issues, and cell phone reception strength.

Results from the online surveys allowed for the application of stakeholder-specific implementation science interventions that supported the uptake of the App on a wider scale across the health region. For example, we obtained an understanding of the preferred mechanism of training on App use and applied appropriate education strategies, such as offering Zoom drop-in question and answer training sessions at accessible times during the day, to accommodate shift work hours. Furthermore, we cultivated relationships with opinion leaders (EM Chiefs), early adopters, and sought advice from experts in implementation science research to maximize survey responses, and increase uptake and use of the App. In the case of the IC group, concerns were raised about password recall, so biometric authentication was added to aid with the log-in experience. Finally, key barriers related to concerns over technological challenges and privacy issues were addressed with the development and distribution of educational materials, such as user guides that highlighted multiple successful security tests from internal privacy, security, and information technology staff along with external third-party vendors. Table 3 illustrates the barriers by theme and the implementation strategies that were utilized to facilitate uptake and use of the App.

While all three groups shared concerns over potential technological challenges, privacy issues and cell phone reception strength, there were differences in the barriers and enablers reported by group (Table 2). As the App was previously implemented in the IC group during the pilot phase in 2020, several of the barriers expressed by the EM physicians and EMS paramedics were not reported by the ICs. For example, the ICs were aware of App functionality and ECG image quality and so did not report these as a barrier to use. However, the majority of EM physicians and all EMS paramedics had no prior experience with using the App at time of survey collection, and so responses illustrate apprehension of the unknown. Across each stakeholder group, common enablers were the expected speed of ECG image sharing and the associated timely access to that knowledge distribution. All groups reported comments that were both in favour and against App implementation.

From the barriers and enablers that were identified in the survey responses, select CFIR constructs were found to be represented more frequently than others (Table 2). Under the technological issues and constraints theme, CFIR constructs such as complexity and knowledge and beliefs about the intervention were commonly referenced. This indicated that the individual's personal perception on how difficult the App would be to use, and their personal attitudes toward utilizing the App for cases of suspected STEMI, were going to be a contributing factor into whether they took the necessary steps to download and use the App. Under the perceived capabilities, alternatives and comparisons of the App theme, CFIR constructs of compatibility and relative advantage were commonly cited, signifying that the participants view on whether the App was considered to be valuable to their care, whether the App filled a current need in their treatment of STEMI patients, and whether the App offered an advantage

when compared to alternative practices for sending ECG images, impacted their willingness to use the App. In the attitudes and beliefs toward the intervention theme, there were no dominant CFIR constructs, however, responses indicated that participant perception on the evidence supporting the need for an App to transmit ECGs images influenced whether they themselves would download and use it. Finally, in the impact on current workflow and requirements for implementation theme, complexity and relative advantage were again most commonly referenced, demonstrating that the perceived difficulty of incorporating the App into their current workflow processes and their perception on the benefits to using the App, would impact uptake. Our findings of the barriers identified in the survey responses, combined with our analysis of the most commonly cited CFIR constructs, facilitated the development of implementation strategies for App use and scale-up.

Limitations

As the surveys were distributed prior to the majority of EM physicians and EMS paramedics gaining access to the App, there was limited understanding of App features, capabilities and usability among these two groups. This made it difficult for participants to answer certain questions and was reflected in survey responses that noted inadequate knowledge affected their ability to reliably answer some questions. Nonetheless, this provided valuable, unbiased responses to questions aimed at understanding the need for such a tool. Additionally, as links to the survey were shared directly by senior leaders of each stakeholder group, it was challenging for the research team to manage follow-up emails that may have improved survey completion rates. However, this was the preferred means of communication by the senior leaders to maintain anonymity, confidentiality, and avoiding coercion to respond to questionnaires. It is also possible that response rates were improved as participants were being directly asked to complete the survey by the chief or chair of their department. This study leveraged a convenience sampling strategy, which can introduce selection and sampling bias. As such, caution is necessary in generalization of the results. Reassuringly, there was significant representation from each hospital and paramedic region with similar themes and responses for both the qualitative and quantitative questions.

Conclusions

The implementation of system-level interventions in health care can be affected by unexpected barriers, leading to poor uptake and acceptance. In order to circumvent the challenges of implementing change to an organization's culture, understanding the variables that influence or have an impact on the population's willingness to accept and adopt the change is critical. This study exemplifies the importance of identifying barriers faced by the target population and utilizing that knowledge to create successful implementation strategies to optimize research interventions. Results from the pre-implementation surveys disseminated to ICs, EM physicians and EMS paramedics helped inform the strategies for the SMART AMI App implementation program in Hamilton and the surrounding region. They will be vital in informing active scaling of the App into additional areas throughout the Province and local ambulance services.

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barriers and facilitators to implementation of the App technology.

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Conflicts of Interest

Dr. Hassan Mir is an inventor and sole owner of the background intellectual property of the smartphone application used in this study. There is no specific financial conflict of interest to declare as the tool is being used for research. However, it may be commercialized in future. None of the other authors have a relevant conflict of interest to declare.

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Abbreviations

CFIR: Consolidated Framework for Implementation Research
ECG: electrocardiogram
EM: Emergency medicine
ERIC: Expert Recommendations for Implementing Change
HGH: Hamilton General Hospital
HHS: Hamilton Health Sciences
IC: Interventional cardiologist
SMART AMI: Strategic Management of Acute Reperfusion and Therapies in Acute Myocardial Infarction
STEMI: ST-elevation myocardial infarctions

Figures and Files Legend

Figure 1: Map of Hamilton General Hospital (HGH) and the Non-PCI Hospitals in the region
Figure 2: Summary of survey responses from interventional cardiologist, emergency medicine physicians, and EMS paramedics

Supplementary File 1: Table 1. Codebook created for the analysis of themes on the barriers and enablers to App implementation
Supplementary File 2: Table 2. Barriers and enablers to implementation
Supplementary File 3: Table 3. Mapping barriers identified from survey responses to implementation strategies
Supplementary File 4: STEMI activation questionnaire (Interventional Cardiologists)

Supplementary File 5: STEMI activation questionnaire (Emergency Medicine Physicians)
Supplementary File 6: STEMI Activation Questionnaire (Paramedics)

Figure 1. Primary PCI hospital STEMI partnership map, adapted from the 2017-2018 Ontario Local Health Integration Network Annual Report[23]

HAMILTON HEALTH SCIENCES (HHS)

STEMI Partnerships with Non-PCI Hospitals

ED LHIN	Non-PCI Hospital Partnership with HHS	Drive Time to HHS (mins)
HNHB	St. Joseph's Healthcare (Hamilton)	5
HNHB	Hamilton Health Sciences - West End Urgent Care	7
HNHB	Hamilton Health Sciences - Juravinski	8
HNHB	St. Joseph's Healthcare - Community Health Centre	13
HNHB	Joseph Brant Memorial Hospital	16
HNHB	Hamilton Health Sciences - West Lincoln	25
MH	Halton Healthcare Services - Oakville-Trafalgar	28
HNHB	Brantford General Hospital	32
HNHB	West Haldimand General Hospital	39
HNHB	Brant Community Healthcare System - Willet	40
HNHB	Niagara Health System - St. Catharines	41
HNHB	Niagara Health System - Greater Niagara	50
HNHB	Haldimand War Memorial Hospital	52
HNHB	Niagara Health System - Welland	60
HNHB	Norfolk General Hospital	64
HNHB	Niagara Health System - Douglas Memorial	65
HNHB	Niagara Health System - Port Colborne	70
Primary PCI: Target transfer to HHS ≤60 minutes		
Pharmacoinvasive: Target transfer to HHS ≤24 hours		

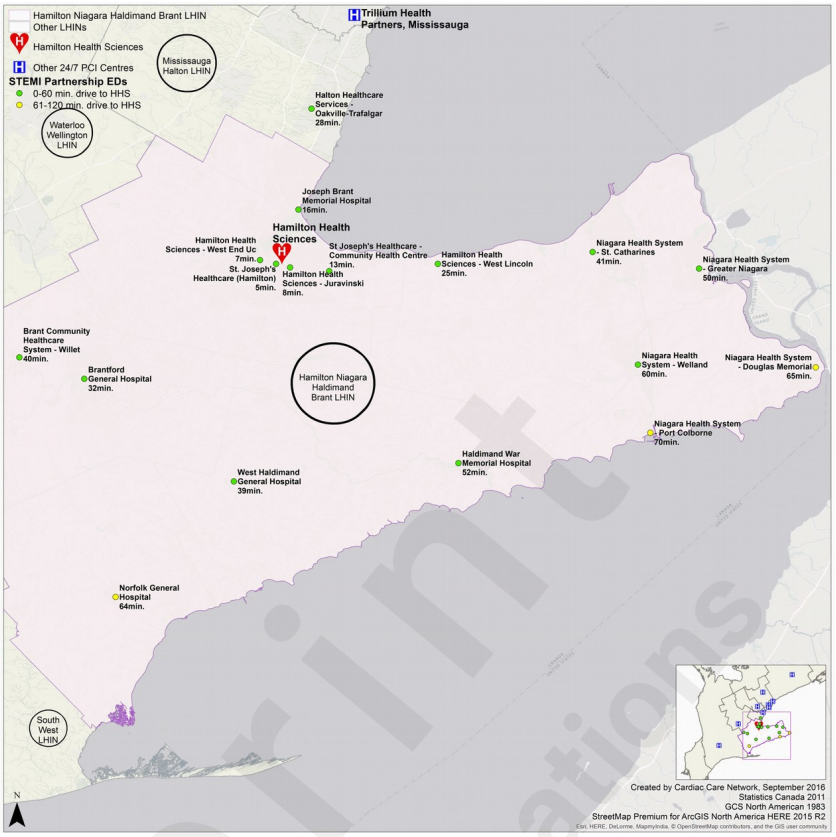
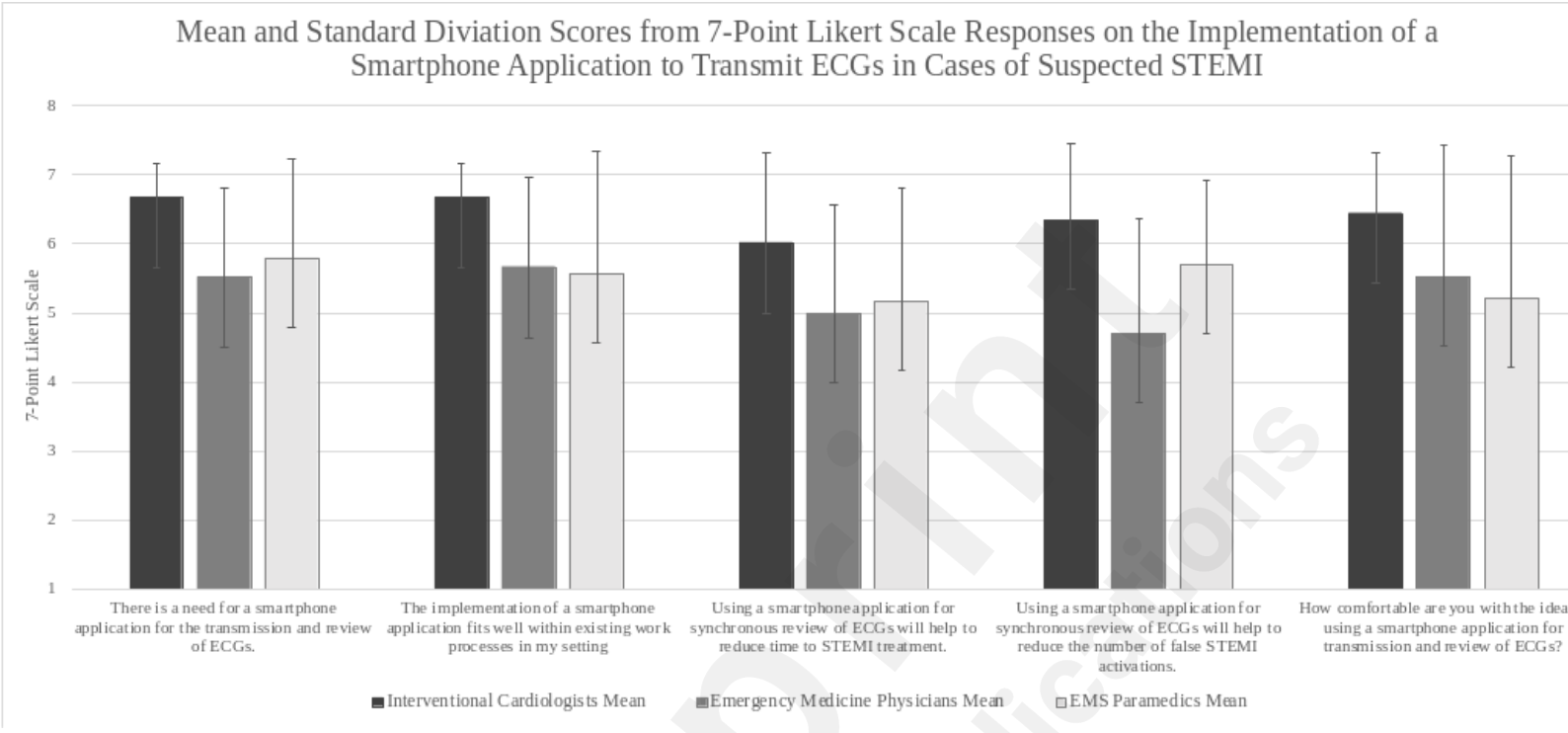


Figure 2. Means and standard deviations on the implementation of a smartphone application to transmit ECGs in cases of suspected STEMI



Supplementary Files

Multimedia Appendixes

Table 1. Codebook created for the analysis of themes on the barriers and enablers to App implementation.
URL: http://asset.jmir.pub/assets/5f2a7d829f78d9c65282d4190de43c4d.docx

Table 2. Barriers and enablers related to the implementation of a smartphone application to transmit ECGs in cases of suspected STEMI across all sampled groups.
URL: http://asset.jmir.pub/assets/393d97b54f10059c15e3f5cd0fcd7729.docx

Table 3. Mapping barriers identified from survey responses to implementation strategies.
URL: http://asset.jmir.pub/assets/9d5445fb610bf42eb861a1d80e80199f.docx

STEMI Activation Questionnaire: Interventional cardiologists.
URL: http://asset.jmir.pub/assets/42d8bf89fc976168771bfe2ca200bd30.docx

STEMI Activation Questionnaire: Emergency Medicine Physicians.
URL: http://asset.jmir.pub/assets/2e3e1d2aa5271b1ce390d6998de6a5c4.docx

STEMI Activation Questionnaire: Paramedics.
URL: http://asset.jmir.pub/assets/a34c2300933e1c9896e9760c75c099e4.docx