
Brief Communications

Implementation of a mHealth solution to remotely monitor patients on a cardiac surgical waiting list: service evaluation

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ABSTRACT

Background: The emergence of COVID-19 resulted in postponement of nonemergent surgical procedures for cardiac patients in London. mHealth represented a potentially viable mechanism for highlighting deteriorating patients on the lengthened cardiac surgical waiting lists.

Objective: To evaluate the deployment of a digital health solution to support continuous triaging of patients on a cardiac surgical waiting list.

Method: An NHS trust utilized an app-based mHealth solution (Huma Therapeutics) to help gather vital information on patients awaiting cardiac surgery (valvular and coronary surgery). Patients at a tertiary cardiac center on a waiting list for elective surgery were given the option to be monitored remotely via a mobile app until their date of surgery. Patients were asked to enter their symptoms once a week. The clinical team monitored this information remotely, prompting intervention for those patients who needed it.

Results: Five hundred and twenty-five patients were on boarded onto the app. Of the 525 patients using the solution, 51 (9.71%) were identified as at risk of deteriorating based on data captured via the remote patient monitoring platform and subsequently escalated to their respective consultant. 81.7% of patients input at least one symptom after they were on boarded on the platform.

Discussion: Although not a generalizable study, this change in practice clearly demonstrates the feasibility and potential benefit digital remote patient monitoring can have in triaging large surgical wait lists, ensuring those that need care urgently receive it. We recommend further study into the potential beneficial outcomes from pre-operative cardiac mHealth solutions.

Key words: remote patient monitoring, mHealth, telemedicine, waiting list, cardiac surgery, smartphone, mobile phone, triage

LAY SUMMARY

The COVID-19 pandemic has resulted in the postponement of many nonurgent or emergency surgical procedures for cardiac patients in London and across health services worldwide. While these patients remain on waiting lists for surgical treatment, mobile health (mHealth) solutions represent a potential solution for monitoring patient symptoms, including highlighting individuals who are deteriorating and may need to be seen with a higher priority. This service evaluation evaluates the implementation of an mHealth solution to support the continuous triaging of patients on a cardiac surgical waiting list. The service consisted of 525 patients on a cardiac surgery waiting list, submitting symptoms using a smartphone app. This was then reviewed by the team of nurses. Of the 525 patients using the app, 51 were identified as at risk of deteriorating based on information provided through the app and were subsequently flagged for review by their consultant. 81.7% of patients entered at least one symptom onto the platform. This change in practice highlights the feasibility and potential benefits of digital remote patient monitoring for continuous triaging of large waiting lists, ensuring that those who need urgent care can receive it.

INTRODUCTION

Increasing healthcare costs and an ageing population pose a considerable challenge to healthcare systems.¹ Telemedicine and remote patient monitoring (RPM) present an opportunity to expand limited resources to care for a larger scope of patients than is otherwise possible using traditional healthcare practices.

The emergence of COVID-19 in December of 2019 created an unprecedented challenge for healthcare systems worldwide. Subsequently, a significant number of nonurgent surgical procedures, such as elective cardiac surgeries, were postponed. In addition, patients with cardiac disease were quickly identified as being at particular risk of severe disease and mortality from the virus.² As a result, the vast majority of in-hospital visits for cardiac patients, including nonurgent surgery and face-to-face consultations, were canceled in the United Kingdom.^{3,4}

In response to the pandemic, there was an emergence of novel triaging systems to stratify patients on substantially growing waiting lists, as elective surgery was postponed.^{3–5} In the United Kingdom, the Royal College of Surgeons (RCS) released a list of criteria to triage surgical patients into five separate groups depending on the urgency of their need for surgery. Groups ranged from priority 1a, requiring urgent surgery, to priority level 4, describing individuals for whom surgery could be delayed by more than 3 months.⁴

Although the classification of patients into urgency groups is possible at the time of initial scheduling of surgery, patients may clinically deteriorate the following classification and therefore require escalation into a more urgent category. Regular monitoring of patient symptoms indicating clinical deterioration is therefore crucial in optimally triaging these patients. Current standard practices of care often lack frequent contact between patients and their clinical teams following an initial triaging decision/urgency grouping decision. Studies have shown RPM to be a viable means to identify patient deterioration with potential for presurgical triaging.^{6–9} Importantly, key symptoms used to identify clinical deterioration that would require escalation of a patient into a higher risk bracket, such as chest pain, worsening dyspnea, or syncope, can be communicated to clinical teams without the need for face-to-face consultation, and so are suitable to be captured via remote monitoring.

The use of digital RPM via a smartphone application to triage patients for cardiac surgery remains largely a new avenue of practice, due to general barriers to the adoption of new technologies within nationalized healthcare systems and a need for strong evidence in support of their efficacy.^{7,8} As such, further exploration of the use of RPM in this context offers value to HCPs seeking to better support their healthcare systems and patients.

AIMS

This article aims to evaluate the deployment of an RPM mobile health (mHealth) solution at a tertiary cardiac center to support continuous triaging of patients on a cardiac surgical waiting list. The evaluation focuses on the feasibility of identifying clinical deterioration in cardiac patients and patient acceptability of the tool. In addition, we highlight potential implications for the use of RPM on clinical outcomes and identify avenues for further research that may support the further proliferation of RPM solutions.

METHODS

In response to the pressure on the cardiac surgical waiting list at The Royal Brompton and Harefield NHS Clinical Group, a digital remote patient monitoring solution was implemented with the aim of identifying and prioritizing patients in the most urgent need of surgery. The Trust comprises two large cardiac center hospitals, both of which employed a smartphone application-based mHealth solution (“Medopad,” developed by Huma Therapeutics Ltd) to gather key health information on patients awaiting cardiac surgery.

The Trust stratified waiting list patients into urgency groups according to RCS guidance.⁴ Eligible patients who were risk-stratified into triage groups p2, p3, and p4 were given the option to be monitored remotely via the Medopad platform. Patients who opted into the scheme were then either on boarded as outpatients from the clinic or from an inpatient setting.

Eligibility was determined by the clinical team opinion, willingness of patients to use the solution, and their access to smartphones that met the minimum technical requirements to download and operate the application. Patients who did not take part in RPM monitoring were managed in line with the hospitals’ standard preoperative pathway, which involved an initial assessment when a patient was first put on the waiting list and phone calls by specialist nursing teams every 4–6 weeks. Patients were also provided telephone access to a cardiac specialist nurse if they wanted to self-report worsening symptoms.

Patients who agreed to use the RPM solution were on boarded onto the system by their clinical team and monitored until their date of surgery. The RPM solution requested patients to select symptoms they had been experiencing once a week from a predetermined list. Each symptom was scored using a four-point verbal rating scale. The list of symptoms focused on those associated with myocardial ischemia, decompensated heart failure, and syncope and worded by the RBH clinical team. The list was designed to identify patients who were likely to clinically deteriorate or require urgent interven-

tion (for the full list, see [Supplementary Table 1](#)). The way in which the symptom list was presented to patients was guided by the requests of the clinical team and user experience specialists involved in the design of the smartphone application.

Information submitted by patients via the smartphone application was then transferred to a web-based clinical dashboard, where it could be later reviewed by the clinical team. Symptom severity was presented to the clinical team using a traffic light coded system to help identify deteriorating patients more easily and rapidly. The clinical team monitored this dashboard at least once daily, prompting intervention for those that needed it. Patients could be contacted either via telephone or via an inbuilt telemedicine function within the app that allowed one-way video calls from the clinical team (through the dashboard) to the patient. Following further consultation, patients who were deemed to be clinically deteriorating were then escalated to the consultant responsible for their care. Escalated patients were re-evaluated and rediscussed in a multidisciplinary team meeting regarding the next steps of their care and possibly bringing their surgical date forward.

The application also incorporated educational content deemed relevant to the patients. This included NHS web pages with written education materials on weight loss, smoking cessation, and a link to the British Heart Foundation website.

The use of the application was assessed retrospectively over 6 months as a service evaluation using data collected from the clinical team and user analytic information collected via the back-end of the Medopad solution. Analyses focused on the feasibility of identifying clinical deterioration in cardiac patients (% of patients for whom deterioration was identified by the clinical team) and patient acceptability of the tool (% adherence to the solution).

RESULTS

Enrolment

A total of 525 patients used the Medopad RPM solution. All 525 patients were already on the waiting list for cardiac surgery and in an RCS-defined priority group above p2. Indications for surgery were either valvular disease, coronary artery bypass graft (CABG), myomectomy, or ascending aortic surgery. All patients were reviewed by the clinical team and deemed suitable for use of the solution. Patients were also given access to an online guide explaining how to use the platform.

User analytics—engagement

In regards to engagement, 81.7% of patients input at least one symptom after they were enrolled on the platform.

On average, patients input at least one symptom for 2.52 ± 3.04 consecutive weeks ([Figure 1a](#)). Although patients did not exclusively enter data as frequently as requested of them, on average they continued to submit data for a mean number of 6.68 ± 6.91 weeks in total ([Figure 1b](#)). Additionally, the average weekly number of modules submitted per patient (out of those using the solution) was 3.10 ± 0.51 over 6 months.

The median amount of time spent using the solution during each episode, defined as the time taken for the user to open the application, input data, and close the application, was 1.4 minutes.

User analytics—learn content

38.86% of all users looked at educational content within the Medopad application at least once and were presented with the five links

to external websites. Of these users, 55.88% opened at least one link (the equivalent of 21.71% of all users). These users opened on average 3.33 ± 3.82 links ([Figure 2a](#)) or 1.74 ± 0.87 unique links ([Figure 2b](#)). After opening a link, users spent on average 2.01 min reading the website before returning to the app. Detailed statistics for each of the links are listed in [Table 1](#).

Clinical deterioration

Of the 525 patients using the solution, 51 (9.71%) were identified as at risk of deteriorating by nurses based on data captured via the RPM platform and subsequently escalated to their respective consultant. Patients who were escalated were aged 62 on average ($SD = 12$, range = 36–82; 23 were female and 28 male). Of the patients that were escalated, 11 were awaiting CABG, 19 were awaiting valvular surgery, and 4 were awaiting combined CABG and valvular replacement. The remaining were awaiting complex combined cardiac procedures.

Within the 51 patients that were identified as deteriorating, 45 (88.2%) patients were discussed in a multidisciplinary meeting and had their operation dates brought forward.

DISCUSSION

As COVID continues to change the landscape of healthcare services, a better understanding of the pragmatic implications of telemedicine and RPM in cardiac surgery has become paramount.

The RPM solution described in this article successfully highlighted symptoms of deterioration in a cohort of patients with cardiac conditions awaiting surgery. Following this, 45 (88.2%) patients were deemed high risk for adverse events and had their operation dates brought forward. These data highlights the potential benefit a digital RPM solution may offer with regard to triaging large surgical waiting lists to ensure that patients showing signs of deterioration can be identified and escalated to their clinical teams for intervention.

Whilst our data show that RPM solutions may have the potential to reduce adverse outcomes for patients on waiting lists by identifying those with deterioration symptoms early enough to escalate, the present observations are not conclusive, and further research is needed to fully explore early escalation from RPM data, and the potential limitations and advantages of algorithm-driven escalation.

Implementations of digital health solutions have become increasingly common in the United Kingdom, with many care providers utilizing telemedicine to help manage and monitor their patients. The nature of mHealth RPM solutions and their implementation has resulted in a lack of high-powered randomized controlled studies for the effectiveness of remote patient monitoring. mHealth RPM solutions are often bespoke for their individual patient group and are quick to change as mobile phone hardware and software functionality and technology advances. As such, conclusions drawn from analyses on particular solutions are likely to have limited or short-lived applicability to alternative solutions. Nevertheless, future research is needed to clearly identify the effectiveness of RPM on clinical outcomes for these patients, even if the ubiquity of conclusions drawn from such research may be limited.

Limitations

The service change was not designed as a study but implemented due to acute clinical need in response to the sudden impact of the COVID-19 global health pandemic. This evaluation has been conducted retrospectively. As such there were significant limitations to data collection. Demographic data was only collected for patients

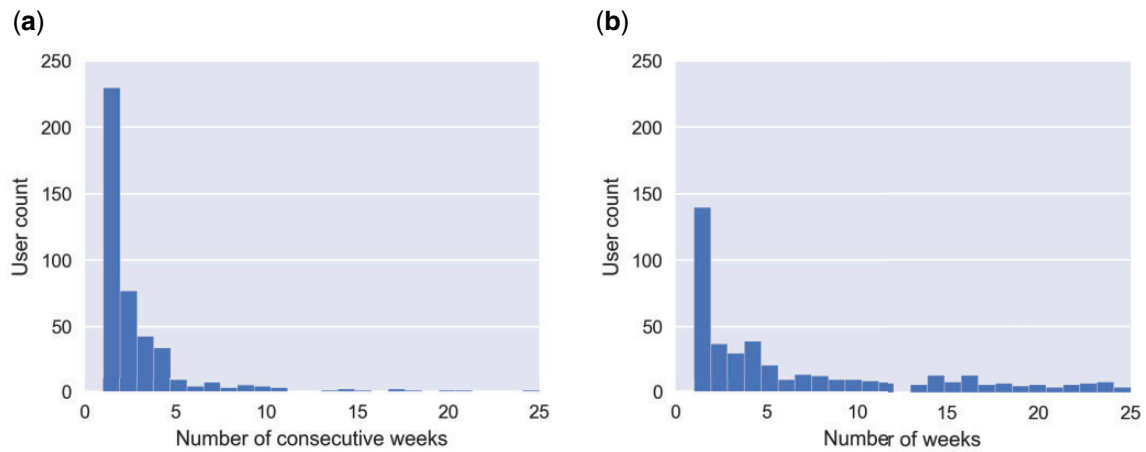


Figure 1. Number of consecutive weeks from first use (a) or total weeks (b) users engaged with the app (ie, completed at least one module).

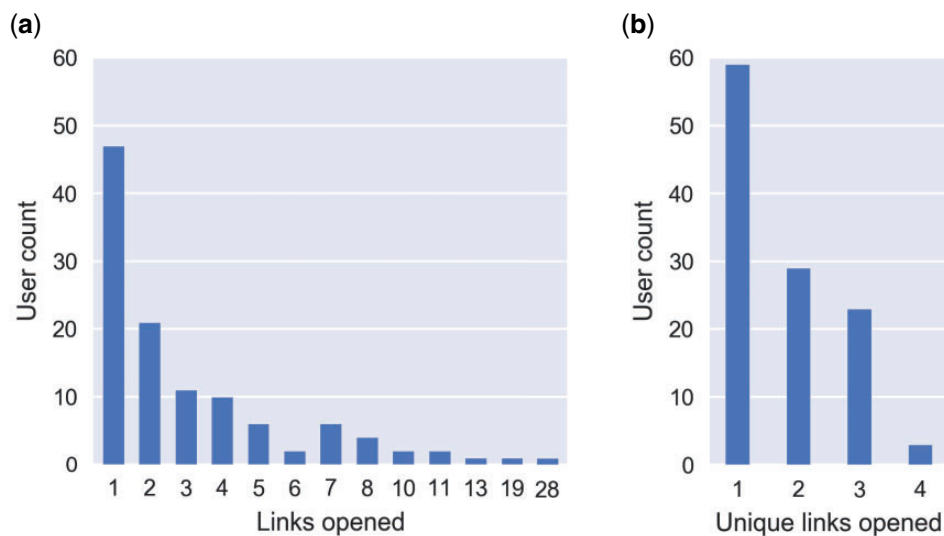


Figure 2. Learn content: numbers of links (a) or unique links (b) accessed by users.

Table 1. Summary of user analytics for the Learn content

	Total number of times link was opened	Number of users who opened link at least once	Average time spent (s)
Any of the five links	380	114	123
COVID 19 content	206	93	
British Heart Foundation webpage	91	46	93
NHS weight loss webpage	56	37	121
NHS smoking cessation tips	15	11	19
NHS smoking cessation services	12	11	44

that were identified as deteriorating via their use of the solution. Similarly, it was not possible to use patients undergoing the usual waiting list care pathway as a comparator group, to determine whether use of the Medopad solution was associated with altered clinical outcomes, such as mortality and perioperative anxiety. Investigation of these outcomes would be valuable in future prospective cohort studies.

CONCLUSION

This article presents the implementation of a remote patient monitoring solution for cardiac surgical patients during the COVID-19 pandemic. We demonstrate the feasibility of implementing such a solution for remotely triaging patient waiting lists and discuss potential clinical and operational benefits to cardiac centers adopting similar solutions. Although research is required to better understand

the clinical and economic impact of such systems, the implementation of these technologies shows promise and remains an exciting prospect.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Journal of the American Medical Informatics Association* online.

AUTHORS' CONTRIBUTIONS

B.D.O. assisted with service evaluation design and write-up. V.M. and M.P. and were clinical leads in implementing and performing this change in practice. N.D. and S.P. assisted with data analysis. B.D.O., S.V., S.N., S.S., J.G., C.D., L.S., S.N., D.P., C.N., S.B. assisted with service evaluation design and original service change and write-up. All authors reviewed and approved the final manuscript.

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DECLARATIONS

The above-described solution was implemented as a service regardless of this article. The guidelines of the Medical Research Council were consulted, and this evaluation was not research as defined by the UK Policy Framework for Health and Social Care Research.

NHS Research Ethics Committee approval was therefore not required but local NHS Trust Information Governance approval was sought and approved to implement the service change.

DATA AVAILABILITY

The data underlying this article cannot be shared publicly for ethical and participant privacy reasons.

CONFLICT OF INTEREST STATEMENT

B.D.O., N.D., S.P., S.V., S.N., S.S., and J.G. are employees of Huma Therapeutics Ltd.

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