

Original Article



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Abstract

Introduction: Paediatric cardiology fellows, tasked with studying a large and dynamic field, may benefit from a quick-access digital resource that reflects contemporary practice. The objective of this study was to evaluate the effectiveness of a paediatric cardiology handbook smartphone app in enhancing the accessibility of information such as guidelines and recommendations for paediatric cardiology fellows. **Materials and methods:** The Peds Cardiology Handbook app (iOS) was designed using XCode and Swift programming. A pre-app survey and download instructions were sent to the US paediatric cardiology fellows, followed by a post-app survey. Fellows were asked to rate the ease of rapid access to various types of information. Responses were compared pre- and post-app using McNemar's test and Wilcoxon signed-rank test. **Results:** Two-hundred and thirty paediatric cardiology fellows were contacted; 23% (n = 53) completed both the pre- and post-app surveys and were included for analysis. After using the app, fellows found it easier to quickly access information in eight out of nine domains evaluated (p < 0.05). All fellows found the app easy to use (100%), most felt that the app was well-organised (98%), contained reliable information (92%), and was useful for finding quick answers to clinical questions (87%). **Discussion:** The Peds Cardiology Handbook iPhone app is a useful, reliable tool that provides quick access to high-yield information, including guidelines and references. Overall, paediatric cardiology fellows found it easier to rapidly access clinically relevant information after using the app. Future studies may be necessary to evaluate long-term use and impact on evidence-based practice.

Since the introduction of the iPhone in 2007, the personal smartphone has played an increasing role in hospital settings. Over 90% of trainees in paediatrics use a smartphone¹ and over 85% use medical applications at least once a week. The use of smartphone applications in clinical practice has steadily increased as a way to engage a new generation of trainees and provide quick, easy access to data and references.^{2,3}

The field of paediatric cardiology spans a broad range of disciplines and subspecialties including general cardiology, non-invasive imaging, cardiac catheterisation, electrophysiology, cardiac critical care, adult CHD, pulmonary hypertension, and heart failure. Each subspecialty offers its own societal guidelines and evolving recommendations as knowledge and technology rapidly advance in each field. As of yet, there is no consolidated source of information that can quickly access these resources.

In recent years, programmes have placed increasing emphasis on evidence-based practice and guideline-directed management and therapy.^{4–10} Currently, there is no smartphone application (app) dedicated to paediatric cardiology evidence-based practice guidelines and recommendations. The purpose of this project was to design a paediatric cardiology handbook smartphone app to serve as a quick-access digital resource reflecting contemporary practice, including current guidelines, and to evaluate its utility for paediatric cardiology fellows.

Materials and methods**App description**

The Peds Cardiology Handbook app was created by author ER for iPhone using XCode and Swift programming language (Fig 1). The app was designed to provide quick answers to clinical questions that arise in daily practice, with a focus on societal guidelines and scientific consensus statements. Topics covered included adult CHD, cardiac catheterisation, critical CHD screening, echocardiography, electrophysiology, endocarditis, genetics, intensive care, Kawasaki disease, medications, and rheumatic fever. Each page on the app included references to relevant peer-reviewed literature and textbooks.

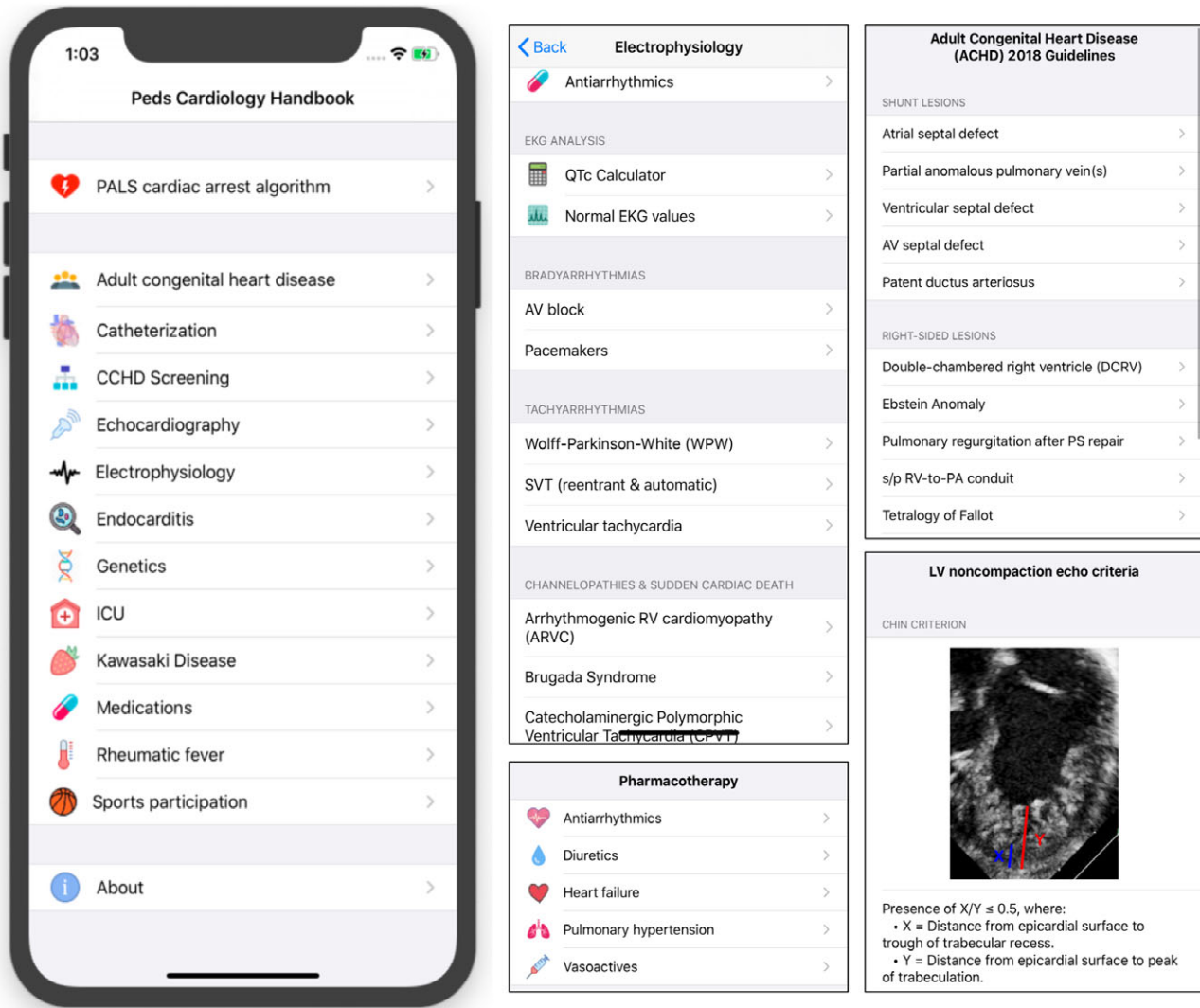


Figure 1. Example screenshots from the Peds Cardiology Handbook app.

Pre- and post-app survey questions

Approval was obtained from the Institutional Review Board of the Albert Einstein College of Medicine prior to data collection. A pre-app electronic survey (Qualtrics, Provo, UT) was sent to paediatric cardiology fellows in the United States of America, followed by instructions to download the app. The pre-app survey contained eight questions, using multiple choice and Likert scales to understand the fellows' usage of various resources and modalities in clinical practice.

Four months later, a post-app survey was sent to the same group of fellows. The post-app survey contained 12 questions, including the same questions from the pre-app survey as well as additional questions regarding usage of the handbook app (Table 1). Pre- and post-app surveys were automatically linked by an anonymous identification number. Respondents were included for analysis if they downloaded the app and completed both pre- and post-app surveys. Respondents were excluded from analysis if they were not iPhone users, as the app was only available on an iOS platform.

Analysis

Data were described using standard summary statistics. Univariate analysis was performed using McNemar's test to compare paired dichotomous variables and Wilcoxon signed-rank test for non-parametric variables, with p-values ≤ 0.05 considered significant. Analyses were conducted using Stata software, version 13 (StataCorp LP, College Station, TX, USA).

Results

Respondent demographics

Of the 230 paediatric cardiology fellows who were contacted, 67% (n = 155) completed the pre-app survey. Of that group, 90% (n = 140) were iPhone users and were, therefore, able to download the Peds Cardiology Handbook app. Of those 140 fellows, 38% (n = 53) downloaded the app and completed the post-app survey, meeting inclusion criteria for analysis. Respondent demographics are shown in Table 2. Most fellows were in their first year (36%,

Table 1. Survey questions.

	Response options when applicable
<i>Questions on pre-app survey</i>	
What is your current year of paediatric cardiology fellowship training?	–
How many fellows per year are trained in your paediatric cardiology fellowship?	–
<i>Questions on both pre- and post-app surveys</i>	
How often do you use medical apps on your smartphone? (Common examples include UpToDate, Epocrates, Micromedex, etc.)	<ul style="list-style-type: none"> • Never • <Once a month • 1–3 times a month • 1–3 times a week • Almost every day • Every day
Rank your preferred methods of learning paediatric cardiology material from favourite to least favourite	<ul style="list-style-type: none"> • Lectures • Textbooks • Medical websites • Online videos • Medical smartphone apps • Journal articles
When looking for a quick answer to a clinical question, rank how often you use each of the following resources	<ul style="list-style-type: none"> • Medical smartphone apps • Google search • Wikipedia • UpToDate • PubMed • Printed textbooks • Online textbooks • Printed fellowship handbook • Fellowship website
How easy or difficult is it for you to quickly access the following resources, from “very easy” to “very difficult”	<ul style="list-style-type: none"> • Normal ECG values • PALS algorithm • Kawasaki disease criteria • Indications for endocarditis prophylaxis • Indications for pacemaker placement • Haemodynamic equation for the catheterisation lab • Critical CHD screening • Adult CHD guidelines • Basic guide to transthoracic echocardiography
<i>Questions on post-app survey</i>	
How often did you use the Peds Cardiology Handbook app?	<ul style="list-style-type: none"> • Never • <Once a month • 1–3 times a month • 1–3 times a week • Almost every day • Every day
How useful did you find the Peds Cardiology Handbook app for finding quick answers to clinical questions affecting children with cardiac disease?	<ul style="list-style-type: none"> • Not at all useful • Not very useful • Neutral • Somewhat useful • Very useful
How reliable did you find the information in the Peds Cardiology Handbook app?	<ul style="list-style-type: none"> • Not at all reliable • Not very reliable • Neutral • Somewhat reliable • Very reliable
Rate your agreement with the following:	<ul style="list-style-type: none"> • Strongly disagree • Disagree • Neutral • Agree • Strongly agree
<ul style="list-style-type: none"> • The app is easy to use. • The app makes it is easier for me to quickly access basic information and treatment guidelines during clinical work. • The organisation of the app makes it easy to find the information I am looking for. 	
How likely are you to recommend the app to your colleagues?	<ul style="list-style-type: none"> • Not at all likely • Not likely • Neutral • Likely • Very likely
Briefly describe what you found to be most useful about the Peds Cardiology Handbook app	–
Briefly describe what you think would improve the Peds Cardiology Handbook app	–

Table 2. Respondent data.

Respondents (n = 53)	
<i>Year of fellowship training, n (%)</i>	
First year	19 (36%)
Second year	24 (45%)
Third year	8 (15%)
Fourth year	2 (4%)
<i>Fellows per year in programme, n (%)</i>	
One	5 (9%)
Two	13 (25%)
Three	12 (23%)
Four	3 (6%)
Five	8 (15%)
Six	6 (11%)
More than six	6 (11%)

n = 19) or second year (45%, n = 24) of training. Over half of patients were in small-to-medium-sized programmes with 1–3 fellows per year (57%, n = 30).

Pre-app survey results

Learning tools

Fellows were asked to rank their preferred methods of learning paediatric cardiology material among the following choices: in-person lectures, online videos, smartphone apps, journal articles, textbooks, and medical websites (Fig 2). The most frequent top-ranked response was lectures (53%, n = 28), followed by textbooks (15%, n = 8), medical websites (11%, n = 6), and online videos/webinars (9%, n = 5).

Resource use

On the pre-app surveys, fellows were asked how often they use various resources when looking for a quick answer to a clinical question (Fig 3). The resources used frequently (defined as at least once per week) were Google (89%, n = 47), UpToDate (72%, n = 38), PubMed (51%, n = 27), and smartphone apps (49%, n = 26). Resources that were less likely to be used frequently as a quick resource included printed textbooks (32%, n = 17), Wikipedia (30%, n = 16), and printed fellowship handbooks (11%, n = 6).

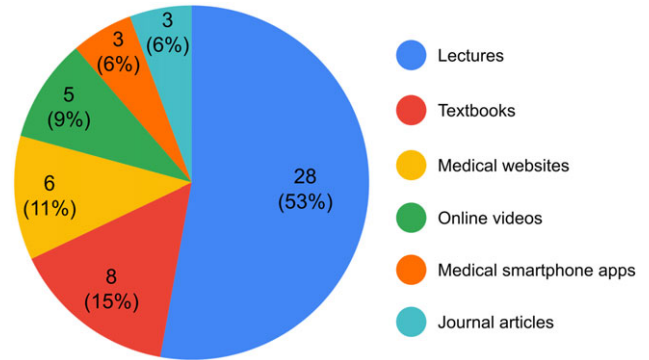
Quick access by topic

Before being introduced to the app, fellows were asked to assess the ease of quick access to various types of information, such as guidelines and normal values (Fig 4). Responses were given on a 4-point scale (1 = very difficult, 4 = very easy). The domains that were ranked as the most difficult were adult CHD guidelines (1.6 ± 0.6), pacemaker indications (1.8 ± 0.8), and the critical CHD screening algorithm (2.2 ± 0.8). Fellows found it relatively easy to quickly access normal ECG values (2.9 ± 1.0) and the paediatric cardiac arrest algorithm (2.8 ± 0.9).

Post-app survey results

Learning tools

When ranking preferred methods of learning paediatric cardiology material on the post-app survey, lectures remained the most

**Figure 2.** Preferred resources for learning paediatric cardiology by share of top choice ranking.

popular top-ranked choice (53%, n = 28). There were no significant changes in the ranking of preferred learning modalities following use of the app. Of note, the ranking of medical smartphone apps as a learning tool did not change significantly on the post-app survey.

Resource use

Regarding resource use for quick answers to clinical questions, the only significant change on the post-app survey was increased frequent use of PubMed (74%, n = 39) by 23 percentage points (p = 0.04) (Fig 3). Google remained the most popular resource for frequent use (92%, n = 49).

Quick access by topic

After using the app, fellows found it easier to quickly access information in eight out of nine domains (Fig 4). The greatest improvements in “ease of quick access” score (1 = very difficult, 4 = very easy) from pre- to post-app were seen in echocardiographic views (2.2 ± 0.9 versus 2.9 ± 0.8, p < 0.01), pacemaker indications (1.8 ± 0.8 versus 2.4 ± 1.0, p < 0.01), adult CHD guidelines (1.6 ± 0.6 versus 2.2 ± 1.0, p < 0.01), and haemodynamic equations for the catheterisation lab (2.4 ± 0.9 versus 3.0 ± 0.9, p < 0.01). The only domain without statistically significant improvement was the incomplete Kawasaki disease algorithm (2.5 ± 0.8 versus 2.8 ± 0.9, p = 0.08).

Evaluation of app

Over half (57%, n = 30) of the fellows used the Peds Cardiology Handbook app 1–3 times per month, while 17% (n = 9) used it at least 1–3 times per week. All fellows found the app easy to use (100%, n = 53). Most fellows felt that the app was well organised (98%, n = 52), contained reliable information (92%, n = 49), and was useful for finding quick answers to clinical questions (87%, n = 46). A large majority (91%, n = 48) of fellows would recommend the app to a colleague.

When asked to describe in free text what they found to be most useful about the Peds Cardiology Handbook app, the most common response (47%, n = 25) was that it provided quick access to concise high-yield and relevant information in one place, particularly guidelines, normal value ranges, and diagnostic and treatment algorithms. The second most common response was the ease of use and accessibility of the app (43%, n = 23).

When asked to provide free text feedback and suggestions for improvement, the most common request was related to expanding app content (81%, n = 43). Of these, there were specific suggestions

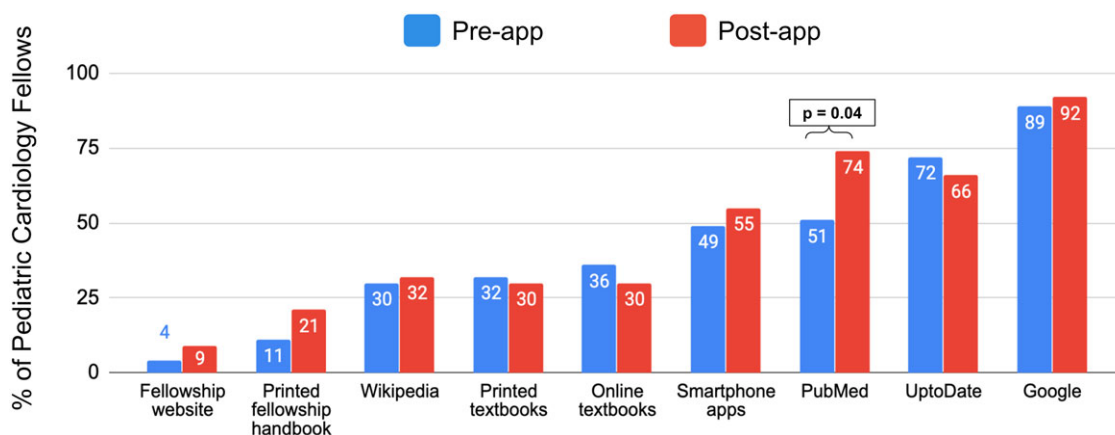


Figure 3. Frequent resource usage (at least once per week) for quick answers to clinical questions by respondents on the pre- and post-app surveys.

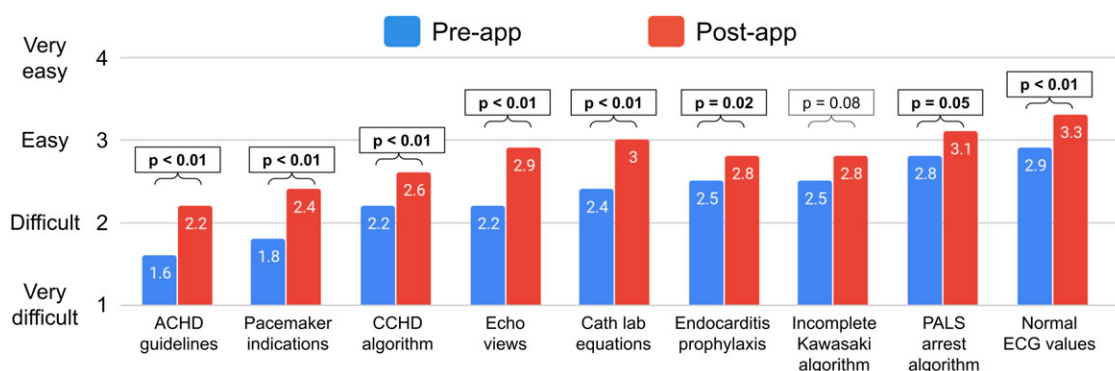


Figure 4. Average fellow responses for ease of quick access to information in nine domains before and after using the Peds Cardiology Handbook app. A p-value ≤ 0.05 was considered significant. ACHD = Adult congenital heart disease; CCHD = Critical congenital heart disease; ECG = Electrocardiogram; PALS = Pediatric advanced life support.

to expand content in electrophysiology (n = 5), echocardiography (n = 4), CHD surgical management (n = 4), pharmacology (n = 2), and catheterisation (n = 1). There were 8 fellows (15%) that did not have any feedback or suggestions for improvement.

Discussion

This project has demonstrated the successful development and implementation of a paediatric cardiology handbook smartphone app. Our survey data of paediatric cardiology fellows indicate that the app is a useful, reliable tool for providing quick access to various guidelines and references. After using the app, fellows found it easier to quickly access resources in almost all domains evaluated, particularly in permanent pacemaker indications, echocardiographic views, adult CHD guidelines, and haemodynamic equations for the catheterisation lab.

The field of paediatric cardiology has seen several novel approaches to aid in trainee education and clinical decision-making in recent years. Simulation training has been shown to improve procedural skills such as echocardiography and clinical performance in the cardiac intensive care setting^{11,12}. There is also an increasing role for virtual reality training to improve fellow education and patient care¹³. To our knowledge, this is the first description of a smartphone application dedicated to providing consolidated quick access to high-yield educational material and concise summaries of current guidelines across all paediatric

cardiology subspecialties to facilitate fellow education and practice of evidence-based medicine.

The results of our pre-app survey highlight the need for a convenient, reliable paediatric cardiology handbook. A majority of fellows (89%, n = 47) reported using Google at least weekly for answers to clinical questions. Though Google’s search engine can be a powerful tool, its results are not peer-reviewed or verified by the medical community. It seems likely that its frequent use is due to its easy interface and accessibility. Nearly half of the fellows (49%, n = 26) reported using smartphone medical apps frequently for quick answers, suggesting that a dedicated paediatric cardiology app could become a high-yield resource for many trainees. These findings should challenge paediatric cardiology educators to create innovative tools and resources with a focus on ease of use.

The primary function of the app was not to teach fundamental principles or concepts. As our survey data show, despite the importance of technology for today’s trainees, in-person lectures remain the most popular method for learning paediatric cardiology. Compared to an experienced educator, a smartphone app may be less able to explain the nuances of CHD and pathophysiology. Instead, the goal of the Peds Cardiology Handbook app was to provide quick answers to clinical questions that arise in daily practice, with a particular focus on guideline recommendations that may be difficult for trainees to memorise and recall quickly.

Development of this app was motivated by the large amount of continuously evolving recommendations and guidelines in the world of paediatric cardiology. Outcomes in patients with CHD

have significantly improved over the last few decades, in part due to the increasing role of evidence-based practice guidelines^{14,15}. By consolidating the knowledge of our field into a dynamic, easy-to-access smartphone app, paediatric cardiology fellows can more readily reference and become more familiar with these guidelines. Interestingly, after using the app, there was a significant increase in the number of fellows that reported frequent use of PubMed as a quick resource for clinical questions (51% pre-app to 74% post-app, $p=0.04$). Use of the app may have encouraged fellows to examine the referenced literature for evidence to guide their clinical decision-making. Future research will investigate if practitioner usage of a smartphone handbook increases the practice of evidence-based medicine by facilitating access to current literature and guidelines.

Based on feedback received in the post-app survey, the app will continue to be expanded to include a wider range of paediatric cardiology topics. Updates to the application continue to be made intermittently, with new content automatically pushed to users' devices through the iOS App Store.

Limitations

This project has several limitations. Only 23% of fellows who were contacted proceeded to download the app and complete both surveys, which may have led to a selection bias; perhaps these fellows were already more likely to benefit from and use a medical smartphone app. Since there is no Android version of the app, fellows who did not use an iPhone were excluded (15 total), limiting the generalizability of our conclusions. Though the app may be responsible for the improvements seen in quick access to information, this is confounded by improvements that may have been due to each fellow's maturation and development over the four-month study period.

Conclusions

The Peds Cardiology Handbook smartphone app was found to be a useful, reliable tool for paediatric cardiology fellows that provides quick access to important guidelines and references in one easy-to-access location. Use of this app may facilitate and encourage evidence-based practice by fellows and will be explored in future studies.

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Conflicts of interest. None.

Social media synopsis. The Peds Cardiology Handbook iPhone app provides quick access to high-yield information, including guidelines and references.

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