Smartphones have the potential to impact clinical decision-making because of their portability and prevalence of mobile medical applications ("apps"). In this case report, we present a 10-step approach for physicians to develop apps. The process is organized into four phases: (1) **App Vision** includes conceptualization, defining objectives, and establishing its innovativeness; (2) **Creation** defines the project’s feature scope and encompasses app development followed by beta testing; (3) **Dissemination** provides pre-release clearance of patient safety issues followed by distribution to virtual marketplaces and social media outlets; (4) **Determining Utility** involves the research and development process. This article serves as a roadmap for future physician app developers based on current guidelines and the experience of physicians and developers in creating Madruga and Marvel’s Medical Black Book App.


### Introduction

In the era of technology, there continues to be a sharp increase in the number of healthcare professionals integrating mobile medical applications ("apps") into patient care.

Industry research predicts approximately 500 million smartphone owners will be using a healthcare app by 2015 and 3.4 billion by 2018. Current mobile health (mHealth) research suggests that the use of smartphone apps can improve physician’s ability to achieve an accurate diagnosis, improve patient safety, increase patient adherence, and increase system efficiency. Additionally, apps can be individualized for healthcare providers or designed for patients. The potential impact on healthcare delivery and economics has encouraged physician use and development of apps. Although physician’s involvement with medical apps is increasing, there is an absence of literature describing the development process. This article provides a framework for physicians to develop their own apps based on current guidelines and a case example of Madruga and Marvel’s Medical Black Book App (M3BlackBook App).

The Black Book concept was first developed by a Program Director (PD) who advised residents to purchase a black address book to record the “black book worthy” clinical points made during “morning reports.” This medical teaching forum covered thousands of cases, 4000 continuing education hours, and contributed to a handwritten compendium of medical data and knowledge that spanned...
17 years. The essence of the “black book” was rapid retrieval of critical clinical information that can be used at the point-of-care. It served as a coach to assist the resident in daily clinical decision-making (e.g. mnemonics as assist devices for easily remembering abundant and complex medical data).

In 2010, a tech-enthusiast medical student recognized the potential of the “Black Book” when first introduced to it in “morning report.” She collaborated with the PD and mobile app developers (Mini Monster Media, LLC) to convert the handwritten “black book” system to a medical app. The M3BlackBook App was comprised of pearls, differentials, mnemonics, and cases in addition to summarized content from standard internal medicine textbooks, peer-reviewed journals, grand rounds, and board reviews. The project timeline was one year from “idea to iPhone” requiring 375 hours of physician time and 175 hours of design/development time at a total project cost of $15,000.

**Phase One: App Vision**

1. **Conceptualization and defining objectives**

Step one is defining the app’s purpose through key questions: (1) What need or problem is driving the creation of this app? (2) How can the app be applied as the solution? (3) Who is the audience? (4) How will this app influence patient safety directly/indirectly? In the case of M3BlackBook App the “problem” was the slow, unorganized, and error-prone system of a handwritten notebook. The “solution” was converting to app technology for accurate and time-efficient information retrieval and providing enhanced content.

2. **Innovation factor**

Step two is performing market research to determine if the app concept has sufficient novelty. For M3BlackBook App research was performed at Apple iTunes Store, Google, Skyscape, and Unbound Medicine September 2010 using the terms: “internal medicine,” “black book medical guides,” “internal medicine mnemonics,” and “clinical pearls.” This search generated approximately 125 apps. There were no apps that combined clinical pearls, mnemonics, clinical cases, and differential diagnosis. If similar apps were found, the next step would have been to review advantages and disadvantages of these apps (i.e., content, layout, and design). This information can be located in the marketplace where the app is sold, end user forums, and app review articles.

**Phase Two: Creation**

3. **Feature Scope**

The next step is defining the app’s functionality. Medical apps need to take into account the environment in which the targeted consumer will be using it. The M3BlackBook App was designed for medical students and internal medicine residents not the general app consumer. Once the medical team finalized the source content, a UX (user experience) designer was involved to design an intuitive user flow that fulfilled the needs of medical professionals. The audience requested clinical pearls, differentials, mnemonics, and cases. Their functionality preferences included quick auto-fill search, browse, and user-defined bookmarks. With this focus on accessibility, these features catered to users in time sensitive situations. Figures 1–5 demonstrate the overall design of the M3BlackBook App.

Figure 1: Main Menu [Madruza and Marvel’s Medical Black Book App]
4. Development

Once the purpose of the app was conceptualized, the novelty was established, and the content and feature set were defined, the next step was recruiting a developer. Budget is the most significant factor along with shared vision, reputation, and experience. The structure of the app itself was defined with the developer based upon the budget. The development process was guided by questions relating to app performance: Will it need to work on a full range of devices and operating systems? How often will the content be updated? Is localization desired either now or in the future? How is the app going to be marketed, supported, and monetized?

Beyond the feature set, the answers to these questions were determined by the budget available as each element adds complexity, which directly correlates to programmer time (ranges $80–300 per hour). Budget and code preference can determine the technology used to create the app. There are many “do it yourself” app creation platforms, like PhoneGapper, Appery.io and AppMakr.com that utilize HTML5 framework and interface builders. Though we avoided third-party app creation tools...
due to our feature set, desire to control our codebase and avoidance of yearly subscription fees, third-party tools are worth investigating if the feature set is limited and codebase control is not a priority. M3BlackBook App selected Mini Monster Media, LLC based upon their experience in a wide variety of interactive media, their small team size that made them affordable, accessible, and personal, and their client list. After discussions with the developer, M3BlackBook App was specified as a universal app for Apple iOS devices given the prevalence of Apple users in the target group and budget. Mini Monster Media’s final proposal included wireframes of the future M3BlackBook App, timetable, and project cost of $15,000 (for comparison, Angry Birds development costs were approximately $140,000).  

Figure 5: iPad Format [Madruga and Marvel’s Medical Black Book App]  

by the developer. Beta testing also allows for the medical team to determine if the app meets their expectations. Apple App Store provides 50 promotional codes, which are time sensitive and must be redeemed by “tester” within 4 weeks of receipt.

Phase Three: Dissemination

6. Patient and Consumer Safety Considerations

In the premarket period, the key issue is patient and consumer risk. On September 25, 2013 the U.S. Food and Drug Administration issued Mobile Medical Applications Guidance for Industry and Food and Drug Administration Staff, which explains the agency’s oversight of mobile medical apps as devices. Table 1 summarizes the subset of mobile apps that pose greater patient risk and require FDA premarket approval. The FDA may be contacted directly via mobilemedicalapps@fda.hhs.gov if there are any questions about a medical mobile app. End users may also be given specific safety precautions via the agreement to terms of use message that appears on-screen before an app may be operated (e.g. In the event of an emergency dial 911 and seek help from a medical provider. This app is not intended to serve as a guide in acute medical emergencies.).

7. Virtual Marketplace

The iTunes App store, Google Play store, and Android Market, are examples of virtual marketplaces. The M3BlackBook App was sold on iTunes App Store after passing the review process, a one week to one month verification process to determine if the app conforms to Apple’s guidelines and performs as expected. When the app is purchased from iTunes App Store, Apple receives a 30% commission per unit.

8. Social media

The latest revolution in the field of medical communication is social media. These technologies, such as Facebook, Twitter, YouTube, weblogs (blogs), and Google+ can promote an app among the medical community. Of note, these are dynamic media sources that require responses to feedback, “tweeting,” and other reciprocal communication on behalf of the development and medical team to be successful.
Phase Three: Determining Utility

9. Updates

Following the initial app release, it’s important to review the app in a timely manner to verify the content remains up to date, evidence-based, and reliable for use in patient care. Updates can be provided to the development team who will perform revisions to the app and “push” the updates out to the end users. The updates may be as simple as revision of existing content, adding new content, or as complex as incorporating interactive features. M3BlackBook App is currently undergoing an update (i.e. additional cases, pearls, mnemonics, and differential diagnosis) to version 2.0.

10. Research and Development

The final step in the 10-step framework [see Table 2] emphasizes investigating the utility of mobile medical apps in medical education and patient care. This is a pivotal step in the framework because the majority of medical apps have not undergone research evaluation. Several methodologies may be used to investigate medical apps such as random assignment to use a particular app and comparing outcomes, pre and/or post user surveys, tracking usage, and analyzing outcome data among a population of specific medical app users. M3BlackBook App 1.0 is being evaluated in an end-user survey research trial among residents and students at Orlando Health Internal Medicine Residency Training Program (Orlando, Florida USA) with specific aims described in Table 3.

Discussion

Future physician app developers would benefit from these lessons learned. (1) Develop a 5-year plan. Prior to embarking on an app project, it is important to plan ahead for “2.0” version which includes new content, development costs for update, user-feedback, and research. Medicine is constantly evolving, as are devices and software requirements for apps, therefore an app should be produced with intent to update within 6 months. (2) Make app available on multiple platforms (Apple iOS, Android, Fire OS, Windows Phone). Investing more in development costs in order to reach more smartphone users is a better strategy for dissemination. (3) Set a competitive price point. The app should be competitively priced upon its inception into the
market to allow for more users to download and generate feedback. *M3BlackBook App* started at a higher initial price, but we found more success with a price point at $4.99. (4) Increased Review Process. A peer review process (i.e. for apps not required to undergo FDA premarket approval) as well as utilizing more editors for all stages of development is advised. The *M3BlackBook App* 1.0 was not peer-reviewed formally, but did have input and editing from physicians and physicians-in-training exclusively. *M3BlackBook App* 2.0 will be submitted to iMedicalApps for peer review.

Of note, in a largely unregulated market, medical apps are being developed by non-physicians who would benefit from medical experts’ professional advice.

**Conclusion**

Medical apps have the potential to revolutionize the practice of medicine from clinical decision-making to healthcare delivery14. The authors’ objective was to provide a framework for mobile app creation that empowers physicians to become involved in the conception, development, and research process. The expansion of medical apps presents regulation challenges13 and patient safety concerns12, but also offers medical providers and developers opportunities to improve efficiency, patient outcomes, and healthcare systems-change.

---

**Table 3: Research aims of M3 Medical Black Book App research**

<table>
<thead>
<tr>
<th>Specific Aims</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic thinking</td>
<td>• Users consider different diagnosis and/or change in subsequent diagnostic approach from initial impression?</td>
</tr>
<tr>
<td>Therapeutic decision making</td>
<td>• Users change treatment plan?</td>
</tr>
<tr>
<td>Tool for improving education</td>
<td>• Users have decreased time from patient admission to intervention?</td>
</tr>
<tr>
<td>System Change</td>
<td>• Users have improved exam scores with use of app supplemental learning materials?</td>
</tr>
<tr>
<td></td>
<td>• Users prefer application technology (faster information retrieval, access to more comprehensive information, improved organization of content) compared to handwritten note system?</td>
</tr>
</tbody>
</table>

**References**


12. U.S. Department of Health and Human Services Food and Drug Administration. Mobile medical applications: Guidance for industry and food and drug administration staff. 23 Sept 2013. Available at,
