MHEALTH: COMMON USABILITY AND USER EXPERIENCE PRACTICES AND FLAWS

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Abstract

Mobile devices show promise as tools for delivering health information and helping users manage their health. This paper aims at identifying common practices among modern mobile health (mHealth) applications available and bring forward typical design errors that spoil the user experience. mHealth, as the practice of medicine and public health supported by mobile devices, is still a relatively new and rapidly developing medium, but that cannot excuse some of the awful user experience issues that users are exposed to on a daily basis. The goal of this effort is to identify any differences between such applications and general purposes mobile applications. A number of mobile applications of various types were inspected by means of heuristic evaluation and cognitive walkthrough, offering useful insights regarding common usability flaws. The analysis offered here, shall help researchers and developers to create more usable applications as well as providing beneficial information for anyone interested in the implementation and assessment of mHealth applications.

Keywords: mHealth, usability, UX, heuristics, evaluation methods.

1 INTRODUCTION

Mobile technologies, particularly high performance smartphones and ubiquitous access to the Internet, are demonstrating these days an unprecedented penetration in all aspects of life. One of the areas expecting a tremendous growth in terms of mobile application development and usage is healthcare industry. Today, through wireless and mobile technologies we have the opportunity to connect information in the real-world via numerous sensors, wearable or fixed sensors embedded in the environment, and produce continuous streams of data on changes of an individual’s health condition and surrounding environment. Such data have the potential to improve our capacity to optimise our health services, in terms of diagnosis and treatment, but also improve our understanding and knowledge of the diseases from a medical perspective.

A number of emerging trends, already happening in healthcare, are nowadays pushing towards more systematic and universal adoption of mobile technologies in healthcare, opening a whole new era of opportunities and challenges for electronic Health (eHealth). For instance, ageing populations and chronic illness are driving a regulatory reform and the need for more accessible, faster, better and cheaper healthcare. At the same time, the foundations for a shift towards “ubiquitous care” care are already in place - industrialisation of healthcare, electronic health records, remote monitoring and communications. And most importantly, healthcare, like other industries, is getting personal for predictive, participatory and preventative care. The need and growth for healthcare mobile applications is related to the willingness of both hospitals and physicians to integrate electronic health records (EHR) in the very near future, the need to integrate the medical records to the pharmacy systems, and the large number of healthcare mobility service providers who are eager to integrate their products into Electronic Healthcare Systems.
This new area of mobile and anywhere healthcare, or simply mobile health (mHealth), has the potential to be a transformative force and change when, where, and how healthcare is provided. In contrast to the Internet digital divide that limited for years, the development of computerized health interventions for lower socioeconomic groups, mobile phone use has been rapidly and widely adopted among virtually all demographic groups. In fact, mobile phone usage appears greater among those populations most in need of such interventions (Pew Internet, 2010). Mobile penetration in developing countries, where wireless technologies have leapfrogged the wired computer infrastructure, have produced considerable excitement in the global health community with the prospects of reaching and following individuals who were previously unreachable (Kossaraju, et al. 2010).

In figures, the growth mHealth application market has had a continuous upward arc. It is estimated to be worth $6.4 billion in 2015, and more than double that in 2016 ($13.5 billion), up from $4 billion in 2014 and $2.4 billion in 2013. The launch of Apple HealthKit and Google Fit in the latter half of 2014, along with the launch of the Apple Watch in the first quarter of 2015, have the world of mobile health applications poised to truly go mainstream in 2015. The number of mHealth applications published on iOS and Android has more than doubled in two and-a-half years, reaching more than 100,000 apps available for iOS and Android in the health and fitness categories in 2014, according to research2guidance's fourth annual study on mHealth app publishing. That doesn't mean all applications are successful. The competition is fierce. According to research2guidance, 68% of mHealth application publishers make less than $10,000 in revenue, and only the top 5 percent make more than $1 million. Eighty-two percent of application publishers generated less than 50,000 downloads with their mHealth portfolios in 2013 while the top 5 percent reached more than 500,000.

So it is not that difficult to create an application on a handheld device that could be used for mHealth. The question is which are actually going to be the ones to emerge that are going to be highly useful and highly different. It is clear that consumer demand for mHealth applications and sensors has far outpaced the science needed to understand their benefits, risks and impact on health outcomes. In the small amount of mHealth research conducted to date, issues of safety, privacy, confidentiality, regulatory control, and interoperability have been known to hamper researchers’ and developers’ efforts.

On the other hand, usability becomes a key factor in the adoption of these applications, which are often used by people who have problems when using mobile devices and who have a limited experience of technology. Furthermore, in many cases in the field of mHealth, the degree to which applications are usable may impact their effectiveness.

This paper aims at identifying common practices among modern mobile health (mHealth) applications available and bring forward typical design errors that spoil the user experience. The goal of this effort is to identify their differences in relation to practices with general purposes mobile applications.

To this end, a number of mobile applications of various types were inspected by means of heuristic evaluation and cognitive walkthrough, offering useful insights regarding common usability flaws and resulting into practical guidance for the design and development of more appealing and competitive mHealth applications.

2 BACKGROUND AND RELATED WORK

2.1 mHealth

The mHealth field has emerged as a sub-segment of eHealth. Mobile applications and services can include, among other things, remote patient monitors, video conferencing, online consultations, personal healthcare devices, wireless access to patient records and prescriptions. To date, no standardized definition of mHealth has been established. For the purposes of a large scale survey, the Global Observatory for eHealth of the World Health Organization (WHO) defined mHealth as
“medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices”. mHealth involves the use and capitalization on a mobile phone’s core utility of voice and SMS, as well as more complex functionalities and applications including general GPRS, 3G and 4G systems, GPS, and Bluetooth technology.

A growing number of countries are using mobile technology to address health needs. The mHealth field is remarkably dynamic, and the range of applications being designed is constantly expanding. Healthcare providers are well aware of the benefits of the mobile apps. Providers are looking for ways on how to improve the care to their patients and make such services more cost efficient. The key applications for mHealth are:

- Communication between individuals and health services
- Communication between health services and individuals
- Consultation between health care professionals
- Intersectoral communication in emergencies
- Health monitoring and surveillance
- Access to information for health care professionals at point of care

2.2 mHealth applications

Health applications serve many different purposes, such as providing medical information through a mobile device, mobile wellness applications, and the applications designed to access electronic health records (EHR) and personal health records (PHR). Mosa et al. (2013) reviewed several healthcare applications for smartphones which are documented on MedLine. They categorized the users and purposes of the health apps into three major types:

1. applications for healthcare professionals on disease diagnosis, drug reference, medical calculators, literature search, clinical communication, hospital information system client applications, medical training, and general healthcare;
2. applications for medical or nursing students on medical education; and
3. applications for patients focusing on disease management with chronic illness and other conditions.

<table>
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<th>Sub-category</th>
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<th>Share (position)</th>
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<td>Medical Compliance</td>
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<td>Reference</td>
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<td>Diagnostic tools</td>
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<td></td>
<td>Continuing Medical Education (CME)</td>
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<tr>
<td></td>
<td>Alerts and awareness</td>
<td>1,1</td>
<td>10</td>
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</table>
Remote monitoring, collaboration and consultation | Remote monitoring (safety) | 0 | 12  
| Remote consultation | 0.6 | 11  
| Remote collaboration | 0 | 12  
Healthcare management | Logistical & payment support | 0 | 12  
| Patient health records | 2.6 | 6  

Table 1. Taxonomy of mHealth according to the Research2guidance (2014)\(^1\).

A recent study by research2guidance (2014) has revealed that there are now 100,000 apps which are listed in the mHealth sections of major platform operators: Apple and Android. Both platforms are by far the leading mobile operating systems for mHealth apps today. Over the last two years Android, similarly to the total app count, has seen a tremendous growth of the number of apps which are listed in the Health & Fitness and Medical sections in Google Play. To develop their apps, mHealth app publishers also make use of other mobile SDKs like WindowsPhone and BlackBerry.

The biggest group of mHealth apps could be categorized as fitness apps. More than 30% of all apps that are listed in the Health & fitness and Medical app sections of the various OS stores are fitness trackers or exercise guides. The second and third largest groups are Medical reference (16.6%) and Wellness apps (15.5%). Medical reference apps provide information about drugs, diseases, symptoms and give advice on how to take drugs or what to do in case of experiencing pain. They also show locations of pharmacies and medical centers/doctors. Wellness apps summarize all kinds of relaxation solutions, yoga instructions and beauty tips. Nutrition apps help their users keep track of their diet, inform them about e.g. vitamins, calories and fat content as well as socio-economic aspects of food products (e.g. fair trade). Medical condition management apps represent the 5th largest group of mHealth apps (6.6%). This group consists of all apps which track, display and share user’s health parameters, medicament intake, feelings, behaviour or provide information on a specific health condition e.g. diabetes, obesity, heart failure. Even though they capture notable event and press coverage, all other mHealth app categories (PHR, CME, Diagnostics, Compliance, Reminders and Remote monitoring apps) are significantly smaller in size than the ones mentioned above.

### 2.3 Usability of mHealth applications

Usability is the effectiveness, efficiency and satisfaction with which specific users can achieve a specific set of tasks in a particular environment.\(^3\) In essence, a system with good usability is easy to use and effective. It is intuitive, forgiving of mistakes and allows one to perform necessary tasks quickly, efficiently and with a minimum of mental effort. Tasks which can be performed by the software (such as data retrieval, organization, summary, cross-checking, calculating, etc.) are done in the background, improving accuracy and freeing up the user’s cognitive resources for other tasks.

Usability evaluation is far broader than the simple process of measuring user satisfaction. Just as importantly, usability metrics include measures of efficiency, effectiveness, cognitive load and ease of learning. Usability emerges from understanding the needs of the users, using established methods of iterative design, and performing appropriate user testing when needed. There are a wide range of design and evaluation methodologies, both subjective and objective, which are continually growing in sophistication. Built-in webcams on modern laptop PCs, robust wireless networking, remote testing software, and compact, inexpensive video recorders make it increasingly easier to “test” in live clinical settings.

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\(^1\) The study represents around 10% of mHealth apps.
2.3.1 Usability of mobile applications at large

The advent of mobile devices has presented new usability challenges that are difficult to model using traditional models of usability. Zhang and Adipat (2005) highlighted a number of issues that have been introduced by the advent of mobile devices:

- Mobile Context: When using mobile applications the user is not tied to a single location. They may also be interacting with nearby people, objects and environmental elements which may distract their attention.

- Connectivity: Connectivity is often slow and unreliable on mobile devices. This will impact the performance of mobile applications that utilize these features.

- Small Screen Size: In order to provide portability mobile devices contain very limited screen size and so the amount of information that can be displayed is limited.

- Different Display Resolution: The resolution of mobile devices is reduced from that of desktop computers resulting in lower quality images.

- Limited Processing Capability and Power: In order to provide portability, mobile devices often contain less processing capability and power. This will limit the type of applications that are suitable for mobile devices.

- Data Entry Methods: The input methods available for mobile devices are different from those for desktop computers and require a certain level of proficiency. This problem increases the likelihood of erroneous input and decreases the rate of data entry.

The usability features are determined by four contextual factors:

- Users: This factor is related to the user demographics and profiles of mobile application users. The user’s culture, age, experience with technology and mobile devices, perceptions, etc. will influence the way they use mobile devices and technology.

- Environment: physical location and environmental types and conditions will affect how users use their mobile devices and access the mobile apps in them.

- Technology: The devices types, interfaces, the access to networks and other technology related factors will affect the way users access their mobile devices and the apps downloaded in them.

- Task/Activity: Based on the task users want to perform in their mobile devices, the mobile apps may be usable or not. Some tasks may be predefined, simple, and closed ones, which increases the likelihood of using mobile apps. Other tasks that the user wants to accomplish may be difficult, complex, open, interactive tasks, and therefore the users may not be inclined to use his mobile device.

3 Method (Procedure)

This work, having in mind to goal of coming up with a list of common usability pitfalls in modern mHealth applications and, ultimately, the development of series of recommendations for designers and developers has designed a review of a number of representative mHealth applications available today on the various OS application stores. Part of this activity was planned as part of a student assessment for an MSc course in medicine at the Aristotle University of Thessaloniki. As a starting point, the

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2, under the supervision of the Professors N. Maglaveras and I. Chouvarda at the department of Medical Informatics.
students of the course were asked to formulate teams of two members, and select an application that they found interesting after searching among the various available applications at the major mobile OS stores. They were asked to justify their selection, and keep not of the perceived usefulness and ease of use, based on the information made available by the providers at the corresponding store. Then, the students were asked to provide a profile of their selected application, based on a number of fields and taxonomies predefined by the primary research team. As a next step, each member in team was asked to work individual and inspect independently their application in terms of its usability.

All students have been taught in advance to use common usability inspection technics, such as heuristic evaluation and cognitive walkthrough (see next section). Each team member, was asked to review their application using both these technics, and by making for each inspection at least three turns: one to receive a general understanding of the application navigation, content and functions, one to review in detail specific parts, and one to search for issues missed during the previous two turns. All inspectors (students), apart from identifying and documenting usability issues, they also rated the issues and proposed potential design solutions to address each issue in question. Then, a usability expert (the lead author), reviewed each inspection in order to remove any issues that were not relevant to usability and UI design, merged and harmonised the two inspection reports, and produced an executive summary for each study.

3.1 Heuristic evaluation

Heuristic evaluation is one of the most commonly used discount evaluation methods due to its low cost (Nielsen, 1994). In this method, usability experts evaluate a system using a set of design principles and guidelines, called heuristics. It is a low cost that tends to addresses both local (interfaces) and global (system) usability problems. It is an inspection method that can prospectively uncover problems with a user interface, indicate the severity of the problems, and make suggestions for fixing the problems. Heuristic evaluation can uncover both major and minor problems not necessarily found with user testing. Although major problems are generally easier to discover than minor problems and are the most important to fix, minor problems can just as easily contribute to data entry errors and are easier to find via heuristic evaluation than by other evaluation methods. Heuristic evaluations that are performed by two or more usability experts can identify more than 50 percent of the usability problems with an interface (Nielsen, 1993). The method requires that a small set of 3 to 5 experts evaluate a user interface based on their knowledge of human cognition and interface design rules of thumb or heuristics (ibid.). Once the experts identify the heuristics violated within an interface, experts rate the problems in terms of severity on a scale from 1, indicating a cosmetic problem (fix can wait), to 4, indicating a catastrophic problem (immediate fix).

Some examples of heuristics include visibility (users should always be informed of the system state), consistency (interface design standards and conventions should be employed), match (user model matches system model), minimalist (limited use of extraneous information), memory (minimize memory load by using recognition versus recall), flexibility (shortcuts to accelerate performance), message (good error messages), error avoidance (prevent errors), closure (clear closure on all tasks), reversible actions (undo functions), control (avoid surprising actions), feedback (provide informative feedback about actions), language (utilize the users’ language), and documentation (help options) (Nielsen, 1994). These heuristics were used in this study (see next section).

However, there are some minor drawbacks with this method. Heuristic evaluations are good at exposing the majority of usability problems within an interface. However, heuristic evaluations cannot reveal all problems within a system. Using this technique along with other methods may reveal both local (particular interface screens) and global problems (system issues) (Dumas & Redish, 1999).
3.2 Cognitive walkthrough

Cognitive walkthrough is a usability inspection method that compares the users’ and designers’ conceptual model and can identify numerous problems within an interface (Wharton, et al. 1994). It can be used to evaluate an interface for ease of learning (Polson et al., 1992) and to disclose many problems that a first-time user would encounter with system functionality and ease of system use. It defines how well the interface supports “exploratory learning,” or how well the first time user can perform a task without formal training. It is a technique that focuses on errors in design that would interfere with the users performing a task. It also explains mismatches between the users’ and the designers’ conception of a task. A cognitive walkthrough is conducted by an analyst using predefined scenarios addressing four steps that identify the users’ goals and how easy it is for users to meet these goals. Before beginning this type of analysis, the designer must know the users, the respective tasks they will be performing, and the accurate order of actions for each task. As the evaluator steps through the actions to accomplish a task, he or she tries to answer four questions: (1) will the user try to achieve the correct effect, (2) will the user notice that the correct action is available, (3) will the user associate the correct action with the desired effect, and (4) will the user notice that progress is being made toward accomplishment of his or her goal. If the evaluator answers “no” to any of the questions regarding the action leading to the goal, then that action is considered to have usability problems.

Cognitive walkthroughs tend to find more severe problems, but find fewer problems than a heuristic evaluation, are labor intensive, and require a usability expert. Cognitive walkthroughs have been successfully used to identify problems with health IT applications.

3.3 Overview of the reviewed applications

In total twenty two mHealth applications were studied and analysed, covering a range of application categories.

Ten of them were targeted to patients and citizens (see Table 2):

- **Blood Pressure (My Heart):** For storing blood pressure measurements. Helps collect and analyse blood pressure data.
- **Medicine Alarm Reminder:** Reminds the user to take his / her pills / medicines on time. Multiple notifications and multi-user support.
- **Θερμιδομετρητής:** A calories meter. The user can create favorites lists add items to a basket in order to calculate daily calories intake.
- **Lab Values Pro.** Contains three components for quick medical reference and lab values: Lab Values, Medical Abbreviations, and Medical Prefix/Suffix. On pay (2,99$ ). Number 1 rated medical reference application.
- **Weight Challenge:** A tool for a successful diet project. The user can set challenges to reach specific goals. Track daily calorie intake, exercise and the waist circumference and see how they correlate with weight.
- **Pillboxie:** Aims to make it easy to remember one medicines. Available on pay (0,99$)
- **Diabetes - Glucose Diary:** Tracks and analyses key diabetes data like glucose level, description, tags, which one can edit, view on interactive graphs or send them directly to the doctor.
- **Color Blindness Test:** Online test for colour blindness (short test or long test available).
- **Blood Pressure (BP) Watch:** Collect, track, analyze and share blood pressure records. Get reminded at the right time. Share and backup using Google Drive or Dropbox.
• **Instant Heart Rate**: A heart rate monitoring application, for optimising exercise and track progress. The best Health & Fitness app on Mobile Premier Awards 2011 according to jury of industry experts.

<table>
<thead>
<tr>
<th>Title / Developer</th>
<th>Score / Ratings</th>
<th>Operating system / Business model</th>
<th>Downloads</th>
<th>Category</th>
<th>Main category / Sub-category</th>
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<td>General healthcare and fitness / Fitness &amp; nutrition</td>
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<tr>
<td>Lab Values Pro / Hipposoft, LLC</td>
<td>4.5 / 746</td>
<td>iPhone / iPad / On pay</td>
<td>0</td>
<td>Medical</td>
<td>Medical information / Reference</td>
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<td>Weight Challenge / motiMind</td>
<td>4 / 994</td>
<td>Windows mobile / Free</td>
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<td>4 / 1.042</td>
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Table 2. List of review mHealth applications that were targeted to patients and citizens at large (ordered by number of ratings).

The rest twelve were mainly addressed to clinicians and health professionals (see Table 3):

- **ACLF Calculator**: This application defines the prognosis of a cirrhotic patient who is admitted to the hospital with acute deterioration with a complication of cirrhosis. The ACLF calculator helps in identifying whether a user has Acute on Chronic Liver failure.

- **Stroke Track**: Stroke track is for tracking and logging stroke cases. It enables the user to capture details of individual stroke patients included detailed NIH stroke scales, potential complications and tPA dose calculation. Individual cases can be saved to a log and reviewed at a later date.

- **Pediatric Growth Charts by Boston Children's Hospital**: A growth charts application for parents caring for their own child or a paediatricians. It allows to track children's growth over time and display the data points on any of the included WHO and CDC growth charts. Can track height, weight, head circumference and BMI and determine the corresponding percentiles.

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3 According to the OS store taxonomy
4 As categorised further to the research2 guidance taxonomy
• **Medical Calculator**: A medical calculator for helping health professionals with the most common calculations (LDL / VLDL Cholesterol, body Mass Index – BMI, Mean Arterial Pressure, Creatinine clearance, Glomerular Filtration Rate, Glasgow Coma Scale, Pregnancy due date, Cardiovascular Disease Risk Score, etc.).

• **A & P Visible Body**: Presents visually and interactively the core concepts of an undergraduate anatomy and physiology course. The complete app includes cells, tissues and all 11 body systems presented with hundreds of 3D, dissectible model sets, 75+ animations, illustrations, and hundreds of quiz questions. Available on pay (1,11 € per downloaded course unit in-app purchase).

• **eGFR Calculators**: Allows medical professionals to estimate kidney function using five separate eGFR calculators.

• **Prognosis-Rheumatology**: Allows to explore 16 varied clinical cases based on actual patients and update your knowledge on the latest therapeutic guidelines. The clinical cases and discussions have been reviewed by our editorial board comprised of 120 physicians across 27 specialties. Designed to update busy physicians while being an educational tool for residents, medical students and other healthcare professionals studying for academic and licensure exams.

• **Clinical Skills**: An evolving, evidence-based guide to history-taking and the physical exam and simple ECG.

• **Calculate**: Medical calculator and decision support tool, freely available to the medical community. Essential tools in General Practice, Internal Medicine, Cardiology, Surgery, Obstetrics, Nephrology, Hematology, Orthopedics, Pediatrics, Gastroenterology, Neurology, Neurosurgery, Respirology, and more.

• **Prognosis - Your Diagnosis**: Test out decision making skills in a risk-free environment. Self-assess clinical knowledge on the go. Learn about diseases within minutes. This is an award winning app for practicing physicians to develop and maintain their clinical acumen in a risk-free setting.

• **Medscape**: Is the leading medical resource most used by physicians, medical students, nurses and other healthcare professionals for clinical information. The Medscape app is the highest rated, fastest growing free mobile app for healthcare professionals with over 4 million registered users.

• **Epocrates**: More than 1 million active members, including 50% of U.S. physicians, rely on Epocrates to enable better patient care by delivering the right information, right when it's needed. Disease information, alternative medications, lab guides and more clinical tools and content are available by upgrading to an Epocrates Essentials subscription.

<table>
<thead>
<tr>
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<td>General healthcare and fitness / Health tracking tools</td>
</tr>
</tbody>
</table>

5 According to the OS store taxonomy
6 As categorised further to the research2 guidance taxonomy
Table 3. List of review mHealth applications that were targeted to clinicians and health professionals (ordered by number of ratings).

4 TOWARDS MHEALTH OF BETTER QUALITY AND HIGHER ADOPTION

4.1 Design tips

The last years have seen dramatic changes in the mobile platform landscape. New user interface (UI) paradigms have emerged, screens and processors are becoming as advanced as desktop computers, and input mechanisms have been revolutionized. Within these shifting constraints, designers should always try to create a look and feel that is cutting-edge, memorable and high-performing. This is not just a matter of reducing image sizes. Decisions made at various levels of the design and the design process will have a significant impact. Building the most appealing design is like navigating a terrain with many hurdles. It is a continual balancing act between functionality, aesthetics, usability and performance. Whilst the usability guidelines for designing for mobile devices are still evolving (based on the audience’s developing familiarity with – and our usability knowledge of – the medium), there are some basic guidelines which appear reasonably robust. These guidelines have been derived from a combination of our literature review and our experience of conducting user research, usability testing and user-centred design projects for mobile devices - both for mobile sites and also mobile applications. These guidelines may help usability professionals to design usable and useful mobile applications.
4.1.1 Create and stick to a UI brand identity

Each user interaction with an application should reflect the story of the brand and should increase recognition, loyalty and satisfaction. Identifying which elements contribute most to the brand’s identity is essential. Examples are features, visuals, wording, fonts and animations.

4.1.2 Display content clearly

Displaying content clearly includes grouping information in a clear, consistent way and making sure that information is easily viewable and accessible. Information grouping, or “chunking,” means organizing information in short sections or groups of related items. Chunking reduces the amount of information in one place and helps users better retain the information. Another common pitfall under this guideline is the misuse or abuse of colours, often leading to colour polluted and hard for eye-scanning UIs.

4.1.3 Less is more

Overstuffing an interface can result in an application that is cluttered and difficult to navigate. In the worst cases, critical parts of the interface may actually be downright impossible to see. Apparently, mobile applications work best when they focus on a single main piece of content or functionality at any one time. This usability guideline can be understood to directly relate to two of the main defining characteristics of mobile devices: the screen sizes on the one hand and the user attention are relatively limited. Most mobile devices are currently used while the user is ‘on the go’ or multi-tasking in some form. Thus, design needs to be clearly focused on the presentation and communication of the primary goal at any given point.

4.1.4 Select the right structure and navigation

Mobile devices have their own set of information architecture patterns, too. While the structure of a responsive site may follow more “standard” patterns, native applications, for example, often employ navigational structures that are tab-based. Depending on the nature of the content, there is often a “right” way to architect the mobile site or application, by selecting among the most popular patterns: Hierarchy, Hub & spoke, Nested doll, Tabbed view, Bento box and Filtered view. Use consistent navigation to reduce the burden on the user and make it easier to move to and from information sources. Low-literacy users can be unfamiliar with the function of common navigation features like dropdown menus and often ignore them, preferring “back” and “forward” buttons (ODPHP, 2010).

4.1.5 Ensure user control

Mobile applications represent self-contained environments that allow designers a great deal of freedom with – and control over – the user experience. Designers are often overwhelmed and forget to provide some key options that allow the user to keep control of the interaction dialogue and flow, including the necessary ‘Back’ buttons, and undo and exit options.

See: http://www.uxbooth.com/articles/designing-for-mobile-part-1-information-architecture/
4.1.6 Minimise user input

Mobile applications designs should generally require the minimum possible data input from users. The main usability reasons for this are that data entry - selection and text entry - on most mobile devices not very easy and requires significant time and attention.

4.1.7 Write actionable content, in simple user language

Action-oriented language is characterized by short statements with positive messages that quickly explain the benefit of a behavior, followed by information on how to take action. Because mHealth applications are often intended to help users adopt healthy behaviors and/or manage their health, action-oriented language is important because it helps users act on the information they find in the application. Action-oriented content should also be written in plain language, which is recognized as one of the keys to health literacy by government, academia, nonprofits, and hospitals (Stableford, 2007). Plain language is communication that allows users to find what they need, understand what they find, and act on what they find (PLAIN, 2013). It isn’t “dumbed-down” language; it is grammatically correct and utilizes full sentences and proper sentence structure, while also making the information easy to understand.

4.1.8 Optimise UI dialogues for performance

Do not leave users hanging. Leaving the user out of the loop when the application is loading or processing could cause users to think the app is malfunctioning. It is also just a poor experience. Google puts “Every millisecond counts” as the second principle of its user experience. Optimizing individual screens, flows and UI elements will reduce waiting times and keep users from thinking that they are wasting their time. Every UI element affects performance. And because every optimization contributes to overall performance, all UI elements should be considered. The number and type of UI elements on the screen will affect the performance of that screen. Furthermore, the characteristics of an element, such as its resolution or image depth, affects drawing time. Then, the way a UI element is drawn by the application affects screen-loading time. Finally, intro animations must not be gratuitously used. Those fun little animations when an application first opens can be really nice, but it is important not to go overboard with them.

4.1.9 Optimise UI dialogues for touch across all screen sizes

Given that the past two months smartphones by major manufacturers ranged from 3.5” to 5.5” two things need to be carefully considered: touch target sizes and placement of controls and information. Any navigation system that needs to work with touch needs to have menu options that can be comfortably used with imprecise fingers. Remember that most users' index fingers are 1.6 to 2 cm wide. Take into account the width of a finger, plus the fact that users are moving quickly and aren’t able to reliably tap a tiny area of the screen. It also needs to be positioned in a way that aligns with how people hold and use touch-enabled devices8.

4.1.10 Optimise UI dialogues for orientation changes

Most users expect a mobile application to respond to device orientation changes - for example, from portrait to landscape - with an appropriate change in layout. Ensuring that mobile designs behave in

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8 See: http://www.lukew.com/ff/entry.asp?1649
this way has the benefit of not only meeting users’ expectations, which is an important usability principle in itself, but also optimising for the available screen size as mentioned above.

4.1.11 Optimise UI dialogues for the operating system

Bad conversions from one mobile OS to another can confuse and annoy users. Every mobile OS has its own style and the OS’s creator has probably published detailed UI guidelines that have codified their unique aesthetic. It is not necessary to make every application look like it was built by the operating system’s creator, but be careful not to blindly copy style from other OS and turn up with an application that looks like it does not belong on the platform.

4.1.12 Optimise UI dialogues for gesture, according to user expectations

A common pitfall is using a gesture-accessed menu or action as the only point of access, especially in situations that this is not expected and understood by the user. Yet, not every single element of the interface has to be fully visible or easy to get to immediately. In other words, keep gestures in mind, but don’t become overly reliant on them.

4.1.13 Optimise UI dialogues for accessibility and usability for all

One need to consider all the above mentioned guidelines for diverse and the widest possible types users and contexts of use, including for people with disabilities and chronic conditions, the elderly, etc. Adaptivity and adaptability are two powerful tools at the hands of designers to achieve this.

4.2 Development strategy

With such a huge opportunity and fierce competition, the question raised is how are mHelath application developers supposed to stand out and join the top tier of publishers with more than 500,000 downloads? Our study brought forward approach mistakes as well as trends driving mobile health application success in the years to come.

4.2.1 Study the user and seek their feedback

The motivation for the application development is often misguided. Regardless of the elegance, ease of use, enjoyable experience, or other appeal of a health application, if it does not address a specific problem, it will not be considered useful and subsequently not adhered to. People searching for health applications and health information in general are likely doing it because of a health problem. Data must be collected and filtered in a way that it translates a message to the end-user, whether that be a patient or clinician. Co-design, which involves end users in testing an application and applies their feedback, is one of the primary principles in designing user-friendly tools. Co-design is one way developers can learn about users and conceptualize, evaluate, and revise the application. It is unique from usability testing in that it encourages developers to engage end users from the onset—building the application from the start with the end user in mind. Developers often assume that everyone will use an application in mind the same way they do themselves. Usability testing is a must, no matter how good an application looks. Consider organizing a closed beta to small group of trusted people (including a few experienced designers) and update the interface before releasing the app to the public.
4.2.2 Involve clinicians and health professionals

The lack of clinician involvement in development of mobile health technologies continues to dominate the landscape today notwithstanding vendor promises of achieving better patient outcomes at a lower cost and better patient experience. Expert clinician input is necessary on a number of levels. It assures accurate and reliable content, and it leads to a better UX for the clinician with regard to how data is obtained, presented and incorporated into clinical workflow. There are processes that the technology fits into which might very well need to be totally redesigned around the technology (this is a good thing, for many processes need changed). These processes may range from someone’s personal schedule to instituting hospital case managers who advise patients on mobile apps. Knowing the healthcare landscape is critical to determining a strategy of adoption. It is imperative, therefore, to have clinician input into the design of the technology.

4.2.3 Involve representative patients

Achieving the final construction of an application must include an in-depth consideration of the experience a user with the need for the application has. Just as clinician involvement is important in the development phase, so is that of the patient and/or caregiver, who are the data sources. If they are not engaged by good UX design, the technology never takes off and no one knows why.

4.2.4 Study the healthcare landscape and the regulatory specifications

It doesn’t matter how much wow factor the app has, if it doesn’t meet regulatory requirements - security, HIPAA, FDA (if necessary), etc., it will need to be reworked as a significant cost. New proposed regulations regarding handling of data from apps might affect development as well and these should be followed in the news closely. Of course the FDA final guidance document is anxiously being awaited.

4.2.5 Identify and focus on core use cases

Teams often face several project kick-offs in which the initial list of requested features is lengthy, unfocused and impossible to build within the requested timeline. When brainstorming on what a product should do, designers often lose sight of the fact that customers look for solutions that help them with very particular needs. The users need to be able to find and purchase quickly, regardless of whatever other functions that enrich the overall experience.

4.2.6 Prioritise and focus among different versions of the same application

Whether a company wants to launch a product quickly, or develop a product portfolio (i.e., multiple products on one platform, the same product on multiple platforms, or both), or if facing limited time and resources, hard choices have to be made. Design and optimization efforts should be targeted at those products in the portfolio that matter most. A design priority matrix helps us understand where design efforts will pay off the most.

4.2.7 Offer connectivity to other applications

Most mobile health apps today are islands. They don not interact with other applications beyond simple sharing to social networks. This lack of integration hurts mobile health applications in more ways than one. First, it limits their value. Data from other applications cannot flow into or out of the application, limiting utility for the user and creating redundant tasks that require input into multiple application databases.
4.2.8 Offer access to medical databases and cloud services

The demand for apps that allow for monitoring, compliance, and consultation will by default require connectivity to medical databases and patient records at the physician, hospital and service provider offices where care is administered, even if done remotely. This connectivity will be driven in part by hospitals and healthcare organizations and their electronic medical records management services, and by a host of new providers building connectivity tools that act as a secure bridge between application and patient databases. This is the frontier of mobile health applications. Apps that can hook into patient records and patient management systems will enable the valuable interactions and functionality that will drive long-term value and growth. Developers who take advantage of this growing new layer of interoperability can bring new solutions to the market and create a whole new category of powerful mobile health solutions.

5 DISCUSSION AND CONCLUSIONS

There is good reason to be excited over mHealth. Mobile technology can enable much-needed, thoroughgoing change in healthcare systems worldwide and in turn bring significant social and economic benefits. Yet, mHealth is still a work in progress and is growing and changing along with healthcare needs. The mHealth marketplace has lived up to its hype, but where it goes next depends on our changing healthcare needs. While fitness applications are hot now, the future for mHealth applications lies in remote monitoring and consultation.

Access and use of mHealth applications is still on the rise and the opportunity for application developers is clear. Yet, our studies demonstrate the importance of adapting health applications to users’ need. One way to maximize the potential of mHealth applications to improve health is to ensure that these are designed to deliver health information that is simple, engaging, and easy to use for patients and health professional of all literacy levels. There must be age, healthcare and educational literacy and ethnic language appropriateness. The value of an application is simple, intuitive and pleasurable interaction. Efficiency of the presentation, interaction and feedback are important to a good user experience.

Today, all users are reported to experience usability issues, including in finding the right applications for them, and pinpointing the added value in these applications (Franko & Tirrell, 2012). Application consumers are overwhelmed by the great number of tools available for download. Lots of them choose not to download any of them because they cannot decide which ones will meet their needs and they do not want to have too many (health) applications on their mobile devices (van Velsen, et al. 2013). So the initial and potentially one of the greatest challenge for health applications is the quality of the perceived usefulness and ease of use in the process of the selection from the existing large inventory and then of integrating those selected into the user’s mobile device and its associated use routines.

New applications developers need to comprehend that from now on their applications success will not only rely on what their applications do but to a great degree also on how they actually do their thing. Developers and research need to work more towards understanding common usability pitfalls and what may affect the user experience of an mHealth application user. They need to consider appropriate design guidelines and development strategies that fit the specific characteristics of this emerging medium for health care delivery and management.
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