JOURNAL OF MOBILE TECHNOLOGY IN MEDICINE

Volume 2 Issue 2

Featured Content

Tablet Computers in Surgery

Epilepsy at a Glance: A Mobile Medical Record

Operational Challenges in the Cambodian mHealth Revolution

Featured Article

Virtual avatars, gaming, and social media: Designing a mobile health app to help children choose healthier food options
EDITORIAL

001 Unusual Utilisation of Mobile Technology in Medicine
   R. Halim

ORIGINAL ARTICLE

003 Epilepsy at a Glance: A Mobile Medical Record
   M. Reider-Demer

CASE REPORT

008 Virtual Avatars, Gaming, and Social Media: Designing a Mobile Health App to Help Children Choose Healthier Food Options
   Y. Hswen, V. Murti, A.A. Vormawor, R. Bhattacharjee, J.A. Naslund

PERSPECTIVE PIECES

015 Tablet Computers in Surgery
   D.T.S. Chang, K. Yao

020 Operational Challenges in the Cambodian mHealth Revolution
   P.A.B. Bullen

LETTER TO THE EDITOR

024 Preliminary Study on Use of Mobile Phone by Interns to Answer Pager Messages
   D.N. Perera
The popularity of mobile technology has grown rapidly over the last few years and the integration of mHealth is transitioning from a curiosity to an accepted part of health-care delivery. With the growing number of mHealth applications, systematic reviews have highlighted limitations in evidence for their benefits. Despite the paucity of high-quality evidence, the unpublished and grey literature is littered with excellent examples of innovative applications and implementations of mHealth that may benefit patients and be of interest for future research. This has spurred interest from developers to think “outside the box” when trying to solve healthcare issues. We bring to the reader’s attention some of these ‘unusual’ applications and the exciting potential offered by new developments.

With iPhone adoption being as high as 59% amongst anaesthetists, it is a field that ripe for interesting applications of mobile technology. Like other specialties, there are an extensive number of apps and attachable peripherals for the device. One particularly innovative use of the device involves the utility of the accelerometer built into the phone. Reversal from neuromuscular blockade is best measured with a Train-of-four ratio technique, which requires a nerve stimulator and a measurement device for the force generated, such as an accelerometer. The nerve stimulator causes a short burst of muscle twitches the force of which is related to the degree of muscle paralysis. Whilst nerve stimulators are easily accessible, accelerometers are generally more difficult to access in the clinical setting. By combining the built in accelerometer in the iPhone along with the iSeismology app (Figure 1), clinicians have developed an alternative way of measuring the aforementioned ratio.

Recent interest in augmented reality (AR) technology have resulted in several novel applications.

DoctorMole™ is a dermatology smartphone app that aims to aid the assessment of skin moles and diagnosing malignancies. The app can assess a mole through the phone's camera and analyse the image via an algorithm for symmetry, border, colour & diameter to estimate the risk of a suspicious lesion being malignant. Whilst such applications have been shown to have varying degrees of accuracy, potentially resulting in incorrect diagnoses, it serves as an example for the future potential for AR use.

AR is also being utilised for medical education. The newly unveiled Google Glass™ has featured prominently in technology news and has now been utilised during surgery. A percutaneous endoscopic gastrostomy was performed by a surgeon with the live video feed used to educate doctors in training on how to perform the procedure. The device allowed for an "operator view" and the sharing of the endoscopic view as well to enable a better understanding of the procedure for the trainee.
One of the most unusual applications that has been reported involves the development of highly specialised patient slippers. Termined "smart slippers," these devices use pressure sensors to analyse gait and identify possible medical issues or high falls risk. The device would then be able to alert the patient’s clinician of such risks or falls via a transmitter\(^\text{11}\).

These imaginative and unusual applications of mobile technology highlight the potential for further development in the field of mHealth. Furthermore, they help spark the creativity that is essential to such novel implementations of mHealth that will one day become mainstream. We recognise that there will be an inherent limitation in the amount of clinical data available with such developments in the early phases of development, however providing robust clinical data to support the use of any medical technology should be the ultimate endpoint of development. Here at the Journal of Mobile Technology in Medicine, we encourage sharing of these new developments with other mHealth researchers through our news section, and eventually with original research data published in the journal.

References
EPILEPSY AT A GLANCE: A MOBILE MEDICAL RECORD

Melissa Reider-Demer  DNP, MN, CPNP
1Brandman University Irvine, Pediatric Neurology, Children Hospital Los Angeles, USA
Corresponding Author: mrdemer@mednet.ucla.edu

Introduction: Inefficient transfer of health information among facilities fragments care and motivates duplicate interventions. This pilot study was designed to demonstrate the effectiveness of “Epilepsy at a Glance” (EAG), a portable medical record that contains medical records of children with epilepsy. This mobile tool enables medical providers to expedite information sharing to decrease fragmentation of patient care.

Methods: This randomized study included 30 children with epilepsy, 15 each in the experimental and control groups. The experimental group received the EAG while the control group received usual care and a medical alert bracelet at the end of the study. At the beginning and end of the study, participants completed a written survey about their contact with outside providers of epilepsy care. The experimental group was also surveyed at two follow-up clinical visits to determine the usage and impact of the EAG.

Results: The experimental group brought the EAG to over 90% of outside care encounters. More than 80% of primary care, 68% of urgent care, and 100% of emergency room providers viewed the EAG at the point of care. No outside provider who viewed the EAG inappropriately altered the established long term plan of care or performed duplicate testing. Patients and outside providers were enthusiastic about the value of the EAG.

Conclusions: This pilot study demonstrates the value of EAG usage by patients and medical providers, and suggests a promising use of transferring patient medical information using mobile technology. Future studies should be performed with larger groups using EAG or alternative devices to document improved care and reduction in test duplication.


Introduction

Care for children with epilepsy can be overwhelming for patients and their families. The level of intervention required from medical providers has increased due to disease complexity and needs of patients and families. Primary care providers, neurologists, nurse practitioners, and physician assistants must schedule frequent office visits to follow patients and monitor diagnostic tests. Current practice is also influenced by demands and restrictions of managed care and third party payers,1 making it increasingly difficult for medical providers to provide adequate and consistent treatment. For instance, after seeing one medical provider for years, a patient may be re-assigned to a new provider because of changes in insurance coverage. Insurance restrictions may require that diagnostic tests be performed at a location different from that of the medical provider. Similarly, a patient in an epileptic crisis may be brought to an
outside facility where medical personnel are unfamiliar with the patient’s medical history, necessitating redundant testing and possibly motivating inconsistent changes in management.

While the medical system continues to face cost constraints, patients’ diagnoses become increasingly complex. The use of medical information technology is a reasonable tool to improve patient management. In order to meet today’s expectations for patient care, methods of accessing and transferring medical information must change to enable patients to access and transfer their medical information.

During most neurology clinic visits, a discussion takes place among the patients, their families, and the medical provider, clarifying the level of the patient’s seizure control and defining treatment goals. A plan of care is developed and is evaluated at follow-up visits. If an outside medical provider unfamiliar with these goals cares for the patient between visits, this plan of care may be modified from the long-term approach. One solution is to allow patients and their families access to their medical information and plans of care. This information can be stored on a widely accessible universal serial bus (USB) memory device. This device is small enough to be attached to a key chain carried constantly by the patient. By making available medical history and other useful information such as demographics, the memory device could facilitate continuity in patient care. While earlier versions of this portable electronic medical record did not provide as much detail as a complete medical record, newer versions can provide a treating provider with the necessary information to adequately manage patients without duplicating medical service. These devices are typically encrypted and password protected to ensure that a patient’s medical and demographic information remain private. The present study was designed to assess the usability of accessing and transferring the plan of care and neurological healthcare information of a child with epilepsy stored on the EAG.

Methods and Implementation

This pilot study was randomized and controlled, evaluating 30 children with epilepsy followed over a five month period. Participants were patients at the Neurology Clinic of the Children’s Hospital of Los Angeles (CHLA) but also visited other facilities and providers, such as emergency rooms, more than once a year. The exclusion criteria were: inability to speak English or Spanish; parents or guardians unable to provide consent; Assignment was by a random number table so that 15 participants received the EAG and 15 did not. Each participant was assigned a study number to ensure confidentiality. The EAG was encrypted and password protected to safeguard confidentially. The encryption was implemented through the encryption feature of Adobe Acrobat Pro. This study received Institutional Review Board, (IRB) approval from CHLA and Brandman University.

It was hypothesized that use of the EAG containing a summary of medical history and current plan of care for children with epilepsy would improve continuity of care above existing practice.

The EAG included the individual patient’s demographic, general medical and relevant neurological information. Specifically, the patient’s neurological diagnoses; seizure semiology; current vagal nerve stimulator (VNS) settings; a listing of past and current anti-epileptic medications and their dosages; most recent electroencephalograph (EEG), magnetic resonance (MRI), computed tomography (CT), and positron emission tomography (PET) scan reports; management strategies for status epilepticus; known drug allergies; and neurology and primary care provider contact information.

To recruit participants, a medical assistant at the CHLA Neurology Clinic presented a flyer outlining information about the study to eligible patients and their families during their regularly scheduled visits. A flyer was also displayed in the clinic’s waiting room. The nurse practitioner principal investigator approached the parent or guardian to determine ability to understand and willingness to participate in the study. Upon agreement to enroll in the study, consent was obtained. This survey was comprised of seven questions addressing: the average number of seizures experienced; frequency of seeking medical care from outside facilities; availability of a primary care provider; school absences because of seizures; parental work absences due to the child’s seizures; and availability of a nurse at the school attended. This survey was not evaluated against a validation tool. The study group received an EAG at the beginning of the study; the control group received a medical alert bracelet at the end of the study. At the time of the study, none of the patients in the control group wore a medical alert bracelet.

The questionnaire for the study group included questions evaluating the utility of the EAG when
used between scheduled visits to the CHLA Neurology Clinic. The study group completed this questionnaire at two subsequent clinic visits. There were two follow-up study visits scheduled at approximately two-month intervals after the initial study visit. The post-implementation questionnaire evaluated the effectiveness of the EAG as compared to the current practice of verbalizing the patient’s history to the outside medical provider. The questionnaire indicated if the EAG was presented to outside healthcare providers, and if outside healthcare providers viewed the EAG and implement the suggested plans of care. At these clinic visits, the information in the EAG was updated as needed.

### Informed Consent

Children unable to understand the concept of “voluntary” or “research” after age-appropriate explanations were deemed unable to give informed consent. Young adults (18–21 years) were enrolled into the study only if able to read the consent with basic assistance and verbalize understanding of the nature of the procedures. Those unable to read or understand the consent were enrolled only upon consent of the parent or legal guardian. The study consents were offered in English and Spanish. Interpreters were available.

The study group received an information card to carry with them explaining the purpose of the EAG. During the course of the study, parents were asked to provide the information cards to any outside medical care provider with whom they interfaced.

Each patient within the study group carried the EAG attached to a key chain. The control group received a medical alert bracelet upon study completion. Both groups received a $10.00 gift certificate at the end of the study. The EAG data was stored as an encrypted, password protected, “read only” portable document format (PDF) file on a USB memory so that patient data was modifiable only by the study staff, which ensured the safety of the information that was being transferred throughout the study. To ensure patient confidentiality, no one other than the individuals with the password could access the information held within the USB memory drive. Once the study was completed, the patient’s information was destroyed per their request. Future studies should allow providers to input and transfer patient information among the respective medical providers.

### Results

Families and patients were willing to participate in the study, accepted randomization, and were reasonably compliant with the study. There was a waiting list to join this study. Although several patients who expressed an interest in being part of the study did not meet inclusion criteria, they indicated they would be willing to participate in similar studies in the future if they were applicable to their child’s needs.

Participants ranged in age from 0–22 years, with the majority under age 10 years, as demonstrated in (Table 2). Control and study groups were unequal at the study start for gender and primary language, as shown in (Table 1). Data on the frequency of using

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Control n</th>
<th>%</th>
<th>EAG n</th>
<th>%</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>8</td>
<td>53.13</td>
<td>13</td>
<td>86.7</td>
<td>046</td>
</tr>
<tr>
<td>Male</td>
<td>7</td>
<td>46.9</td>
<td>2</td>
<td>13.3</td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>1</td>
<td>6.7</td>
<td>0</td>
<td>0</td>
<td>.595</td>
</tr>
<tr>
<td>White</td>
<td>2</td>
<td>13.33</td>
<td>2</td>
<td>13.33</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>12</td>
<td>80</td>
<td>13</td>
<td>86.7</td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>12</td>
<td>80</td>
<td>10</td>
<td>66.7</td>
<td>.409</td>
</tr>
<tr>
<td>Non-Hispanic</td>
<td>3</td>
<td>20</td>
<td>5</td>
<td>33.3</td>
<td></td>
</tr>
<tr>
<td>Language</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spanish</td>
<td>3</td>
<td>20</td>
<td>7</td>
<td>46.7</td>
<td>.121</td>
</tr>
<tr>
<td>English</td>
<td>12</td>
<td>80</td>
<td>8</td>
<td>53.3</td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medi-Cal</td>
<td>12</td>
<td>80</td>
<td>14</td>
<td>93.3</td>
<td>.283</td>
</tr>
<tr>
<td>Non-medi-Cal</td>
<td>3</td>
<td>20</td>
<td>1</td>
<td>6.7</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Participant Demographics
the EAG device was also collected; positive outcomes of the use of the EAG are demonstrated in Table 3.

One of the 15 study group participants was lost to follow-up; the remaining 14 were assessed at two subsequent study visits. Fourteen of the 15 study participants (90%) presented their EAGs to their outside medical providers. During the first study visit, eight out of 10 (80%) participants reported that they presented the EAG to their medical providers, who viewed the information on the EAG. During the second visit, nine out of 11 (81.8%) reported that they presented EAGs to the primary care providers, all of whom viewed the information on the EAGs.

Among the 14 study group participants, data from the first study visit showed that 4/4 (100%) presented EAGs to their outside emergency room providers, all of whom viewed the EAGs. Between the first and second study visits, 2/2 (100%) emergency department medical providers viewed the EAGs. Among the 14 study group participants, three reported that they presented EAGs to their urgent care providers. Of the three such providers, two (66.7%) viewed the EAGs. No participant visited an urgent care provider between the first and second study visits.

Patients reported that the EAG was also presented to dentists, orthopedists, and school nurses. These providers stated that the information on the EAG was helpful. In one case, a school nurse was able to verify the seizure medication dose required by a patient who was on a field trip, and was informed of appropriate management for status epilepticus in that child. The nurse indicated that she typically had such information on file, but with over a thousand students, the EAG was more accurate and timely. Outside providers noted that it was useful to have the individual neurological information in the EAG at the point of care. There were no reported unintended effects associated with the use of this device and no negative feedback was provided by the participants or outside medical providers regarding the EAG.

Outside medical providers were very willing to use the device (Table 3). Over 80% of primary care providers and 68% of urgent care providers viewed the information on the EAG when it was presented to them, as did 100% of emergency department providers. All of the 10 study participants who presented EAGs to outside treating facilities reported the names of the outside facilities and the treating providers and filled out releases that allowed the study to obtain medical records from outside facilities. The study received feedback from 6/10 (60%) of treating outside providers. These providers verified their use of the EAG and indicated that they followed the proposed patient plan of care and did not order further studies because of the information in the EAG.

After using the EAG, emergency department medical providers expressed an interest in it and were satisfied to have the information available. Because they had the most recent information about the patient’s neurological status, outside providers avoided performing additional diagnostic tests, and made no changes in neurological plans of care.

**Discussion**

This study demonstrated that the EAG is a valid alternative to the conventional way of accessing and transferring medical information. The EAG emerged as a useful, practical, and innovative tool for improving medical information access and transfer, and improving patient care outcomes. Patients were willing to participate, accept randomization, and use

<table>
<thead>
<tr>
<th>Age</th>
<th>0–10 Years</th>
<th>11–18 Years</th>
<th>19–22 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>7</td>
<td>46.7</td>
<td>7</td>
</tr>
<tr>
<td>Study</td>
<td>6</td>
<td>40.0</td>
<td>5</td>
</tr>
</tbody>
</table>

**Table 2:** Participant Age Ranges

<table>
<thead>
<tr>
<th>Encounter</th>
<th>EAG Presented</th>
<th>EAG Viewed</th>
<th>% Viewed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Care</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visit 1</td>
<td>10</td>
<td>8</td>
<td>80.0</td>
</tr>
<tr>
<td>Visit 2</td>
<td>11</td>
<td>9</td>
<td>81.8</td>
</tr>
<tr>
<td>ER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visit 1</td>
<td>4</td>
<td>4</td>
<td>100.0</td>
</tr>
<tr>
<td>Visit 2</td>
<td>2</td>
<td>2</td>
<td>100.0</td>
</tr>
<tr>
<td>Urgent Care</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visit 1</td>
<td>3</td>
<td>2</td>
<td>66.7</td>
</tr>
<tr>
<td>Visit 2</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**Table 3:** Frequency of EAG being viewed by medical professional when presented
the EAG, which supports the utilization of a novel device by medical providers in various settings.

Technological options such as cellular phones, portable digital memory devices, and digital medical alert bracelets can be utilized to improve communication and facilitate access to health information. These new alternatives enable medical care providers to better access and transfer medical information, and to store it in an accessible, confidential, and practical place. Patients seem willing and ready to use communication technologies such as mobile phones and the internet. Mobile technology can provide personalized messaging and efficient data collection for health management and promotion. As hospitals acquire electronic health-record systems, wireless telephones and other technological devices will likely become an integral part of the architecture.

There are important limitations to discuss in this study. Though randomization was utilized, the difference in baseline population characteristics between the two groups meant that outcome data could not be meaningfully compared using quantitative analysis. A sample size of 30 participants does not fully represent the epilepsy population; a larger population would be required to fully represent the patient spectrum. The current EAG did not contain images of radiological or EEG data, although it could be included in the future. Another limitation was that the information collected from the questionnaires was dependent on participant answers, which could have influenced external validity. A different mobile device such as a digital medical alert bracelet might also be considered. This device allows medical providers access to essential information without requiring a password in emergency situations, and a secondary option that requires a password for more extensive medical information enabling the medical provider to implement less urgent medical intervention at the point of care.

Conclusion
Mobile technology is the future of transfer of patient medical information. This study demonstrated the utility of the EAG, a patient-carried, digital medical record available to medical providers in primary, emergency, and urgent care settings. Availability of patient medical information at the point of care allowed providers to appropriately manage patients, make educated decisions about care, and avoid duplicating tests. The present study shows promise for improvements in accessing and transferring medical information.

Disclosure: Funded in part by The Epilepsy Foundation of Greater Los Angeles.

References
VIRTUAL AVATARS, GAMING, AND SOCIAL MEDIA: DESIGNING A MOBILE HEALTH APP TO HELP CHILDREN CHOOSE HEALTHIER FOOD OPTIONS

Yulin Hswen MPH1, Vaidhy Murti2, Adenugbe A. Vormawor3, Robbie Bhattacharjee3, John A. Naslund MPH4

1Center on Media and Child Health, Boston Children’s Hospital, Boston, MA, USA; 2Department of Computer Science, Princeton University, Princeton, NJ, USA; 3Department of Computer Science, Dartmouth College, Hanover, NH, USA; 4The Dartmouth Institute for Health Policy and Clinical Practice, Lebanon, NH, USA

Corresponding Author: yulin.hswen@childrens.harvard.edu

Background: Rapid growth in Smartphone use among children affords potential opportunities to target health behaviors such as dietary habits; however, few mobile health applications are specifically designed with these individuals in mind. This brief report describes our step-by-step approach towards developing a mobile health application for targeting nutrition behaviors among children.

Methods: Descriptions of the 10 most popular paid and 10 most popular free Smartphone applications available on the Apple iTunes store for ages 4 and up as of March 2012 were qualitatively analyzed. The relevance of key characteristics found in these applications was then further explored for their potential to improve dietary behaviours amongst children, and a mobile application was developed.

Results: Three prominent characteristics of the most popular applications emerged: 1) virtual avatars or characters (observed in 50% of the applications); 2) gaming (observed in 75% of the applications); and 3) social media (observed in 45% of the applications). These features were then incorporated into the design of a mobile health application called Avafeed, which uses a virtual avatar and gaming to help make choosing healthier food options easier among children. The application was successfully released onto the Apple iTunes Store in September 2012.

Conclusions: In this unconventional approach, evidence-based research was combined with information procured from a qualitative review of popular applications available on the Apple iTunes Store in order to design a potentially relevant and popular mobile health application for use among children.
for targeting nutrition behaviors among children. The unprecedented growth in Smartphone use and availability yields exciting opportunities to support efforts to prevent and potentially reverse childhood obesity.

This is especially relevant as children represent one of the fastest growing segments of the population using these devices. By mid-2012, 58% of American teens owned Smartphones, up from 36% in 2011, and 12% higher than the national average. Over half (52%) of children ages 8 and under have access to Smartphones or similar mobile devices (e.g., iPod Touch, iPad, or tablet computers) in their homes, and 10% of 0- to 1-year-olds, 39% of 2- to 4-year-olds, and 52% of 5- to 8-year-olds use these devices.

The potential for Smartphone applications (apps) to improve children’s nutrition behaviors is promising, given existing evidence that mobile phone-based interventions can influence health-related behaviors. However, these emerging technologies are not without limitations. For example, several health apps evaluated in research are not always readily available to consumers, and few health apps are specifically designed to promote health behavior changes among children. An important challenge for health apps is their inability to sustain use over time, with consumer feedback citing that many health-related apps are cumbersome and uninteresting to use, all of which contributes to their dramatic underuse when compared to popular mainstream apps. These considerations are important when determining how best to utilize mobile health technologies towards addressing childhood obesity.

This brief report describes efforts to bridge the gap between the potential of health apps towards effectuating positive health behavior change and the serious impediments to their widespread adoptability and use. This work was guided by two objectives: 1) to determine what characteristics contribute to the success and widespread adoption of popular mainstream apps available on the Apple iTunes Store and to consider how these features can be applied to address health behaviors; and 2) to then incorporate these characteristics into the development and implementation of a novel health app designed to target nutrition behaviors among children.

Methods and Results

Objective 1: Reviewing Popular Smartphone Apps

To identify characteristics of popular Smartphone apps, Google was searched in March 2012 using the terms: “most popular smartphone apps”, “most downloaded apps” and “top apps”. This search generated reviewer sites, blogs and popular sources with testimonials, consumer ratings and rankings of popular paid apps (cost money to download) and popular free apps (free to download). The most popular apps were defined as having the most downloads. The search was limited to apps available only on iTunes for Apple’s iOS operating system (includes iPod, iPad, and iPhone devices).

From mobile app reviewer websites, the 10 most popular paid apps and 10 most popular free apps were selected. These rankings were considered accurate because Apple Inc. posted them onto their website and onto iTunes. The search was further refined by selecting only apps that were suitable for children, determined by an iTunes rating for ages 4 and up (contain no objectionable material). This age rating is set by iTunes, and ranges from 4 and up to 17 and up. Generic apps (such as Google Search or Google Maps) or apps considered unlikely to be used by children (such as The Weather Channel or shopping apps such as Groupon or Amazon) were also excluded. The top apps identified are presented in Table 1.

The descriptions of these popular apps posted on the Apple iTunes Store were reviewed to identify similarities in their content, design, and function. A qualitative analytic approach was adopted, where the descriptions of the popular apps were coded for common characteristics or themes. Two authors (Y.H. & J.A.N.) independently coded the descriptions for each app, and then compared their code lists. Similar codes were combined into common app characteristics, and any differences were discussed until consensus was met. This systematic process served to limit bias and assure that only characteristics of the apps that stood up to repeated scrutiny would be reported as relevant. This strategy has been applied in similarly designed research evaluating products from an online format.
Three characteristics of these popular apps emerged on repeated occasions: 1) virtual avatars or characters (observed in 50% of the applications); 2) gaming (observed in 75% of the applications); and 3) social media (observed in 45% of the applications) (see Table 1). The scientific literature was then searched pertaining to each characteristic to explore ways to integrate them into a mobile health app designed to promote positive nutrition behaviors among children.

1) Virtual Avatars or Characters

Virtual avatars or characters have been used in clinical research to stimulate behavior change in lifestyle habits such as physical activity and nutritional consumption.15–17 For example, children who received either positive or negative feedback from a mobile Tamagotchi-style virtual pet in response to photos of their breakfast were twice as likely to eat breakfast when compared to children without a pet, or to those with a pet that only gave positive feedback.18 In the game “Fish’n’Steps”, players’ daily step count was linked to the growth and activity of an animated virtual pet fish.19 Caring for this virtual pet fish raised participants’ motivation to increase their physical activity levels and attitudes towards participating in physical activity.19 These findings support the potential benefits of using virtual avatars or characters to promote positive health behavior change.

2) Gaming

Gaming is one of the most popular online activities for children, particularly among ages 6 to 11,20, and a systematic review of 34 studies supports its use as a potential strategy to combat childhood obesity.21 For example, trials have shown that when children play games targeting higher consumption of nutritious foods they consume significantly more servings of fruits and vegetables when compared to children who do not play these games,22,23 or children who visit standard knowledge-based or instructional websites.24–28 Pemprek and Cavert (2009) found that the use of rewards is an important

<table>
<thead>
<tr>
<th>Top iTunes Apps</th>
<th>Star Rating</th>
<th>Number of Ratings</th>
<th>Virtual Avatars/Characters</th>
<th>Social Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paid Apps</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Angry Birds</td>
<td>$0.99 4.5</td>
<td>818,589</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2. Fruit Ninja</td>
<td>$0.99 4.5</td>
<td>606,959</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3. Doodle Jump</td>
<td>$0.99 4.5</td>
<td>386,259</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4. Cut the Rope</td>
<td>$0.99 5</td>
<td>254,590</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>5. Angry Birds</td>
<td>$0.99 4.5</td>
<td>219,236</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Seasons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Words with Friends</td>
<td>$2.99 4.5</td>
<td>479,075</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>7. Tiny Wings</td>
<td>$0.99 4.5</td>
<td>203,008</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>8. Angry Birds Rio</td>
<td>$0.99 4.5</td>
<td>148,358</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>9. Camera+</td>
<td>$0.99 4</td>
<td>26,215</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>10. The Moron Test</td>
<td>$0.99 4</td>
<td>83,023</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Free Apps</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Facebook</td>
<td>– 4</td>
<td>1,968,469</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2. Words With Friends</td>
<td>Free</td>
<td>– 4</td>
<td>1,156,571</td>
<td>✓</td>
</tr>
<tr>
<td>3. Skype</td>
<td>– 3.5</td>
<td>349,074</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4. Angry Birds Free</td>
<td>– 4</td>
<td>367,414</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>5. Paper Toss</td>
<td>– 3.5</td>
<td>411,668</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>6. Twitter</td>
<td>– 3.5</td>
<td>187,108</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>7. Bump</td>
<td>– 3</td>
<td>321,294</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>8. Pac Man Lite</td>
<td>– 3</td>
<td>502,114</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>9. Unblock Me</td>
<td>– 3.5</td>
<td>292,220</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>10. Temple Run</td>
<td>– 4.5</td>
<td>1,553,028</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 1: Characteristics of the top paid and top free apps for ages 4 and up available on the Apple iTunes Store.
element of gaming that can modify preferences and behaviors among children, with games that award points for capturing nutritious snacks and deduct points for capturing less nutritious snacks emerging as most effective. These findings suggest that by providing nutritional information in a game-based format with a reward system, there is the potential to improve the food preferences among children.

3) Social Media

Social media is one of the most popular online activities among children, with upwards of 90% of US teens having used social networking sites, and over 50% using these sites daily. Despite limited data regarding Internet users under the age of 18, reports highlight that the median age of Facebook’s one billion users is 22 years, and over 30% of young Internet users (ages 18–24 years) use Twitter. Social media also penetrates groups regardless of education level, race/ethnicity or access to healthcare, and its use is highly correlated with Smartphone ownership. Further, 31% of online teens retrieve health, dieting or physical fitness information from the Internet, which can include social media sites and community forums. Social media not only forms a central part of the younger generation’s social environment, but also represents a unique avenue through which to distribute health-related content and potentially address nutrition behaviors among children.

Objective 2: Developing a Mobile Health App

The characteristics of virtual avatars or characters, gaming, and social media were combined into the development of an app with the potential to captivate young audiences and influence nutrition behaviors. Development took place from April to September 2012 in 5 steps: 1) Concept; 2) Design; 3) Content; 4) Computer Animation; and 5) Computer Coding. Across each step, the health app progressed from an idea and sketches on paper, to a functioning and downloadable app intended for children ages 4 to 10 and available for Apple devices on the iTunes Store.

The final product is called Aafadeed: a mobile health app with a virtual animal avatar that responds directly to users’ food choices to help make choosing healthier food options easier (see Figure 1). An important strength of using a virtual animal avatar is that it does not exclude anyone on the basis of race or ethnicity, and thereby appeals to a larger user-base. Users choose what Aafadeed eats, where healthier choices make the avatar lose weight and become more physically active, while unhealthier choices make the avatar gain weight and move more slowly. Through immediate feedback from the avatar, users are prompted to make healthier food choices and learn about what items are healthier than others.

Gaming was integrated into the app where users collect coins for making correct food choices, for

![Figure 1: Overview of the Aafadeed mobile health app interface](image-url)
which they can redeem virtual prizes. As users choose healthier foods, an algorithm in the computer code presents increasingly difficult choices over time. The correct choice is based on calorie content, allowing users to learn that some foods advertised as healthy, such as Goldfish Crackers\textsuperscript{36} or fruit juice\textsuperscript{37}, may actually be much unhealthier than other choices. The avatar’s reactions and animations in response to users’ food choices combined with rewards for correct choices are designed to make the app fun and engaging, and encourage sustained use.

To include social media functions within Avafeed, users are able to connect with others through the app interface and share their progress using popular social networking sites. Unlike many existing health apps, Avafeed does not require users to enter personally identifying information, which is important for young participants, as there are no risks to confidentiality. Implementation was the final step, with Avafeed’s successful release to the Apple iTunes Store in September 2012 (https://itunes.apple.com/app/avafeed/id556744693?mt=8). Presently, Avafeed is accessible to over 575 million iTunes users and is available to download free of charge in 155 countries. This method of implementation is low-cost and highly scalable, making it possible to reach large numbers of individuals quickly and effectively.

Discussion

This brief report presents a unique approach to mobile health app development for targeting childhood obesity. The process was rapid, progressing from research to implemented product in 7 months (March-September 2012), and involved identifying what the target population would be likely to adopt and use by way of their likes, then determining how to apply these characteristics to health promotion, and finally incorporating this research into the design and implementation of a mobile health app. This approach recognizes the needs and interests of the target population before determining its scientific justification, and parallels recent trends in technology development that focus on usability as opposed to operational reliability or efficiency.\textsuperscript{38}

Comparable methods have proven successful in business, where consumer feedback and perspectives oftentimes drive the development and popularity of a product, as opposed to its quality or utility.\textsuperscript{39}

With a multitude of health apps available on iTunes, Avafeed may have greater appeal among children by incorporating popular features such as virtual avatars, gaming, and direct links to social media outlets. The app is designed to make choosing healthier food options easier and can be accessed at any place or time throughout the day, potentially allowing small frequent bursts of nutritional information necessary to provoke subtle behavior changes that may lead to gradual long-term health benefits. For example, if using Avafeed could encourage an individual to make one healthier food choice each day, thereby cutting out 100 calories, it could translate to upwards of 10 pounds over an entire year. Evidence shows that even modest 3–5% reductions in body weight can dramatically reduce risks for obesity-related chronic health conditions\textsuperscript{40}, which is particularly important in the context of childhood obesity.

Given the exploratory nature of this project, there are limitations that warrant consideration. Firstly, we focused our review on popular apps available only on the Apple iTunes Store. Even though many popular apps are available across various Smartphone platforms, the characteristics of the most popular iTunes apps identified in this project may not be generalizable to these different platforms. Our team is currently planning the next steps towards developing Avafeed for the Android operating system, which will extend our app’s reach among Smartphone users. Additionally, while this project focused on the development of Avafeed, future efforts should be aimed at the evaluation and validation of this mobile health app. For example, the popularity of Avafeed could be assessed by examining user data, download reports, or consumer ratings posted to the Apple iTunes Store. Also, by observing a group of children using Avafeed and then conducting follow up interviews or focus groups, it may be possible to learn about their experiences using the app, gain insight into their patterns of use, and better understand what aspects of Avafeed worked well and what needs to be changed in order to improve the app’s overall appeal.

Further, a clinical trial involving a cohort of children instructed to use the Avafeed app for a period of time would be valuable towards determining whether this app that combines avatars, gaming and social media can successfully promote healthier food choices within this demographic. Such a trial could evaluate children’s perceptions about food choices and overall food consumption based on self-report or parent reporting before and after using the
Avafeed app, and then compare these findings to those from a cohort of children not using the Avafeed app. With an increasing number of children having pre-existing access to a range of Apple devices (i.e. iPhones, iPads or iPods), piloting the Avafeed app in this group could be accomplished on a modest budget.

Conclusion
With childhood obesity looming before public health officials and researchers alike, an immediate shift in practice and the adoption of novel consumer-first approaches in the planning and design of mobile health interventions, such as those presented in this report, may be necessary in tackling this immensely complex public health concern.

Disclosures: None for any author.

References


The use of tablet computers in surgery has been increasing due to a number of reasons, such as a highly portable build, useful clinical software and wireless connectivity. Tablet computers can be used in surgical consultations, operating theatres, post-operative care and surgical education. Current intra-operative uses are mainly in thoracic, orthopaedic and ophthalmic surgery where it was shown to improve surgical performance and safety. Tablet computers also play a key role in surgical consultation and telerounding via means of videoconferencing. This allows for better communication between doctors and patients and improves care delivery. Furthermore, telerounding can facilitate rapid post-operative review by surgeons, which can increase patient turnover, resulting in financial benefits for the hospital. In addition, virtual dissection software on tablet computers improves surgical anatomy teaching, reduces the need for cadavers and simplifies the process of dissection.

Tablet computers – otherwise commonly known as “tablets” – are devices that possess both the computing powers of an average computer and the portability of a mobile telephone. Measuring 7–10 inches in diagonal length, about 1 cm in thickness and around 600–700 grams in weight, most tablets can fit anywhere a paper notebook can. Common features of tablets include touch-enabled high-definition screens, quality cameras with video recording capabilities, long-lasting batteries (up to ten hours in some models) and wireless Internet connectivity. This combination of highly sought-after features have earned tablets a growing user base.

Tablets have also found their way into the medical field. Soon after the launch of the iPad (Apple Inc., Cupertino, USA), a number of major medical schools, including Stanford University and the University of California, began incorporating the iPad into their curriculum in an attempt to improve the performance of their students.\textsuperscript{1–3} This initiative has extended beyond medical schools – the University of Chicago integrated the iPad into their residency training program and found that the use of iPads was associated with improvements in both perceived and actual efficiency of their residents.\textsuperscript{4,5} The impact of tablets has been particularly prominent in surgery, with various applications in surgical consultations, operating theatres, ward activities and surgical education.

The nature of surgery requires a surgeon to be highly knowledgeable and thus it helps to have an easily-accessible source of information when required. A number of useful surgical texts are available as electronic books – colloquially known as “e-books” – which can be read on tablets. Examples include Zollinger’s \textit{Atlas of Surgical Operations} and \textit{Current Diagnosis and Treatment in Surgery}.\textsuperscript{6,7} There are also important online resources such as \textit{Therapeutic Guidelines} and \textit{UpToDate\textsuperscript{®}} from which a surgeon can conveniently obtain quality information,\textsuperscript{8,9} as well as print patient information handouts for patient education.
An important aspect of surgical consultations is the pre-operative assessment, where the patient’s current health is evaluated with the aim of minimising peri-operative risks. Tablets can run software such as PreOpEval (conceived from recommendations from the American College of Cardiology and American Heart Association), a program which provides an algorithm for pre-operative cardiac assessment, medications and investigations. In addition, there are also other software that can be used on tablets in the pre-operative phase to help determine the type and extent of surgery required, by referencing vast collections of medical scoring systems.

Videoconferencing via a tablet is a novel addition to surgical consultations – surgeons at different physical locations are able to communicate with one another by means of real-time video. The advantage of videoconferencing is that off-site surgeons are able to see patients and the surgical problems rather than relying only on verbal descriptions via telephone. This is particularly useful in orthopaedic surgery and trauma cases, for example, a team of surgeons in California utilised the videoconferencing feature on a tablet to discuss the details of a novel surgical approach pre- and intra-operatively in order to save a patient from a limb-threatening infection.

The effective intraoperative use of tablet computers requires their integration into the sterile operating field. As conventional sterilising methods may damage tablets, other techniques have been developed to maintain functionality and sterility of tablets within the operating field. The simplest of these were disposable sterile covers into which tablets were placed. A team of plastic surgeons in the United Kingdom developed a similar method, using large-sized Tegaderm dressings as sterile covers for iPads. Other methods are more complex and include surgeons controlling electronic devices and computers via motion-sensing devices such as the Microsoft Kinect.

Tablets have been used in various types of surgery. A team of Japanese thoracic surgeons have been performing lung segmentectomies with the assistance of a three-dimensional (3D) imaging navigation software on the iPad. They found that this enhanced their ability to identify important anatomical structures, thus improving the safety of the operation. Inclinometer software on tablets are also increasingly being used in orthopaedic surgeries, in particular aiding the insertion of orthopaedic prostheses. This was demonstrated through a study which investigated the use of software to accurately place acetabular cups in total hip arthroplasties, achieving minimal variance in peri-operative acetabular inclinations. Similarly, tablets have the potential to improve computer-assisted orthopaedic surgery (CAOS). Multiple studies have found that acetabular cup placements performed with the assistance of CAOS devices were more accurate compared to the conventional method of free-hand placement or placement with a cup positioner, with significantly less variability in the resulting abduction and anteversion angles of the hip.

Furthermore, small and inexpensive video microscope devices can be attached to cameras on tablets to facilitate their use as microscopes in low resource settings. Ophthalmic surgeons have also accurately measured the peri-operative eye alignment of patients undergoing lateral canthopexy using an augmented reality software available on tablets. Results indicating good inter-observer agreement as verified by manual measurements.

Tablets are also particularly useful in the ward setting. They are capable of providing access to medical records, investigation results and radiographic images at the bedside. Mount Sinai Hospital in Canada has developed VitalHub – a software that presents patients’ medical records, investigation results and nursing observations on tablets. The incorporation of tablets into daily ward activities has also been well-received by clinical staff. In a mixed-methods study, a system using smartphones, for communication enabled a more thorough transfer of information among healthcare staff as compared to the traditional paging system, thus improving the coordination of patient care.

Post-operative care can also be improved with the use of tablets. Many surgeons practice at multiple locations and the concept of telerounding was introduced to aid the provision of patient care. Telerounding enables a surgeon to conduct an interactive ward round without being physically present through the use of mobile remote videoconferencing equipment. Through telerounding, surgeons can visually examine their patients and make informed decisions regarding further management. In addition, surgeons can use other software to complement telerounding. SurgiChart is one such program, allowing surgeons to log their surgical case records, including operation notes, charts, images
and videos, into their tablets so that they have access to their patient’s case history whilst conducting rounds. An example of telerounding in use is at the Royal National Orthopaedic Hospital in London, which has produced its own software through which the patients can input their post-operative progress into tablets to allow their surgeon to track their progress remotely. Furthermore, a combination of regular bedside visits with telerounding has been shown to result in a reduced length of stay amongst patients undergoing laparoscopic gastric bypass at Sinai Hospital in the United States. This particular study demonstrated that the earlier discharge of patients resulted in significant financial gain to the hospital due to additional capacity created within the hospital. Studies suggest that telerounding is associated with similar morbidity rates, postoperative complications and length of stay, and increased patient satisfaction as compared to traditional bedside rounds.

Tablets also serve as highly useful adjuncts to surgical education. The availability of e-books has already been discussed. Internationally renowned journals and surgical associations, such as the European Journal of Cardiothoracic Surgery and the AO Foundation for orthopaedics and trauma science are producing their own tablet software to provide surgeons access to their vast online database of up-to-date journals and clinical practice. Clinicians are also able to upload endoscopic videos to an online database allowing for simultaneous viewing by surgical trainees. A recent innovation is the creation of a life size virtual dissection tablet with a touch-screen surface large enough to fit a human cadaver. Anatomy instructors at the Stanford University of Medicine have used this device to good effect – it has the advantage of reusability, which negates the need for a source of cadavers, and rapid dissection without the need for actual dissection devices. Although hardly a conventional tablet due to its size, further technological advances may incorporate more compact virtual dissection software into smaller tablets – a revolution in surgical education.

Conclusion
Tablets are remarkably versatile and useful devices with vast potential for applications in various aspects of surgery. The principal features of tablets – superior portability, technological strengths and wireless connectivity – open up new doors for advancement of new and existing surgical technologies. This may translate to better patient care, higher hospital income and enhanced surgical training. Further research and innovation is the key to unlocking new prospects for tablets in improving the field of surgery.

Competing interests
All authors have completed the Unified Competing Interest form at www.icmje.org/doi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous 3 years; no other relationships or activities that could appear to have influenced the submitted work.

References


The use of mobile phones to deliver health programs (mHealth) has great potential in developing countries, and mHealth initiatives such as the NightWatch malaria prevention program are becoming increasingly popular. However, even when an mHealth intervention is known to be effective, the structure of the telecommunications industry, combined with user behaviours, can make it extremely difficult to implement in some countries. This article describes the case of Cambodia, where more than 90% of the population have access to a mobile phone due to limited accessibility of landlines, but operational challenges plague even the simplest mobile interventions. The impact of this is already apparent with commercial mobile banking services. In Kenya the M-Pesa mobile banking system grew to around nine million users (21% of the population) within three years of launch. Despite Cambodians having a similar need for financial services, an equivalent mobile banking product (Wing) has only reached around 250,000 Cambodian users (2% of the population) in its first three years.

Four significant operational challenges facing mHealth programs in Cambodia have been identified through the author’s own experiences implementing mHealth initiatives with the Cambodian Health Education Media Service (CHEMS). These challenges are potentially relevant to other countries with similar telecommunication markets.

**Switching Subscriber Identification Module (SIM) cards**
Perhaps the greatest challenge facing mHealth interventions in Cambodia is that most Cambodians have multiple Subscriber Identity Module (SIM) cards - and thus multiple phone numbers - which they change regularly. This practice is not limited to low-income groups. It is also common among wealthier Nongovernmental Organisation (NGO) workers and government staff.

There are several factors that promote this practice among users. The first is that, as of 2011, the Ministry of Posts and Telecommunications recognised eight different mobile networks within the country (some have since merged). It can be significantly cheaper to call within a network than between networks, so people keep different SIM cards for each network in order to save call costs. The introduction of phones such as the Nokia Dual SIM which are capable of taking two SIM cards at once may help with this, although many Cambodians have three or more SIM cards.

Fierce competition between the Cambodian mobile networks also promotes SIM card switching. Some companies offer free air time with their new SIM cards in an effort to get people to switch. This can make it cheaper to buy a new SIM card than to purchase credit for an existing SIM card. In addition, some Cambodian users have developed a preference for keeping different phone numbers for different personal relationships – particularly when they want to keep those relationships separate. For example, they may have different phone numbers for their various girlfriends or boyfriends, or a separate phone number for sensitive work contacts. If the relationship sours then the SIM card is discarded so the person can no longer contact them.

In practice this constant switching of SIM cards can cause havoc even in basic mHealth interventions, such as sending Short Message Service (SMS)
reminders. It is common for at least 20% of all phone numbers to be invalid immediately after collection, as people often provide one of their less used mobile phone numbers when asked. It is also common for a substantial proportion of the phone numbers to become invalid each month, as people switch SIM cards and discard their old numbers. This means that 6-12 months after the phone numbers have been collected the majority are invalid and need to be collected again. For example, in one mobile phone based survey that CHEMS conducted more than 50% of the numbers were invalid only 3–4 months after they were collected. Keeping the numbers up-to-date is difficult and time consuming, which ultimately reduces the cost effectiveness of mHealth interventions.

One possible solution is to provide incentives for people to keep the same SIM card and phone number. Participants could be periodically entered into a lucky prize draw, but will only be notified about the result by phone. However, the value of the future prize needs to be large enough to outweigh the immediate financial benefits of switching SIMs. Typical prizes such as digital cameras or gift vouchers have not been successful in getting participants to keep the same SIM card for CHEMS programs, although larger or more frequent prizes may give different results. Another option is to provide participants with free SIM cards that have subsidised call rates to all networks. This would make it financially beneficial for users to keep the same SIM card, but is likely to be cost-prohibitive for large scale programs.

**Lack of functionality and Khmer language capability**

Another significant challenge to implementing mHealth programs in Cambodia is that most mobile phones are not smart phones. Although the availability of accurate statistics is limited, experience from CHEMS programs suggests that the majority of Cambodians are using basic handsets with limited functionality. For most Cambodian households the cost of even a basic handset is substantial relative to their income. This means that mHealth systems for use by the general population are limited to SMS and voice messaging, as most people do not have a smart phone and so are not able to install applications on their device.

The majority of mobile phones also do not support Khmer (the national language). Khmer is written in an Indian-derived script and the Cambodians successfully resisted an attempt by French colonizers in the 1940s to Romanise the alphabet. As Khmer is only spoken by around 15 million people, it is a low priority for handset and operating system providers compared to languages such as Thai, Chinese or Hindi. Although there are a small number of Nokia handsets that support a Khmer user interface, uptake has been slow. Even when they are available users often find the process of sending an SMS in Khmer time consuming and difficult. Similar challenges may be faced in other countries that have a unique alphabet, such as Ethiopia.

Since most mobile phones do not support Khmer language, SMS messages for mHealth programs need to be sent in English, which is not understood by the majority of the population. There are several ways to address this, although none are ideal. One alternative is to send picture messages rather than text SMS, although many phones are also unable to receive picture messages.

Another option is to use audio messages. The user receives a call and when they answer a pre-recorded message is played in Khmer, with responses being given using numbered options or a voice recognition system. While this solves the language problem, it also dramatically increases the cost of the message. Sending one SMS costs around two cents, while sending a one voice message costs around 15 cents. Some mobile networks also send an English SMS first informing the recipient they have a voicemail and asking them to call a number in order to hear the message. If the recipient cannot read the instructions for accessing the voicemail they will not be able to listen to the Khmer voice message.

Although organizations such as Innovative Support to Emergencies Diseases and Disasters (InSTEDD) have created successful voice response systems in Khmer to circumvent the language barrier, the inability to use text SMS continues to be a major limitation. Young Cambodians are already finding their own ways around this problem by writing SMSs using unofficial Romanised Khmer. A recently launched SMS dating service called Chibi has been very successful, with the majority of messages being written in a hybrid of English and Romanised Khmer. The creator of Chibi has developed a system that is able to interpret this hybrid language. However, since the majority of users are young Cambodians who have greater exposure to
English at school this is unlikely to be a workable solution for older users.

Sharing mobiles
Although more than 90% of Cambodians have access to a mobile phone, a USAID assessment estimated that only around half actually own a mobile phone. This means that a large proportion of the population share a mobile with other people, often their family members. In one program for HIV positive rural women conducted by CHEMS and Cambodia HIV/AIDS Education & Care (CHEC), around 30% of the women could not be reached on the mobile number they provided, often because their husbands or another family member had the phone. This can make it particularly difficult to deliver mHealth interventions on sensitive topics, such as gender based violence or HIV. Even on less sensitive topics, such as maternal and child health, it can mean that the intended recipient of the message never receives it.

One option is to provide participants with a mobile phone and SIM card, although this is prohibitively expensive for large scale programs. Oxfam and their local partner Women for Prosperity took this approach with their Pink Phones program. They spent around $750 United States Dollars to purchase 30 mobile phones for women leaders in rural areas. The women leaders used the phones to help other women, for example by getting market updates, calling the police to respond to domestic violence cases or accessing health information. At $25 per phone plus the cost of a SIM card and credit, scaling up this intervention would require a very large budget.

Competition with commercial spam
Cambodia enforces very few regulations regarding consumer privacy and spam for the telecommunications industry. Mobile networks regularly send unsolicited mass SMS and voice messages promoting their own products, and as advertisements for other companies. In most cases it is not possible to unsubscribe from these messages. This makes users more likely to ignore an SMS or to hang up immediately on a recorded voice message, regardless of the topic or sender. Since mobile networks are able to make substantial revenue through these messages they are less interested in sending messages for targeted mHealth programs that may have lower volumes and budgets compared to advertising campaigns by private companies.

Some mobile networks are willing to support mHealth programs as part of their corporate social responsibility program. For example, Smart mobile has partnered with InSTEDD (Innovative Support to Emergencies Diseases and Disasters) to implement mHealth systems for the Ministry of Health. However, the proliferation of NGOs and health programs in Cambodia means that it is not possible for mobile networks to support all of them.

Conclusion
Organizations implementing mHealth programs in Cambodia face a range of operational challenges that can make even the simplest interventions unworkable. The potential solutions are expensive and may offset any cost-effectiveness gains. As a result, Cambodia could be left behind in the mHealth revolution.

Of course, Cambodia is not the only country facing challenges in mHealth implementation. The need to address socio-cultural, informational, economic and individual vulnerabilities in mHealth programs has also been identified with HIV/AIDS SMS campaigns in Uganda. Network coverage continues to be a issue even in developed countries, such as in rural Australia, and the sharing of mobile phones and language barriers have both been raised as concerns in South African HIV/AIDS mHealth programs.

It is possible that over time the challenges in Cambodia will disappear as market competition is reduced through mergers and acquisitions. A younger generation of Cambodians will grow up using Romanised Khmer, and Khmer language phones may become more widely available. Cambodians may also eventually find that keeping the same phone number is more useful than getting the cheapest possible calls. Ministry of Health support for mHealth programs such as the Day 3 malaria alert system created by Malaria Consortium, may also provide the impetus for change. However, these changes are likely to take many years. In the meantime donors, NGOs and government need to have a clear understanding of how these operational challenges will be addressed before implementing new mHealth initiatives in Cambodia.

References


PRELIMINARY STUDY ON USE OF MOBILE PHONE BY INTERNS TO ANSWER PAGER MESSAGES

Dhara N. Perera

Dr. MBBS, Bsc. (Hons), House Medical Officer – Eastern Health, Victoria; James Cook University, Queensland, Australia
Corresponding Author: dharanalika@gmail.com

Background: Improved communications within the healthcare sector is imperative to enabling increased clinical efficiency and enhanced quality of patient care. Mobile phone use has been demonstrated to enhance clinical practice by improving communication between physicians, junior medical staff and other healthcare members.

Aims: This study aims to assess use of personal mobile phones to answer pager messages (use versus non-use) among Intern medical officers.

Methods: A literature search was performed. A survey instrument was designed to identify intern medical officers who used their mobile phones to answer pager messages and those who did not. 12 intern medical officers were surveyed. Verbal consent was obtained. Following completion of the instrument, when necessary, participants were asked to clarify their comments.

Results: Among the 12 intern medical officers, 8 intern medical officers (67%) used their personal mobile phone to answer pager messages. Main reasons highlighted were convenience, hospital phone accessibility and time-saving. Reasons for non-use by 33% participants were to keep work and private calls separate and not wishing to pay for work-related calls.

Conclusions: Those junior medical officers who answered pager messages using their mobile phone found it beneficial due to increased productivity. Those who did not chose to do so due to privacy and cost. Further validation with larger scale randomized control studies in this field are required.

Introduction
Mobile technology is a rapidly advancing field with widespread uses demonstrated in the healthcare network, particularly in relation to improving communications within the hospital system. Efficient and timely communications within the hospital is imperative to enable delivery of timely services and quality care to patients. This is dependent on a constant stream of communication between all levels of staff including medical, nursing and allied health staff on a daily basis. Whilst mobile technology continues to advance, there is limited evidence demonstrating improvements in communications within hospitals and in clinical outcomes.

The benefits described in the literature include perceived faster communication amongst clinicians, more efficacious time usage, reduction in response time and response errors, improved quality and efficiency of communication between physicians.
The effects of poor communication systems and patterns of communication behaviours within different hospital sectors (e.g. in general medical wards and emergency departments) have been investigated locally and globally in several quantitative studies\(^1\,\,2\,\,4\,\,8^\). The researchers have mainly adopted observational methods, mixed-method studies involving surveys, monitoring activities and interview based methodologies, collectively highlighting problems such as communication interruptions affecting (doctors and nurses equally) and consequentially resulting in communication errors translating into adverse clinical outcomes. Hence these studies demonstrate the adverse impact that ineffective clinical communications can have on delivery of quality care by causing preventable errors\(^3\). The studies performed are small-scale level involving students, doctors and nursing staff.

Several studies highlight the lack of efficiency in current pager messaging systems, which are still the main mode of communication within most hospital networks\(^1\,\,2\,\,8^\). The lack of efficiency in the paging systems has seemingly led to an increased trend towards adopting Smartphone use, Webpaging to Smartphones, and messaging via email\(^2\,\,4\,\,7\,\,8^\). Quantitative studies have shown improved perceptions of communication and some improvement in communication metrics, whilst the qualitative studies demonstrated improvements in efficiency of communications. However, despite the increasing number of studies, there is a paucity of high quality quantitative studies identified\(^2\,\,8^\). In a clinical study, Ramesh et al. demonstrated that among 116 medical students, junior medical officers and Consultants, 67% used their phones for work related calls and 47% whilst attending patients\(^6\). Haroon et al. validated these findings by demonstrating a 98.3% rate of mobile phone use among doctors for work purposes\(^4\). Another benefit found was quicker contact of medical staff by hospital telephone operators and perceived efficiency in communication by doctors themselves\(^6\). Additionally, a significant reduction in the number of fixed-line calls received in hospital wards, reduced response time and response errors with Smartphone use compared with pagers and were strongly preferred over pagers by junior medical officers due to and improvements in perceived quality and efficiency of communication\(^1\).

The potential disadvantages highlighted were a lack of reliability, potential breach in confidentiality, contamination of mobile phone devices and potential electromagnetic interference (EMI) in with other electromagnetic devices (e.g. automated external defibrillators and electrocardiogram machines\(^9\,\,13^\). Therefore in the hospital setting one needs to maximise the benefits while taking necessary steps to avoid collateral damage.

As a medical intern a significant proportion of time is spent answering, sending and receiving numerous pager calls on a daily basis, of varying urgency. In the traditional hospital systems, junior doctors are paged and expected to answer using the hospital telephones available. An important limitation preventing answering pager messages promptly is a lack of easily accessible/available hospital phones. Hence both junior and senior medical officers of various disciplines are known to use their personal mobile phones for work related calls to facilitate time effective communication within the hospital system. This action helps reduce time-wasted waiting/searching for hospital phones, alleviates stress and provides an easier mode of communication.

In view of a paucity of information in relation to junior medical staff using their personal mobile phones to answer pager messages, a small-scale preliminary study was performed on a small cohort of intern medical officers working at a regional level hospital in Victoria.

**Methods**

A PUBMED search was performed which revealed 155 articles. The search results were screened for articles relevant to the current study, which revealed 13 studies on the use of mobile phones in hospitals by medical staff. Keywords used were mobile phones in hospitals, Smartphones, Pager, mobile phone, intern medical officer and efficiency.

A small-scale descriptive study was performed on a group of intern medical officers in order to determine current mobile phone practices to answer pager messages and identification of factors for non-use at Ballarat Health Services (BHS). The survey instrument used is given in the Appendix. The survey was administered to a group of 12 out of the 28 intern medical officers who were chosen based on their availability and accessibility. Survey was explained and verbal consent obtained. Participants were requested to score each item form 0-10 on a linear scale where 0 was not at all a reason and 10 being very important A post-survey interview was conducted primarily to clarify some of the
information provided. All of the doctors who were requested to fill the form agreed to participate. The survey instrument was designed following discussion with colleagues and an assumption was made of its face validity.

Results
With the exception of one doctor the other 11 used the mobile phone on a regular basis. Eight doctors (67%) used their personal mobile phone in the hospital to answer their pager.

Table 1 summarises the advantages as noted by those who used their phones. There were two important reasons demonstrated i.e. time-saving and accessibility of a phone.

Figure 1 illustrates the individual response scores for the above, combining time-saving and convenience as one unit and availability and accessibility of phones as one unit. For the sake of clarity when a 0 was scored for any item we assigned a score of 1.

Those who did not use a mobile phone to answer their pager, felt that they should not have to pay for work related calls and preferred to keep their private phones for personal use only (see Table 2).

On interview of participants among the comments revealed issues related to mobility, and the benefit noted was that they could attend to other tasks and move around the ward whilst answering a pager message.

The primary reasons identified for regular use of their mobile phone were convenience, time-saving, not having to wait for phones to become available/search for a phone on the ward, easier mode of communication with senior staff (e.g. Registrar) and facilitates mobility between wards, operating theatres and within the ward e.g. to bedside of patient whilst speaking to senior if required.

The four individuals who did not use their personal mobile phones to answer pager calls stated that they wish to keep their private phones separate from work related activity and felt that they should not

<table>
<thead>
<tr>
<th>Factors for mobile phone usage</th>
<th>Average score for each item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convenience</td>
<td>9</td>
</tr>
<tr>
<td>Time-saving</td>
<td>9</td>
</tr>
<tr>
<td>Reduction in stress levels</td>
<td>6</td>
</tr>
<tr>
<td>Availability of phones</td>
<td>9</td>
</tr>
<tr>
<td>Accessibility of a phone</td>
<td>9</td>
</tr>
<tr>
<td>Facilitates communication</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 1: Rationale for regular use of mobile phones
be paying out of their pocket for official duties. One individual also commented that it was a matter of principle.

Discussion
Taking advantage of mobile phones to improve communications has been widely demonstrated in both quantitative and qualitative studies to increase efficiency, reduce clinical errors and adverse effects, improve quality of patient care, enhance communication between physicians and ability to deal with a myriad tasks simultaneously, particularly at a junior level\(^2\). The present small-scale quantitative study was performed in order to ascertain the feasibility of a larger scale evaluation in a similar setting. The study sample was limited by time and resources constraints faced by the author.

The benefits demonstrated in the present study were similar to the findings in the study by Haroon et al. where all but one of the 60 doctors in the study reported using their mobile phone to answer pager messages, and for private for communication and paid privately\(^3\). Similarly, in the present study it was demonstrated that the majority of junior doctors used their personal mobile phones for work related calls as they found it beneficial. The main reasons were convenience, easy accessibility and availability of their phone and the reduced wastage of time (Figure 1). However, there is a dependency on adequate network coverage within the hospital premises to successfully utilise ones mobile phone which maybe variable. This is particularly associated with some phone carriers especially in rural or remote areas. Those who did not use their phones indicated that it was due to wanting to separate official and personal communications and also not wanting to pay for hospital related calls.

In view of the challenges associated with communication systems within hospitals, multiple alternative interventions have been explored by various research groups. Whilst some of the challenges have been overcome by introduction of Smartphones in certain hospitals e.g. in Canada, no clear resolution has been reached. Other traditional hospitals continue to use the traditional pager messaging system for communication. Some of the unintended issues found with Smartphone use was an increase in communication interruptions.\(^3,12\) Lo et al. aptly described disadvantages of pager systems - a lack of information causing frustration for the receiver with provision of only a call back numbers and little

<table>
<thead>
<tr>
<th>Factors for not using mobile phones</th>
<th>Average score for each item</th>
<th>maximum score = 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of mobile phone</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Payment for work related calls</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Private vs. official phone use</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>On principle</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Reasons for not using mobile phones

![Figure 2: Individual responses for each reason among those who did not use their phone to answer the pager](image-url)
or no context to the message leading to difficulty in prioritization as well as causing interruption to patient care and workflow\(^2\). This can be a significant deterrent to clinical outcomes.

Whilst individuals are applauded for their principles in not using their personal phones for hospital work, the advantages of using a mobile phone seem to outweigh the disadvantages or perceived losses. Those who mentioned cost as a reason for not using their mobile phone need to take into account that work related calls are tax deductible. Additionally the time saving factor would most likely increase productivity thus making work more rewarding.

In a much larger study by Wu et al. (2011), where Smartphones were supplied and used for communication between staff, the benefits were replicated, although a drawback identified was significant increase in interruptions to work due to the messages themselves\(^1\). Other negatives were variability in urgency, lack of reliability and unprofessional conduct in terms of lack of confidentiality whilst using this mode of communication\(^{12,13}\). However, this situation had arisen in the context of an attempt to replace the paging system with use of smart phones.

Use of the mobile phone is likely to increase productivity and reduce time wasted on waiting around for a land phone to answer pagers. Furthermore if the individual who sent the page is not immediately available, having the mobile phone will allow the intern to attend to the numerous other duties, instead of waiting by the land phone awaiting the return call.

In view of the potential for increased workplace productivity, provision of mobile phones to intern medical officers may be a cost-effective measure. When pager calls are answered promptly and dealt with, this becomes more cost-effective for the medical workforce by enabling ward-based work to occur within the rostered hours. Hence less overtime claims. If there are concerns regarding potential misuse of the facility, calling limitations could be placed (call barring).

It maybe postulated that provision of a work mobile phone would also reduce the workload on the busy hospital telephone operators in cases where an extension number is not provided.

Overall this study has helped to elucidate some of the factors that make communication via mobile phones favourable among clinicians and medical officers. Although a small-scale study it significantly contributes to the existing pool of evidence that highlight the advantages associated with Smartphone/ mobile phone usage in the clinical setting. Some of the limitations identified in this study are selection bias associated with administering of survey to colleagues who were readily accessible and the small sample size.

Concluding remarks

The findings of the current study supports the literature suggesting enhanced inter-professional communications with mobile phone usage within the hospital network. The primary reasons promoting regular mobile phone use identified were time-saving in the context of having to multi-task and reduce time-wasted searching for a landline or waiting for a phone to become available and convenience among the junior medical staff.

Time wasted on waiting for hospital phones would then be reflected in an increased number of overtime hours claimed, which translates as an extra cost incurred by the hospital healthcare sector.

Finally, in order for formal implementation of improved communication methods within the hospitals globally, further high quality large-scale studies and randomized control trials on use of mobile phones to answer pager messages need to be conducted. Additionally in order to ascertain the value of providing intern medical officers with mobile telephones, the attitudes of the health care practitioners and allied health members need to be further examined as well as the impact on delivery of quality clinical care. Potential benefits and problems need to be further evaluated to clearly identify whether the benefits outweigh the harm.

References


The use of personal mobile phone to answer the pager

As an intern I found that using my mobile to answer the pager was very helpful. There were others who felt they should not.

At the end of the intern year I thought of asking around regarding the matter.

Do you use a mobile phone on a regular basis Yes/No

Do you use your mobile phone in the Hospital to answer your pager Yes/No

Please answer the following if you use the phone to answer the pager
giving a score of 0 if not a reason at all and 10 being extremely important

Convenience ............................................................................................................................

Time saving ............................................................................................................................

Causes me less stress .............................................................................................................

I do not have to wait for a phone to become available ....................................................

I do not have to go looking for a phone .............................................................................

I can speak with the person who paged me directly ....................................................

Any comments /other benefits ..........................................................................................
Please answer the following if you do not use the phone to answer the pager
giving a score of 0 if not a reason at all and 10 being extremely important

I might lose the phone .............................................................................................................

I should not be paying for Hospital related calls ............................................................

I like to keep my private phone separate from work ..........................................................

On principle ....................................................................................................................

Any other disadvantages ..................................................................................................

........................................................................................................................................

Any further comments

Optional: Your Name/email