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The Trustworthiness of Mobile Health Applications for Emergency Medicine

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Abstract: The use of mobile medical applications has increased over the past few years. Limited knowledge is available about the types of emergency medical applications currently in use and authenticity of information enclosed within each emergency medicine mobile health applications. The purpose of this study was to examine the trustworthiness of mobile medical health applications used in the emergency medicine. To evaluate the trustworthiness of the information within the mobile medical emergency applications, the “Health On the Net” (HON) survey was applied to measure which of the mobile apps met the HON code certification guidelines for providing trustworthy information. A mobile application was included in the study based on the following criteria: the mobile app was written in English, it was related to emergency bedside care, had more than 1000 downloads, a minimum review rating of 3.5 stars or more and was found on both the GooglePlay and iTunes. The total number of applications discussed and reviewed by the websites and literature searched was totaled 42 unique mobile health applications for emergency medicine. Upon reviewing the 42 applications, 18 relevant emergency medicine mobile health applications were included for further study. The results found in this study provided reassurance that certain mobile applications for emergency medicine are safe to be used. The mobile applications should be recommended by hospital administrations and insurance companies to help in decision-making and they can be listed for use by residents in the residency training. The culture of verifying the authenticity and trustworthiness of the information found in mobile applications should be incorporated in training and faculty development programs in the Emergency medicine.

Keywords: Health Applications, Emergency Medicine, Trustworthiness, Mobile, Authenticity.

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1. INTRODUCTION

The Emergency department is a chaotic environment that has been challenged by high patient volumes leading to overcrowding, reimbursement issues, shortage of staff, a poor public image, and workflow issues impacting the quality of emergency healthcare services delivered [1]. A variety of interventions have been implemented to help improve the quality of care delivered in the Emergency department. Some of these interventions have included treating patients by general practitioners, diverting patients to other hospitals, providing clinical and non-clinical staff training, and developing ambulatory care pathways [2]. Other, and more novel, interventions to manage the workflow of the emergency department have included the use of technologies such as queuing theory [3], mobile devices [4], electronic health records [5], and telemedicine [6], with mobile devices being the least studied.

At present, there are over 100,000 medical mobile health apps on both the android and iPhone market combined [7]. A number of studies on mobile health have been conducted in a variety of health care environments relating to healthy lifestyles, finding a healthcare professional, diagnosis, education, filling a prescription, mental health, oncology, women's health, and child health [8]. Limited knowledge is available regarding the number of mobile health (mHealth) applications and the type of information they contain to support clinical decision-making in the emergency department.

A number of studies have been conducted on the use of mobile health applications in the emergency department. Yamada, Watarai, and Sakai, conducted a study on the transfer of radiology images (e.g., MRIs, CT Scans) in the emergency department by clinicians using a mobile telephone. The findings of this study demonstrated that there were benefits of transferring radiology images that helped in early treatment and diagnosis by the Emergency department physicians. The study found that the image quality was sufficient for Emergency department physicians to interpret; the mobile health app was easy to use; and the quality of MRIs displayed through the mobile health app were better than CT scans. The authors concluded that mobile health application assisted in early diagnosis and initiation of treatment in emergent cases. The authors also noted the advantages of transferring images between remote and rural locations between hospitals [9].

Park et al. reported the use of mobile health apps to encourage mobile consultation for coronary computer tomography angiography (CCTA) in the Emergency department for patients with acute chest pain. The study included a total of 107 patients with acute pain who underwent CCTA and a coronary angiography (CAG) was included in the study. The images were reviewed by on-call physicians working for the Emergency department using a mobile

health application. The study results showed that in-house physician's diagnostic performance using the mobile health application was higher than in-house physicians working in the hospital [10].

Pathipati et al, studied visual acuity as measured with a mobile health application in the emergency department. The authors assessed the accuracy of the best-corrected visual acuity (BCVA) as measured by non-ophthalmology specialists working in the emergency department. The study included 128 patients whom requested an ophthalmology consultation. The study reports that non-ophthalmic emergency department clinicians using the mobile health app were more accurate in their diagnosis than physicians using the traditional Snellen chart. The authors conclude that mobile health apps may help improve emergency department ophthalmologic care [11].

A pilot study conducted by Schragger et al. assessed the influence of a mobile health app and smart watch technology on the improvement and monitoring of medical resident's exercise [12]. The objective of the study was to measure the effectiveness of a wearable mobile health device to track their physical activity and measuring their adoption and continued use of the mhealth device. The use of mobile device tracker increased the physical activities of emergency medicine residents that were least active prior to the study being conducted. The authors also reported little difference and already physically active emergency residents.

There are only limited research studies available examining the impact of mobile health devices in the emergency medicine. With the growth of mobile medical apps, and especially, mobile medical apps in emergency medicine, little is known about the types of different emergency medical apps that exist, the type of information they hold, and the credibility of the information included in them. The purpose of this study is to examine the trustworthiness of information included in mobile health apps commercialized for emergency physicians. Examining the trustworthiness of information included in emergency medical mobile apps can help emergency physician's select mobile apps that can help support medical care and improve the quality of services provided in the emergency department.

2. METHODS

On January 10, 2016 a search of the medical literature and the world-wide-web on information related to the use of mobile applications in emergency medicine was conducted. A search of the medical literature through PubMed using the following key terms: "Emergency medicine" and "Mobile applications" was performed. Articles written in

English, conducted after the year 2014, related to mobile health, and mainly focusing on bedside emergency care were included. Articles excluded from the study were studies written in a language other than English, not related to bedside emergency care or mobile health, and were before 2014.

A Google web-based search using the terms “emergency medicine”, “mobile applications” and “top” was conducted. The word “Top” was used to help identify the most widely commercialized and highly regarded emergency medicine mobile health applications. The selected websites and blogs that reviewed and ranked emergency medicine mobile health apps were included. Websites and blogs that did not explore the use of mobile health applications in the emergency medicine were excluded. Finally, the information from both the PubMed and Google searches on emergency medicine applications was reviewed. A list of emergency mobile health applications based on the retrieved literature and websites was created through Microsoft Excel. A mobile application was included in the study based on the following criteria: the mobile app was written in English, it was related to emergency bedside care, had more than 1000 downloads, a minimum review rating of 3.5 stars or more, and was found on both the GooglePlay and iTunes.

To evaluate the trustworthiness of the information within the mobile application, the Health On the Net (HON) code of conduct survey was applied to measure which of the mobile apps met the HON code certification guidelines of providing trustworthy information [13]. The HON code survey is based on eight criteria to evaluate the trustworthiness of health information found on the Internet. The criteria are used to evaluate the trustworthiness of online health information by asking questions related to: authoritativeness, complementarity, privacy, attribution, justifiability, transparency, financial disclosure, and advertising policy. Each of the mobile applications included in the study using the eight criteria of the HON code survey was evaluated. As a reliability check, a second researcher reviewed a sample of reviewed emergency mobile apps completed by the primary researcher. Any discrepancies between the two researchers were resolved by consensus.

3. RESULTS

The PubMed search results yielded a total of 121 articles of which one research article met the inclusion criteria. The Google web-based search revealed over 10 million websites of which the first 200 relevant results were reviewed for possible inclusion in the study. After further review of the contents of the websites and blogs, only 7 websites met the inclusion criteria. The total number of applications discussed and reviewed by the websites totaled 42

unique mobile health applications for emergency medicine. Upon reviewing the 42 applications retrieved from both the PubMed and Google web search, eighteen relevant emergency medicine mobile health applications were included for further study. The inclusion/exclusion of the mobile health emergency apps are illustrated in Figure 1 along with the reason for exclusion for each application.

In Table 1, the emergency medicine mobile health applications are categorized into six categories: Medical Calculators, Emergency Medicine References, Drug References, Eye Manuals, and Cardio Pulmonary Resuscitation (CPR) aid applications. The table shows the mobile health metrics (e.g., number of downloads and review ratings) while, the results of applying the HONcode survey on each emergency medicine mobile health application is shown in Table 2.

3.1 Medical Calculators

There were a total of two medical calculators included in the study, which were, MedCalc and MediQuation. Both of the mobile health applications were medical calculators that are used for emergency medicine clinicians. The Mobile health Application MedCalc is a free application with more than 100,000 downloads and with a consumer review score of 4 out of 5. MedCalc has been reviewed by more than 2000 people and was recently updated in April 2016. Although MediQuation medical calculator has a slightly higher review score of 4.4 out of 5, it has been downloaded and reviewed less frequently, costs 5 USD, and has not been updated since 2013.

As for trustworthiness of the information according to the HONcode principles, MedCalc is the only application that was found to fulfill all the requirements of the HONcode. The developer's website also carried the HONcode certification seal. For the MediQuation Medical Calculator, it lacked clear policies regarding privacy and advertisement and no financial disclosures for the app were made. More importantly, it was not clear who was the author or editor responsible for the medical information.

3.2 Emergency Medicine References

A total of mobile health applications were general bedside references for emergency medicine. There was a variety in the cost structure for the mobile health applications in this category. Five of the applications were free to download, however, they needed either a paid subscription (UpToDate), an in-app purchase to enhance the free content (WikiEM, AgileMD, and 5–Minute Emergency Medicine consult) or a fixed payment to get upgraded

content of information (Epocrates). The other three applications were paid applications: the Atlas of Emergency Medicine Flash cards (49USD), ERres (10USD) and PalmEM: Emergency Medicine (6USD). The most downloaded applications with most reviews were Epocrates followed by UpToDate and WikiEM. All the applications went through recent updates in 2016 except the three applications, 5–Minute Emergency Medicine consult, PalmEM: Emergency Medicine and ERres. The highest review score was 5 out of 5 for the Atlas of Emergency Medicine Flash cards, however, it was based on one sole reviewer. Therefore, the highest review scores were Uptodate (4.6 out of five), WikiEM (4.5 out of five) and AgileMD (4.5 out of five), if you take into account there were many reviewers of the application.

As for trustworthiness of the information according to the HONcode principles, six of the emergency mobile applications (UpToDate, WikiEM, AgileMD, Epocrates and 5–Minute Emergency Medicine consult) were found to fulfill all the requirements of the HONcode certificate except for one principle, the advertisement statement. The two remaining applications, ERres and PalmEM: Emergency Medicine had not met several HONcode principles. ERres did not have a statement regarding its complimentary nature to the practice of medicine, a privacy statement, and an advertisement policy statement. PalmEM: Emergency Medicine suffered lack of any policies or statements. It did not indicate the authors or editors of the content. PalmEM: Emergency didn't give a clear indication of the source of information or described whether the information was supplementary to good clinical judgment. The developer's website was simply an advertisement for the application.

3.3 Drug References

The two drug references that were included are Micromedex drug information and EMRA Antibiotics guide. They are different in their goal and contents. As the former is a general reference for drug effects while the other is a guide to select antibiotics for different emergency conditions. The Micromedex Drug information is a free application with more than 100,000 downloads and a review score of 4.1 out of 5. It has been extensively reviewed by more than 1,100 people and has been updated in September 2015. The EMRA Antibiotics guide has a slightly higher review score of 4.2 out of 5, it has been downloaded and reviewed less frequently, and cost incurred was 17 USD. However, these statistics are for the EMRA Antibiotics guide 2017 edition.

As for the trustworthiness of the information according to the HONcode principles, both applications were found to fulfill most of the requirements of the HONcode certificate as

trustworthy information. However, financial disclosure of the EMRA Antibiotics guide could not be found. Likewise, a statement regarding the advertisement policy in Micromedex applications was not found.

3.4 Manuals for Eye Problems

Two Manuals for eye problems were included in the study including eye emergency manual and eye handbook. The Mobile Application Eye emergency Manual is a free application with more than 10,000 downloads and a review score of 4.4 out of 5, based on the reviews of 100 users. In contrast, Eye handbook is free to download but has some in-App purchase options. Eye handbook has been downloaded more often, over 5,000 downloads, and reviewed by more than 688 people with a score of 4.2 out of 5. The app has been recently updated in October 2016. With regards to the trustworthiness of the information according to the HONcode principles, two applications were found similar in trustworthiness of the health information they provided: they both lacked clear statements regarding privacy and advertisement.

3.5 Pediatric Resuscitation Guides

These are mobile applications that functioned as quick guides to appropriate dosage of medications and selection of instruments used in resuscitation for each age group in pediatrics. Two of these applications were included in the study, which were Pedi-Stat and PalmPEDI. The Mobile Application Pedi-Stat costs around 7USD application with more than 10,000 downloads and a review score of 4.6 out of 5. It has been reviewed by more than 160 users and has been recently updated in February 2015. Although PalmPEDI was cheaper at 1USD, it had a similar review score of 4.6 out of 5 and has been downloaded and reviewed less frequently. Furthermore, it has not been updated since December 2013.

Trustworthiness of the information according to the HONcode principles: Pedi-Stat was found to fulfill all the requirements of the HONcode code certificate as trustworthy information except for the financial disclosure and the advertisement policy statement. While PalmPEDI suffered lack of any policies or statements. It did not indicate the authors or editors. It didn't give a clear indication of source of information or that the information was supplemental to good clinical judgments. The developer's website was simply an advertisement for the application.

3.6 CPR Aid Applications

The Application CPR Metronome was described as a useful medical emergency mobile health application. It is an application that gives sounds and tones that pace the speed of chest compressions and indicates an appropriate time to ventilate the patient during cardiac arrest resuscitation. Two applications named CPR Metronome were found having the same name and function, however, they had a different user interface and developer. “Narumikuro” developed one application and “Omnimed Solutions” developed the other one.

Both applications were free applications that were downloaded more than 50,000 times and were last updated in the year 2013. The mobile health application developed by Narumikuro had a higher review score compared to the one developed by Omnimed (4.2 vs 3.8 out of 5), however, it was reviewed by far less users (233 vs 10,000). Both mobile health applications follow the compression and ventilation rates of the latest Basic Life Support guidelines from the year 2015 as outlined by the American Heart Association. For the trustworthiness of the information according to the HONcode principles, the application developed by Narumikuro had a dead link to its developer’s website and the reviewers couldn’t find any information in the application itself to assess its trustworthiness. While the one developed by Omnimed only lacked a privacy policy and an advertisement statement.

4. DISCUSSION

This review was the first to assess the most widely used and popular mobile applications for Emergency medicine and rate them for trustworthiness based on the HONcode principles. Medcalc was the only application that met all the HONcode principles and seems to be the most trustworthy application found in this study. Overall, the study identified applications under the categories of general emergency medicine references, drug references, eye manuals, pediatric resuscitation guides and CPR Aids to have a high degree of trustworthiness. The findings of this study offers health care practitioners of emergency medicine an initial guide on applications that are both helpful in the emergency department and follow the HONcode principles for trustworthiness.

Emergency medicine departments are in need for mHealth applications to help in the delivery and management of patient care [14-17]. The emergency department environment is unpredictable and the need for knowledge preparedness for clinicians and staff is high. Having bedside mobile applications that give immediate answers can help in improve the delivery of care in emergency medicine. The results of this work can help reinforce the concept of trustworthy information needed for all health care practitioners working in

Emergency medicine. It is important that health care practitioners assess this in all the mobile applications, they are using for patient care, especially if they are trainees that may find it difficult to identify unverified claims found in mobile applications.

The most common HONcode principle that was not fulfilled in the mobile emergency medical applications studied was having a clear advertisement statement. The issue may stem from the fact that most applications are ad-free applications, so the editors or developers didn't see the need for advertisement statements. The HONcode principles require at least a statement regarding advertisement that legally clarifies the position of the editors regarding advertised merchandise even when they are not applying advertisements on the mobile application.

Another common issue was that a number of applications did not have a clear privacy policy stating that the private information of the user is protected. With these applications the user may choose to trust the application at their own risk, however, the risk is low since the applications are not requesting private information and do not require any permissions to access data on the mobile device. The most serious problem found in the study was that some mobile applications did not have a clear author or editor with clear healthcare credentials that are visible to the users of the application. This was observed in PalmEM, PalmPEDI, and Mediequation Medical Calculator. These three applications should be used with caution by emergency medicine staff and clinicians.

Lin et al [18] selected many mobile applications for emergency medicine that were available exclusively on the iPhone platform reducing the number of people that can use them, especially in the developing countries. In contrast, this study focused on applications that are available on both platforms which can provide more choices for emergency medical physicians, especially in developing countries. It is also noted that Lin et al [18] have recommended PalmPEDI. This study finds this application does not provide enough information to make it a trustworthy source of health care information based on the HONcode principles, Pedi-Stat is a more appropriate alternative.

Among the limitations of the study include the limited mobile applications that were in publications or on websites recommending their use. The applications included in this study were all sources of information for healthcare providers or decision-making support systems, other forms of emergency medicine applications were not included.

Future studies may review all medical mobile applications in the emergency medicine, in particular, applications that communicate between individuals and health services, in addition facilitates consultation between health care professionals.

5. IMPLICATIONS FOR PRACTICE

The results found in this study provide reassurance that using certain mobile applications for emergency medicine are safe to be used. The mobile applications should be recommended by hospital administrations and insurance companies to aid decision-making and they can be listed for use by residents in residency training. The culture of verifying the authenticity and trustworthiness of the information found in mobile applications should be incorporated in training and faculty development programs in the Emergency medicine.

6. CONCLUSION

Not all mobile applications commercialized to be used in the Emergency department are trustworthy sources of health care information. HONcode principles should be verified in mobile applications prior to their use or recommendation.

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8. APPENDICES

Figure 1: Inclusion and Exclusion Criteria Results

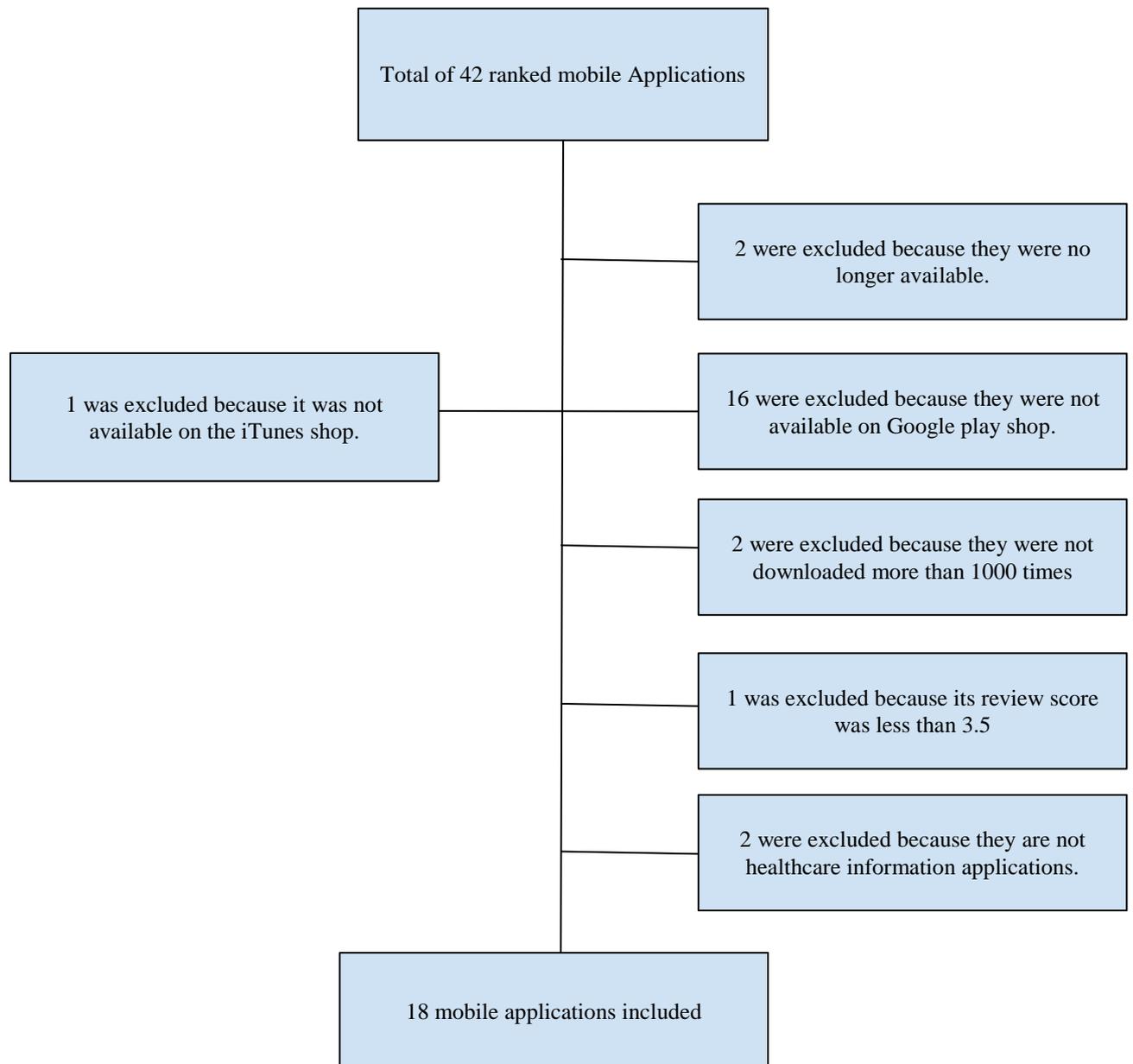


Table 1: Characteristics of Emergency Medicine Mobile Applications

<u>Mobile Application</u>	Mobile Application Metrics				
	Price on Android	Number of Downloads	Date created	Number of reviews	Review stars
Medical Calculators					
MedCalc	Free	100000+	Apr-16	2242	4
Mediquation Medical Calculator	5 \$	5000-10000	Aug-13	197	4.4
Bedside Emergency Medicine references					
UpToDate	Free / Needs paid subscription	500000+	Nov-16	4915	4.6
wikEM	free / inapp purchases	100000+	Nov-16	1202	4.5
AgileMD	free / inapp purchases	10000+	Sep-16	220	4.5
Epocrates	Free / pay for upgrade	1000000+	Dec-16	23392	4.3
5-Minute Emergency Medicine Consult	Free / in-app purchases	10000+	Aug-14	49	4.2
Emergency Medicine Flashcards	49 \$	10000+	May-16	1	5
ERres	10 \$	1000-5000	Aug-15	41	4.3
palmEM: Emergency Medicine	6 \$	1000-5000	Jul-14	63	4.2
Bedside Drug references					
Micromedex Drug Information	Free	100000+	Sep-15	1183	4.1
EMRA Antibiotic Guide	17 \$	1000-5000	Jul-16	66	4.2
Bedside Eye Manuals					
Eye Emergency Manual	Free	10000-50000	Nov-13	100	4.4
Eye Handbook	Free / in-app purchases	50000+	Oct-16	655	4.2
Pediatric Resuscitation Guides					
Pedi-STAT	7.2 \$	10000+	Feb-15	116	4.6
palmPEDi	1 \$	1000-5000	Dec-13	58	4.6
CPR Aid Applications					
CPR Metronome (from Omnimedica)	Free	50000+	Nov-13	10000+	3.8
CPR Metronome (from mikuro.info)	Free	50000+	Sep-13	233	4.2

Table 2: HONcode Review Ratings of Emergency Medicine Mobile Health Applications

Mobile Application	HONcode Survey For Trustworthy Information							
	Authoritative	Complementarity	Privacy	Attribution	Justifiability	Transparency	Financial disclosure	Advertising policy
Medical Calculators								
MedCalc	✓	✓	✓	✓	✓	✓	✓	✓
Mediquation Medical Calculator	✗	✓	✗	✗	✓	✓	✗	✗
Bedside Emergency Medicine References								
UpToDate	✓	✓	✓	✓	✓	✓	✓	✗
wikEM	✓	✓	✓	✓	✓	✓	✓	✗
AgileMD	✓	✓	✓	✓	✓	✓	✓	✗
Epocrates	✓	✓	✓	✓	✓	✓	✓	✗
5-Minute Emergency Medicine Consult	✓	✓	✓	✓	✓	✓	✓	✗
Emergency Medicine Flashcards	✓	✓	✓	✓	✓	✓	✓	✗
ERres	✓	✗	✗	✓	✓	✓	✓	✗
palmEM: Emergency Medicine	✗	✗	✗	✓	✗	✗	✗	✗
Bedside Drug References								
Micromedex Drug Information	✓	✓	✓	✓	✓	✓	✓	✗
EMRA Antibiotic Guide	✓	✓	✓	✓	✓	✓	✗	✓
Bedside Eye Manuals								
Eye Emergency Manual	✓	✓	✗	✓	✓	✓	✓	✗
Eye Handbook	✓	✓	✗	✓	✓	✓	✓	✗
Pediatric Resuscitation Guides								
Pedi-STAT	✓	✓	✓	✓	✓	✓	✗	✗
palmPEDI	✗	✗	✗	✓	✗	✗	✗	✗
CPR Aid Applications								
CPR Metronome (from Omnimedie)	✓	✓	✗	✓	✓	✓	✓	✗
CPR Metronome (from mikuro.info)	✗ / website link dead	✗	✗	✓	✗	✗	✗	✗