ANAESTHETISTS' USE OF MEDICALLY RELATED MOBILE DEVICE APPLICATIONS AND THE EVALUATION OF THOSE MOST COMMONLY USED

Garth Bartlett

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Medicine in the branch of Anaesthesiology

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DECLARATION

I, Garth Bartlett declare that this research report is my own work. It is being submitted for the degree of Master of Medicine in the branch of Anaesthesiology in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

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day of , 2016

ABSTRACT

Background: The use of mobile devices and medical software applications (apps) for mobile devices have been increasing amongst medical professionals. Medical apps can be used for a variety of functions and clinical decisions may be made based on the information provided by these apps. However these apps do not need to have a medical professional involved in the development before being made available for use. Little data could be found regarding app use amongst anaesthetists.

Objectives: To describe anaesthetists in the Department of Anaesthesiology at the University of the Witwatersrand's use of medically related mobile device applications and the assessment of the credibility of those most commonly used.

Methods: Anonymous and self-administered questionnaires, requesting demographic data and information regarding apps used, were distributed among anaesthetists. From the participants list of apps the five most commonly used were assessed against a credibility template.

Results: A total of 127 questionnaires (61% of the department) were distributed with 117 (92.1%) being returned. All participants owned a mobile device, the most popular brand being Apple. There were 99 (84.6%) participants who have used a medical app in their practice. Differences in app use were seen between different age groups, 88.0% in those less than 40 years vs 58.8% in those 40 years or older. More females than males (35.1% vs 22.0%) and more participants younger than 40 years (31.8% vs 10.0%) used an app daily. Daily use of apps varied from 0% to 33.3% among participants with different years of experience. The most commonly used apps were Medscape (61.6%), ECG Guide (10.1%), Qx Calculate (10.1%), The Oxford Handbook of Anaesthesiology (9.1%) and Pedistat (9.1%). Recommendation by a colleague influenced the choice of app in 40.9% of participants. The five most commonly used apps in the department all appeared credible.

Conclusions: Mobile devices were owned by all participants and 84.6% made use of medical apps in their practice. The majority of participants used an app at least once a week with the older participants making less use of them. Medscape was the most frequently used app. The five most commonly used apps in the department all appear credible.

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1.1. Background

The availability and use of mobile devices and their related software applications (apps) have been increasing over the last few years, and with that has come the development of medically related apps. These apps have been developed for use by either a patient, a clinician or both. The development of an app requires knowledge of software development. However, in terms of medically related apps, the software developer may not necessarily have a clinical background, be working with a medical professional or be affiliated with an institution involved in the medical field.

Previously, medical professionals had to rely on textbooks, journal articles, reference charts and tables, calculators etc. for medical information. These medical professionals often used what was known as the "Little Black Book" to record information for future reference.

In this review of the literature, mobile device apps will be discussed under the following headings. Mobile device ownership amongst medical professionals, app use among medical professionals, medical professional involvement (MPI), regulation by medical controlling bodies and reviews of apps. This review then ends with independent validation of apps and the difficulties involved in fully assessing apps used by medical professionals.

1.2. Mobile device ownership by medical professionals

Within the medical community, mobile device use is popular and appears to be on the increase, although differences may exist between levels of training (medical student to consultant) and even amongst various specialties. With regard to smartphone ownership between different levels of training, a 2012 study in the United Kingdom among medical students and "junior doctors," that is interns, was conducted via an online survey. There were 257 medical students from 1706 surveys who responded and 79% of those owned some form of smartphone. Amongst the junior doctors, 131 replies from 601 surveys were received with 74.8% of those responding owning a smartphone. In both groups, Apple was the more popular phone brand where 56.6% of students and 68.4% of junior doctors owned an Apple iPhone respectively. (1)

Between 2013 and 2014, smartphone ownership amongst junior doctors appeared to have increased. A written voluntary questionnaire was given to 82 interns based at two hospitals in Ireland during 2013 (Mater Misericordiae University Hospital, and St Vincent's University Hospital). Of the 61 respondents, 98.4% of interns owned some form of smartphone and the Apple brand was owned by 76.7% of those. (2)

In 2014, a survey conducted in Ireland by the National University of Ireland in Galway sent 203 interns in two of its teaching hospitals an online survey, with 108 being returned. Responses showed that 94.4% of interns reported owning a smartphone. The Apple iPhone was again the more popular brand, with 66.7% of interns owning one. (3)

In 2014, the University of Alberta in Canada also described smartphone ownership. Initially a group of 18 medical students, residents and faculty members were interviewed. This was followed by an online survey where 2550 surveys were sent out with a low response rate of 213 surveys. Overall, smartphone ownership was 87%, with 90% of residents and 85% of both medical students and faculty members owning some form of smartphone, the Apple iPhone once again being the most popular brand. (4)

A study done at the University of California in 2011 to compare smartphone usage amongst 27 specialties, sent an online survey to residents and attending doctors at 678 Accreditation Council for Graduate Medical Education institutions in the United States. Respondents included 1397 residents, 524 fellows and 1385 attending physicians (n = 3 306). On average, 85% of medical professionals owned some form of smartphone. Between the different specialties, smartphone ownership varied from 77.3% amongst radiologists to 98.1% amongst surgical subspecialties. The Department of Anaesthesiology was not specifically mentioned and possibly placed under the category of "other" in the study. The most popular smartphone brand was the Apple iPhone with 48% of respondents owning one. (5)

A separate study specifically on urology trainees at the University of Limerick, Ireland in 2014 showed that 100% of its members (36 respondents out of 44) own a smartphone (6).

1.3. App use by medical professionals

Apps are programs designed for use on a mobile smartphone or tablet, the scope of which has extended into various fields, including medical disciplines.

1.3.1. Categorising app use in the medical field

Mobile device apps can be developed for an array of potential uses. The following five categories by have been created by Ventola (7) a consultant medical writer.

- Administration: apps can be used for time management, such as the calendar feature built into the smartphones, or can be used for information storage, such as on “the cloud”. Information sharing can also occur via these apps. Note taking, highlighting of documents and storage of photographs fall under this category. Many of these apps are not designed specifically for the medical field.
- Health record and maintenance: apps are designed to record a patient’s data into a patient’s medical record or into a hospital system. They can be used to facilitate patient handover or allow access to patient records, such as laboratory data, x-rays, ECG’s and the like, however remote.
- Communication: apps in this category are used in order to improve communication between healthcare workers. Again, the majority of these apps are not specifically designed for the medical profession. Examples of apps used for communication include WhatsApp and Skype.
- Reference and information gathering: apps designed to allow for the searching of medical literature; including journals, drug references and medical news.
- Medical education and patient management: These are apps that may assist in clinical decision making, such as the use of medical calculators (defined later) and screening tools, or those apps that assist in patient monitoring. Patient monitoring can occur by

connection of the app to the monitors in a ward or they may be used with a patient at home to measure blood pressure or glucose for example. (7)

1.3.2. Use of apps by medical professionals

Medically related app use appears to be increasing. Amongst UK interns in a 2012 study, of those owning a smartphone (98 interns), 75.5% reported having at least one medical app that they could potentially use in their clinical practice. However, 29.6% reported that they used an app at least once a day while 27.6% reported never using their apps. The use of an app one or more times a week accounted for 26.5% of junior doctors (1). No mention was made as to whether the apps downloaded were free or purchased.

In 2013, 91.7% of 60 interns owning a smartphone at the Mater Misercordiae University Hospital and St Vincent's University Hospital had at least one medically related app on their phones. Of those owning apps, 43.6% reported a minimum daily use of one or more apps. Other categories of app use frequency were not considered here. The Oxford Handbook of Clinical Medicine was the most commonly used app. (2)

In 2014 at the National University of Ireland, 102 of 108 interns responding owned a smartphone. There, 50% of interns used an app daily, while 14.7% said they used an app at least once a week. The most popular app used was the British National Formulary. (3)

The above studies show that preferred apps differ between different institutions.

With regard to the apps used, popularity may depend on the level of training of the individual medical practitioner and which specialty they are in. A study on urology trainees found that 77.8% downloaded some form of medically related app, lower than that used by interns in other studies (1, 2) with 25% using an app at least once daily. The most commonly used apps by these urologists was E-Logbook, (75% had downloaded it on their mobile devices), followed by the Oxford Handbook of Urology, bought by 46.4% of urologist trainees. (6)

Another factor that may potentially play a role includes the cost of the app. Prices of apps mentioned in these studies vary extensively, from free apps to apps costing around €90 (2, 6). Among interns in Ireland 91.7% owned at least one app of which 52.3% were paid for apps (2). Urology trainees in Ireland had fewer registrars purchasing an app, 30.6%, despite 77.8% downloading at least one (6). This suggests that cost may be a factor influencing the choice of apps downloaded.

1.4. Medical professional involvement in the development of apps

As the use of medically related apps increases, concerns exist as to whether the apps currently available come from trustworthy sources for use in clinical practice (4). Studies have been done by various disciplines looking at apps with a particular function and have shown poor levels of MPI, which is taken to include a named clinician, affiliated institution or from a manufacturer of medical equipment.

1.4.1. Surgical apps reviewed

Colorectal apps were reviewed by O'Neil and Brady (8) at the University of Edinburgh. Sixty-three apps were identified and reviewed with only 32% reporting MPI in the form of a named clinician or organisation. Twenty-nine apps were designed for patient education, with only four of them having MPI. Eight apps were directed towards education of health care workers and only one did not have any form of MPI. Six apps were developed as a "diary" to record follow up dates, bowel habits and other medical problems. Two of these apps mentioned involvement of a medical professional, but only one included a named medical professional. Cancer support was offered by four apps, only two of which had MPI. Five reference apps out of 11 had some medical professional involved in development. The remaining five apps were classified as "miscellaneous" and only one of those had some MPI. In this study, 65% of the apps without documented MPI charged for the use of the app.

Vascular themed apps were also reviewed by O'Neil, Brady and Carter (9), of which 49 were found and reviewed. Only 29% reported MPI, although one did not clarify in what form, whether a named clinician or organisation. Eleven of these were directed towards patient education on various vascular conditions with only one having MPI. Twelve apps were aimed as education tools for health care workers, yet only 75% of these had any form of MPI. There were four surgical textbooks which contained vascular content, all four of which had documented MPI. Three apps were patient diaries, three diagnostic aids for patients, two apps analysed vascular ulcers and the remainder were classed as "miscellaneous". None of the apps in these categories had named medical professionals involved in development. Of the apps reviewed, 67% were charged for.

A study at the University of California, focused on neurosurgery apps and found 111 related to neurosurgery. There were 66% of these which were found to have MPI in their development. Apps were divided into seven categories; 16 clinical tools, 17 conference adjunct, 27 education (for health care workers), 18 literature, 15 marketing, 10 patient information and 8 reference. Only 16 of the apps designed for health care worker education showed evidence of MPI. With regard to the apps classified as clinical tools, the functions of which also include "clinical decision support, prognosis scores, risk calculators", 10 had MPI. The apps aimed at patient education had only one showing MPI. Of these apps, 36% of these apps had to be paid for, although how many of the paid apps had some MPI is not mentioned. (10)

Breast related apps were reviewed by the Department of Surgery at the Imperial College in London and included 185 apps for review. They were classed into 15 categories; 94 educational tools, 30 self-assessment apps, 3 breast cancer risk assessment tools, 30 for raising breast cancer awareness and 8 for social networking and support. Two apps claimed to be able to remotely heal breast cancer. The remaining categories included visualisation tools, conference guides, glossaries, patient diaries, breast services listing, product advertisement and "breast enhancers". Apps that were for conferences, advertisements, fund-raising and social networking were then excluded as they did not require any evidence based practice. As such, 148 were included. Only 14.2% documented that their app was evidence based with a further 12.8% mentioning a medical professional being involved, of which 78.9% of these specifically named the medical professional. Only 20% of the apps used as a self-assessment tool had MPI or evidence based information. This study mentions that 29 apps "had the potential to cause indirect harm" to a patient. Twenty-six of these 29 apps had no form of MPI. (11)

Cardiothoracic apps were reviewed by the Department of Cardiothoracic Surgery at King's College Hospital. Their search included 379 apps, 21% of which were affiliated with a named medical professional or institution. (12) It is mentioned that there are apps specifically for patient education while others are intended for healthcare workers. However, how many were directed towards one or the other is not mentioned.

1.4.2. Apps reviewed by other disciplines

The Pharmacy Department at the Complejo Hospialario in Spain reviewed 23 apps on viral hepatitis for MPI. Four were for patient education, 12 for health care workers and seven were meant to be used by both. MPI was found in only 56.5% of the apps. It was not reported how many of these apps had to be purchased, but it was mentioned the cost of purchasing apps ranged from €0.69 to €89.99. (13)

From an anaesthetic point of view, apps used for the conversion of opioids into equivalent doses were reviewed by Haffey, Brady and Maxwell (14). Here, 23 opioid conversion apps were included in the study. Only 22% documented MPI from an anaesthetist, palliative care doctor or another physician in their development. However in one app, where a medical professional was involved, it was developed by an individual termed a "training grade doctor". Further to this only 43% provided some reference. Eighteen of these apps had to be paid for, with prices ranging from £0.69 to £6.67.

Ophthalmology apps have been reviewed in Melbourne by Cheng, Chakrabarti & Kam (15). A search for potential apps was only conducted on the Apple iStore and revealed 182 for inclusion into the study. Apps were classified into one or more of seven categories; 37 for vision testing, 36 education for eye care professionals, 36 for patient education, 35 as clinical calculators and scoring systems, 26 for education of non-eye care specialists and 5 as ophthalmic atlases. Overall, 37% of these apps had MPI. Apps designed for ophthalmologists had 51.6% MPI, those for optometrists had 44.3% MPI, non-eye care specialist apps had 31.1% MPI and apps designed for the general public had 20.6% MPI in the development of the programmes.

In a review in 2012 of microbiology themed apps Visvanathan, Hamilton & Brady (16) found 94 relevant programs amongst the various app stores and they categorised them as "reference", "educational", "antibiotic" and "other". Only 34% of these apps had reported MPI, which included "microbiologists, pharmacists and specialist nurses". It is not mentioned whether these medical professionals were named in the app. A further 20% cited "subject matter experts, team of doctors or hospital team" as their source. These apps were regarded as having MPI. No authorship at all was mentioned by 39.4% of apps, which included four antibiotic dosing calculators, while the remainder stated no MPI. Despite this, 78% of the reference apps, which includes those with and without MPI, charged for the use of the app with prices ranging from £0.64 to £99.50.

These studies reflect a paucity of MPI in the development of the available medically related apps in a wide range of disciplines, and also that many of those which are not validated may actually charge for the use of the program.

1.5. Regulation of apps

With regards to the regulation of apps, certain regulatory bodies, such as the Food and Drug Administration (FDA) are starting to become involved. The FDA currently has comprehensive guidelines concerning the regulation of medically related apps which were released in February 2015.

The following are definitions made by the FDA regarding mobile devices:

- "Mobile platform: defined as commercial off-the-shelf computing platforms, with or without wireless connectivity that are handheld in nature. Examples of these mobile platforms include mobile computers such as smart phones, tablet computers, or other portable computers
- Mobile Application (Mobile App): is defined as a software application that can be executed (run) on a mobile platform, or a web-based software application that is tailored to a mobile platform but is executed on a server

- Mobile Medical Application (Mobile Medical App): is a mobile app that meets the definition of device in section 201(h) of the Federal Food, Drug and Cosmetic Act (FD&C Act)
    - Section 201(h) defines a device as '… an instrument, apparatus, implement, machine, contrivance, implant, in vitro reagent, or other similar or related article, including any component, part or accessory', that is '… intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment, or prevention of disease in man…' or '… intended to affect the structure or any function of the body in man or other animals…' Thus, software applications that run on a desktop computer, laptop computer, remotely on a website or 'cloud,' or on a handheld computer may be subject to device regulation if they are intended for the use in the diagnosis or the cure, mitigation, treatment, or prevention of disease, or to affect the structure or function of the body of man. The level of regulatory control necessary to assure safety and effectiveness varies based upon the risk the device presents to public health.
- Regulated Medical Device: is defined as a product that meets the definition of device in section 201(h) of the FD&C Act and that has been cleared or approved by the FDA review of a premarket submission or otherwise classified by the FDA
- Mobile Medical App Manufacturer: is any person or entity that manufactures mobile medical app in accordance with the definitions of manufacturer in 21 CFR Parts 803, 806, 807, and 820" (17)

According to the definitions that have been set out, the FDA have divided medically related apps into three categories:

- those that are not considered a medical device
- in which the FDA "intend to exercise enforcement discretion"
- those that are to be regulated by the FDA. (17)

Those apps which are considered a medical device for which the FDA "intends to exercise enforcement discretion (meaning the FDA does not intend to enforce requirements under the FD&C Act)" (17) are included in the definitions below:

- “Mobile apps that provide or facilitate supplemental clinical care, by coaching or prompting, to help patients manage their health in their daily environment
- Mobile apps that provide patients with simple tools to organise and track their health
- Mobile apps that provide easy access to information related to patients’ health conditions or treatments (beyond providing an electronic “copy” of a medical reference)
- Mobile apps that are specifically marketed to help patients document, show, or communicate to providers potential medical conditions
- Mobile apps that perform simple calculations routinely used in clinical practice
- Mobile apps that enable individuals to interact with PHR systems or HER systems” (17)

The apps under full FDA control are further classified as:

- “Mobile Apps that are an extension of one or more medical devices by connecting such device(s) for purposes of controlling the device(s) or displaying, storing, analysing, or transmitting patient-specific medical device data
- Mobile apps that transform the mobile platform into a regulated medical device by using attachments, display screens, sensors or by including functionalities similar to those of currently regulated medical devices. Mobile apps that use attachments, display screens, sensors, or other such similar components to transform a mobile platform into a regulated medical device are required to comply with the device classification associated with the transformed platform
- Mobile apps that become a regulated medical device (software) by performing patient-specific analysis and providing patient-specific diagnosis, or treatment recommendations. These types of mobile medical apps are similar to or perform the same function as those types of software devices that have been previously cleared or approved”. (17)

Other regulating bodies involved in the control of medical devices include the European Commission, which also encompasses the United Kingdom. No specific guidelines on medical apps have been formalised and apps currently fall under the heading of “Stand

Alone Software”. Similar guidelines to those developed by the FDA are enforced for this stand-alone software. (18)

The South African Medicines Control Council will regulate software depending on how it is intended for use by the manufacturer. There is no specific definition for apps included currently in the guidelines and therefore apps are treated as software. Software is defined as that which “operates as a controlling agent for an electronic device”. Regulation is classified according to the following definitions:

- “Software that is part of a device and is supplied with a medical device
  - It will be regulated as part of the device
- Software or an accessory to a device that is a device in its own right if it is supplied separately from the related device
  - It will be regulated as a separate medical device
- Software that is used as a diagnostic or therapeutic tool
  - Will also be regulated as a separate medical device
- Upgrades to software supplied separately
  - Regulated as a separate medical device
- Corrections to software errors that have been supplied with a device. *Please note*: Must be a replacement part with no additional functionality
  - Not considered a medical device
- Software that is used in combination with other equipment for handling general patient related information
  - Not considered a medical device” (19)

1.6. App reviews

Despite the regulations that have now been developed surrounding apps, concerns still exist as to whether these definitions are “ambiguous and open to interpretation”. (20) As such, certain websites have been developed in an attempt to offer guidance with regard to the available apps. One such site, iMedicalApps.com, has been cited as a trusted Web 2.0 source by the Cochrane Collaboration (21). The site offers reviews of medical apps as well as news releases regarding medical devices. They are however, not a regulating body and do not control which apps may be released by the various app stores. They only offer advice and reviews of the apps available for download. Another site, Happtique.com was initially developed as a site giving certification to medically related apps, allowing individuals the ability to review the trustworthiness of the app they wish to acquire (22). However, they have halted this service as two apps previously determined as safe had issues surrounding privacy and security (23). At the time of this literature review, they have not resumed certification.

There have been other attempts to improve the credibility of apps. Apple iStore have started removing apps, particularly those acting as drug reference sources, in line with a new policy stating that medically related apps need to have their sources cited (24). At the time at which this literature review was done, no similar policy could be found for the other commonly used app stores. This may change in future, especially if greater clarification occurs surrounding which apps would require regulation

1.7. Independent validation

Due to difficulties surrounding the regulation and validation of apps, independent studies have been performed to validate the use of specific apps. The studies are grouped according to similar app functions:

- apps used for medical calculations
- apps used as a screening tool
- apps acting as a replacement for currently available tools
- apps that allow the smartphone to act as an “accessory” for a current device

1.7.1. Apps used for medical calculations

A medical calculator is a form of software where an algorithm or scoring system has been programmed to facilitate ease of calculation. Scoring systems would require specific criteria for the score to be given. The apps that have been developed which include medical calculations in their programming may contain a wide range of formulae and scoring systems that encompasses many disciplines or they may contain one or a few algorithms or scores that would be dedicated to a particular function or discipline.

A study by Payne and Wharred (25) in 2014 reviewed apps that had three or more calculator functions, of which 14 apps were eventually included. All the calculations were then listed and five internists were asked which calculations they would prefer. If four of the five internists selected a specific calculation, then it was included in the study. Of the 476 available calculations, 13 were eventually tested. Ten different values for each calculation were used. Only 85% of the calculations chosen were 100% accurate amongst all 13 apps. Only the Child-Pugh score and the Model for End-Stage Liver Disease score had a lower accuracy of 97% and 95% respectively. There was however no change in the overall class with regards to the Child-Pugh score found in this study. The Model for End-Stage Liver Disease score errors gave a higher mortality rating. However, only a small number of calculations available were used which included those that were thought necessary by internists and not those that may be useful in other disciplines.

Morris et al (26) looked specifically at fluid resuscitation and replacement in burns patients using the Parkland Formula. Two apps were chosen and compared to the values obtained using a simple calculator. Nine randomly generated scenarios were created and 34 participants calculated fluid requirements for each scenario using both of the apps as well as the calculator. Accuracy, speed and preference were all compared. With regards to speed, a significant difference was found between the different methods ($p = 0.006$) with the calculator being significantly slower ($p = 0.013$ and $p = 0.017$ respectively). With regard to accuracy between the different methods, the calculator was found to have a lower accuracy compared to either app, but this was not found to be statistically different ($p = 0.065$). Overall, participants appeared to prefer the use of a simple calculator compared to the apps but this preference was also not found to be significantly different.

A study by Flannigan and McAloon (27) used a paediatric ICU calculator (“PICU Calculator”) app to calculate infusion rates for two hypothetical scenarios, one involving adrenaline and the other dopamine. There were 28 doctors, ranging from senior house officers to consultants and seven medical students who participated in the study. A random number generator divided the participants into two groups, one group using the British National Formulary for Children for the first scenario and the PICU Calculator for the second scenario while the second group did the opposite. For each calculation, participants were given ten minutes. The infusions calculated were then divided into four groups; "(i) correct; (ii) correct for dose and rate but overall volume too big for administration in a syringe pump; (iii) incorrect; (iv) unable to complete". Values accepted as being correct for dopamine was, if calculated between 5 to 20μg/kg/min and for adrenaline if the calculated infusion was between 0.1 to 1.5μg/kg/min. Of the 35 participants, (28.6%) were able to achieve a correct value for the infusions when using the British National Formulary for Children, which included one of six senior house officers, three of seven registrars, one of three associate specialists and five of eight consultants. None of the students or foundation level two doctors (of which there were four) were able to calculate a correct infusion rate and volume using the British National Formulary for Children. When using the PICU Calculator, 100% of participants calculated the correct infusion dose and rate as well as volume, a difference found to be significant ($p < 0.001$). Use of the PICU Calculator was also achieved faster than the use of the British National Formulary for Children, with a mean time saved of 317 seconds ($p < 0.01$).

1.7.2. Apps used as screening tools

Apps that have been designed for disease/condition screening are mostly directed towards patient use.

The Department of Dermatology at the University of Pittsburgh reviewed apps used in determining whether a skin lesion was potentially malignant or not. A total of four apps were found that had the ability to upload a photograph of a lesion for analysis. Three of these apps utilised an algorithm to evaluate the lesions in the images. It is not mentioned if a medical professional was involved in the development of these apps. The fourth app uploaded the image to a "board-certified dermatologist", although it is not known if the image is sent to a single or many dermatologists. In order to evaluate the apps, images from the university's database where confirmed histological diagnosis had been made were uploaded. A total of 188 images were used, 128 of which were benign and 60 were melanomas. Sensitivity and specificity of each app were tested. Sensitivity in one algorithm based app was 6.8%, however specificity was 93.7%. A sensitivity of 70% and specificity of 39.35% in the second algorithm app occurred in the second and a sensitivity of 69% with specificity of 37% in the third. Sensitivity was highest in the fourth app where an image was uploaded to a dermatologist (98.1%) but specificity was lowest (30.4%). Only 18 of the 60 melanomas algorithm based apps, were identified by the app with the highest detection rate. It is mentioned that although these apps have attached “disclaimers” stating that they are for educational purposes, the authors are concerned that “they have the potential to harm users who may believe mistakenly that the evaluation given by such an application is a substitute for medical advice”. (28)

BinDhim et al (29) at the University of Sydney developed an app that used the Patient Health Questionnaire (PHQ-9), a depression screen. If a patient’s score was high, they were advised to see a health care professional for further evaluation. A random identification number was generated for each user and data collected was synchronised to the research database only when a completed form was submitted. Users over the age of 18 were included in the study. Over a period of four months, 8241 people in 66 countries had downloaded the app, with 6089 completing the questionnaire. Results show that of those without a prior diagnosis of depression, 82.5% were at a high risk for depression. This study shows that apps can also have the potential to be useful screening systems.

The Stroop Test, a neuropsychiatric test for cognitive impairment, has been utilised as a screening test for minimal hepatic encephalopathy and has now been developed into an app. The validation of this app has been tested by Bajaj et al (30) in Virginia. Patients included had cirrhosis and were excluded if they were on psychoactive medication, abused alcohol or other drugs, confirmed overt hepatic encephalopathy or were red-green colour blind. They were compared with healthy controls. Both groups underwent three known cognitive tests to diagnose if minimal hepatic encephalopathy was present. There were 125 patients with cirrhosis (of which 43 had a prior diagnosis of overt hepatic encephalopathy) and 51 healthy controls recruited into the study. An iPod Touch was used as the mobile device platform to administer the test. Within the two groups, 27% of controls were previously familiar with the use of an iPod touch and 24% of cirrhotic patients were familiar with the iPod. The app has what is termed “Stroop Off” where it displays a colour to be named, and “Stroop On” where the name of a colour is given but the word is written in a different colour. During “Stroop On”, participants are required to name the colour and not the word. Reaction times are then measured. There was no significant difference between those who had prior experience with an iPod and those who did not. In the cirrhotic group, a significant correlation was seen between the MELD score and both Stroop Off (0.57, $p<0.001$) and Stroop On (0.61, $p<0.001$).

Another screening app developed in 2014 is that of “Painometer”, which contains four well known pain intensity scales. This was a usability study to describe the potential benefit of an electronic pain diary. Both health care professionals and patients were included and conducted in two phases. Phase one included a convenience sample of 19 healthcare professionals and 14 patients. Healthcare professionals were asked to use the scales on the app as they would for a patient, whilst patients were asked to record their pain intensity, a task done for each pain scale. Participants were then given an open ended questionnaire on the usability of the app and if any improvements could be made. Healthcare professionals preferred the app compared to the traditional methods for the scales (95% preferred the app). Some patients found the apps navigation a little difficult to use but otherwise had no problems. In phase two, a second usability trial was conducted, after changes to the app were made, based on suggestions made in phase one. In this trial, 15 healthcare professionals and 16 patients were included. Fourteen of the healthcare professionals reported that they preferred the use of the app over the traditional paper based scales. (31)

1.7.3. Apps developed that may be used as a replacement for currently used tools

Certain apps developed utilise features built into the smartphone itself, such as the light emitting diode flashlight, camera and accelerometer. The accelerometer is a device that is able to orientate the smartphone in a three-dimensional setting and can be used to measure the position or tilt of the device. While these features themselves have not been marketed for use in a medical setting by the manufacturer, apps have been developed to utilise these features for use in a medical setting, however the app may not have had any form of MPI in its development.

Pelegris et al (32) in 2010 investigated the potential use of a smartphone in detecting heart rate. They developed an app where an individual's finger would need to be placed over the camera of a smartphone, after which a series of images are taken. The images were then scanned to greyscale and an average brightness for each image was obtained. As blood is pumped to the finger, the increase in blood volume increased absorption of light and so reduced the brightness of the image taken by the camera, which is the underlying principle of reflectance plethysmography. The algorithm used by the smartphone measured peaks of brightness with troughs to calculate heart rate. The algorithm used was compared to a pulse oximeter and a two beats per minute error was allowed. Samples from a group of 50 people were taken. Heart rates were initially tested in a well-lit area. In this scenario, the amount of light absorbed was 46% of the maximum the lens was able to absorb. Heart rates measured had an average error of 4.13%. This was then repeated in a less poorly lit environment, where 13% of the maximum amount of light the lens could absorb was available. The average error in this sample was 4.67%. Whether this difference was significant was not mentioned. The authors of this study report that they "demonstrated the proof of concept" for the use of a mobile phone in detecting heartbeat.

Other studies have since been conducted in an attempt to validate heart rate monitor apps. One such study in Taiwan in 2013 compared four heart rate apps (labelled as apps A to D) in paediatric patients to that recorded by an ECG monitor. Patients excluded were those over the age of 18, premature babies whose fingers or toes were too small to cover the camera and light source of the smartphone, patients who were unstable and those where informed consent could not be obtained. In this study, 126 patients were included. An ECG monitor was connected and two separate sites were measured for each app used, the earlobe and either the finger or toe. The pulse rate was measured at each site three times. An accurate value was taken to be a heart rate within five beats per minute if the recorded pulse was less than 100 beats per min on the ECG or within 5% of the ECG recorded pulse if greater than 100 beats per min. According to this definition, patients were divided into accurate and inaccurate groups. Patients were also divided into heart rates below 120 beats per min or greater than 120 beats per min. A paired-test was used to compare the four apps at each site. Three of the apps showed a significant correlation between the pulse rates measured at both finger/toe and earlobe and one (App C) showed significant correlation only when measured at the ear lobe ($R^2 = 0.215$ to 0.857, $p < 0.001$ to $p = 0.003$). App C had a poor correlation at the finger/toe site ($R^2 = 0.071$, $p = 0.097$). Accuracy of the apps was also measured. With regards to accuracy, there were significant differences in accuracy between the earlobe and finger/toe sites measured in two apps, A and D ($p = 0.039$ and $p < 0.01$ respectively). Comparing accuracy with heart rates below 120 beats/min, App D had a higher accuracy when measured at the earlobe ($p = 0.016$), whilst no significant differences amongst accuracy was found amongst the other apps. When the heart rate was above 120 beat/min, accuracy dropped in most apps, and when measured at the finger/toe site, accuracy was less than 50% for all the apps. (33). This study suggests that the capability of a smartphone app to measure heart rate does exist, however it is not a practical function at present.

A study by Wackel et al (34) also attempted to validate apps that measure heart rate. Two apps were "arbitrarily selected" from the free apps available, both requiring the finger to be placed over the camera and light source. Patients undergoing electrophysiology studies, performed under general anaesthesia and who were under the age of 18 were included in this study, with a total number of 26 being enrolled. A baseline heart rate was measured with each app and compared to that on the ECG. After induction of a sustained tachycardia, both apps were again used to measure heart rates. If no result was obtained after two attempts, it was considered a failure of the app. Some measurements could not be made due to spontaneous abortion of the patients' supraventricular tachycardia. At baseline, 34 measurements were made, 33 of which were within 4 beats per min of the ECG ($r = 0.99$). A sustained tachycardia was initiated and 38 attempts to measure heart rate were made. The first app only obtained a reading in 10 attempts out of 21 (Pearson correlation = 0.56). App 2 only obtained a reading in 5 of 17 attempts (Pearson correlation = -0.43). Neither app was found to be accurate enough for use in a clinical setting.

McManus et al (35) utilised the potential for reflectance photoplethysmography not to measure the heart rate, but to detect whether there was an irregular pulse. In order to achieve this they utilised two statistical techniques; root mean square of successive differences of RR intervals (RMSSD), and Shannon entropy, both of which were incorporated into an app developed by the researchers. Patients included in this study were those being admitted for elective cardioversion for atrial fibrillation. Those who had ECG confirmation of atrial fibrillation were deemed eligible for the study, of which there were 76. These patients then placed their fingers over the camera to determine if an irregular pulse could be detected by the app. After the elective cardioversion was performed, patients who achieved successful cardioversion (the number of which were not mentioned) were tested again with the app. This particular algorithm was found to have excellent sensitivity (RMSSD = 0.9818, Shannon entropy = 0.975 and combined = 0.9619), specificity (RMSSD = 0.915, Shannon entropy = 0.8218 and combined = 0.9752) and accuracy (RMSSD = 0.9533, Shannon entropy = 0.9097 and combined = 0.9676).

For orthopaedics, a study by Franko, Bray & Newton (36) evaluated an app that assessed a patient for scoliosis and compared it to a scoliometer. The scoliometer used was attached to the back of an iPhone 4S. This was done so that a reading could be taken by two examiners at the same time, each using one of the two devices. The devices were rotated through randomly selected angles from -30° to +30°. Four different observers; an attending, a fellow, a resident and a nurse practitioner; made 60 measurements each, for a total of 240 for each device. There was significant correlation between each individual observer with the two devices (Pearson correlation coefficients of $r = 0.9994$ to 0.9996, and $p < 0.001$ for each observer).

In Melbourne, Australia, an app for testing the range of motion at the hip was assessed. This app was also developed by one of the co-authors, and utilised the accelerometer built into the phone. A 3-dimensional motion analysis system and bubble inclinometer was used to compare the effectiveness of the phone. Twenty healthy participants were then recruited into the study and range of motion was conducted by a single physiotherapist. For each of seven range of motion test done, three trials were conducted on each patient with the median value used for analysis and intra-class correlation coefficients used to correlate the three different methods. The reported intra-correlation coefficients of the smartphone compared to the 3-dimensional motion analysis was greater than 0.85 for each range of motion compared to the 3-dimensional motion analysis with the exception of one (ICC = 0.71). There were statistically significant differences for three range of motion tests, which included the range of motion with the lowest correlation. (37)

1.7.4. Apps designed to act as an accessory to a currently existing tool

Apps can also be used as an adjunct to currently existing medical devices or tools. One such example was the development of an app linked to a pulse oximeter at the University of British Columbia in Vancouver (38). An iPod Touch® was connected to a certified Xpod® OEM pulse oximeter and software was developed by the researchers that allowed for the heart rate, oxygen saturation and respiratory rate to be visualised on the device's screen. This study was conducted in two phases. Phase one was a usability study amongst 20 participants (in the University of British Columbia) and features were reviewed by the participants. A series of tasks which were standardised were also conducted to assess usability and the time taken for each task recorded and then an additional questionnaire was given to assess the features of the app. Features that were not favourably viewed, such as the tab for changing the settings, were then altered despite an overall satisfaction of 82% was found. The second phase of the study was conducted in a Ugandan hospital, where participants were recruited by word of mouth. This setting was chosen to view the usability of the app and connected hardware in an environment where there was a paucity of available pulse oximeters and many surgeries are conducted without them. Overall satisfaction was 78% in this group. Time to completion of tasks set out during app use was less for the Ugandan portion of the study, as features not found to be favourable had been changed. Whether this decrease in time was significant was not mentioned.

Apps and additional attachments can be used to monitor patients remotely, as was reviewed in a study in Korea (39) utilising a glucometer linked smartphone app. With this app, patients can take their glucose levels and the app would synchronise the readings collected into a database that could be viewed by medical staff. Medical staff would review the data collected and make recommendations specifically for that patient. This was done on a weekly basis. The aim of this study was to assess how effective the smartphone app was for glucose monitoring and the interactive communication between patient and medical staff. Patients between the ages of 20 and 70, who were type two diabetics for more than one year were asked to participate. Thirty-five were included, with a control group also consisting of 35 patients. This study was conducted over a 12 week period, after which patients were requested to complete a satisfaction questionnaire. Patients were then divided into two groups, “satisfied” and “not-satisfied”. No significant decrease in HbA1c ($p = 0.077$) occurred in the study group. The group of patients who were satisfied with how the app functioned included 27 patients, and taking into account only these patients, there was a significant decrease in HbA1c levels from a baseline of about 7.7% ± 0.8% to 7.3% ± 0.6% ($p < 0.001$). Evaluating the less satisfied group, the HbA1c levels increased to 8.1% ± 0.5%, although this was not significant ($p = 0.062$).

1.7.5. Difficulties in assessing apps

Difficulty in evaluating these studies for are described below:

- Not all apps reviewed are within a defined category, such as only a calculator or only as a screening tool
- Some studies randomly chose which apps they were to use
- Some studies chose to evaluate individual apps and so comparison between others claiming to do the same may not be as effective, or possibly may have had better results
- Some studies did not give the names of the apps used, and so further investigations comparing them cannot be done
- Some apps were developed specifically for the study itself and then removed from the store once completed

Published in the British Medical Journal in September 2013 is a news story of three doctors who are accused of plagiarising content in an app they have developed. In addition, two of these doctors are accused of “dishonestly posting favourable reviews of the app on the Apple iTunes Store”. (40) This is potentially another factor that could impede further development of useful apps.

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1.8. Summary

These studies reveal that of the myriad of potential apps available for use by a medical professional or by a patient, they may not have any form of MPI, be it a clinician or an institute, nor may they contain current or even correct information. Conversely, a number of apps have been validated for use as a new tool or even one that could replace an existing tool. The difficulty arises in that there is currently no method or system in place that would allow for a medically related app to be properly evaluated for use in a medical setting.

Regulation of apps currently remains ambiguous and difficult to interpret, with the resulting possibility existing that an app may be released without proper regulations being enforced. The possibility also exists that a potentially useful app may be excluded from use.

Smartphone apps have the potential to influence medical practice, by assisting both patients and physicians. They have the potential to allow for diseases to be screened for, remote monitoring of a patient’s condition and to assist a physician in their practice in a near limitless array of functions.

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Section 2: Journal of Medical Internet Research author guidelines

This section was included to highlight the guidelines set out by the Journal of Medical Internet Research for a draft article, which is the intended journal for submission of this article.

Instructions for Authors of JMIR

For general information about the structure and content of a biomedical manuscript, authors should become familiar (skim through) the ICMJE Uniform Requirements for Manuscripts before reading the specific instructions for JMIR authors below.

The Journal of Medical Internet Research (JMIR) and its sister journals are innovative, international, peer-reviewed medical journals that aim to publish articles relevant for medical professionals, system developers, and system users alike.

These instructions for authors are valid for all JMIR journals. Instructions for authors are subject to frequent revision. Please look them over carefully before submitting your manuscript.

Manuscripts are considered with the understanding that they have **not been published previously in print or electronic format** and are not under consideration by another print or electronic publication. A complete report following a presentation at a meeting or the publication of preliminary findings elsewhere (eg, in an abstract) will be considered. Material that has been published on the Internet can also be considered, but any previous or simultaneous publication on the Internet must be disclosed in the cover letter. Include copies of potentially duplicative material that has been previously published or is currently being considered elsewhere, and provide links to duplicative material on the Internet. Point out possible overlaps with previously published or simultaneously submitted articles in your cover letter. Note that "duplicate publication or the submission of duplicate material is not necessarily unethical, but failure to disclose the existence of duplicate articles, manuscripts, or other material is unethical and may represent a violation of copyright material." (AMA Manual of Style, 9th ed, p. 98). A content overlap of just 10% may be considered duplicative.

JMIR reserves the right to bill authors for the peer-reviewing, copyediting, layout, and publishing costs of articles which need to be retracted during the production process or after publication on grounds of redundant publication, copyright infringements, or other forms of scientific misconduct.

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- case reports
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- commentaries
- book/software reviews
- research protocols and grant proposals (now published in our new spin-off journal JMIR Research Protocols)
- letter to the editor (ONLY in response to a previous publication in JMIR, which must be cited as first reference) [exempt from Article Processing Fee]

Please indicate the intended type of paper on your cover page.

We have no rigorous space restrictions for any of these papers, except for the short paper. However, we urge authors to be concise. A typical paper contains between 3000 and 6000 words.

In addition, all papers must contain the following sections: Abstract (see abstract format below), Keywords, Main article body (see below for original articles), Acknowledgements, Conflicts of Interest, References.

Acknowledgements, Conflicts of Interest

A description of sources of funding, financial disclosure, and the role of sponsors must be included in the **Acknowledgements** section of the manuscript. This description should include the involvement, if any, in review and approval of the manuscript for publication and the role of sponsors.

In addition, authors must disclose in a **Conflicts of Interest** section if they have personal financial interests related to the subject matters discussed in the manuscript. It is not unusual for JMIR authors to be, for example, owners or employees of Internet companies that market the services described in their manuscript. There is nothing wrong with this, but editors, reviewers, and readers should be made aware of such conflicts of interests; thus, these facts must be disclosed.

Format for Original Papers

Papers should be written in accordance with the American Medical Association Manual of Style: A Guide for Authors and Editors. 9th ed. Baltimore, Md: Williams & Wilkins; 1998.

The following format ("**IMRAD Format**") must be used for the paper:

- Abstract (not exceeding 450 words for structured abstracts, see abstract format below)
- Keywords - see Keywords
- Introduction (eg, theory, hypotheses, prior work)
- Methods (eg with the subheadings "Recruitement", "Statistical Analysis", etc.)
- Results (eg, user statistics, evaluation outcomes). If your study consists of different stages/parts, subheadings in this section should mirror subheadings in the methods section to describe these parts.
- Discussion (eg, with the subheadings "Principal Results", "Limitations", "Comparison with Prior Work", "Conclusions")
- Acknowledgements
- Conflicts of Interest
- [optional] Multimedia Appendix of supplementary files (eg, a PowerPoint presentation of a conference talk about the study, additional screenshots of a website, mpeg/Quicktime video or audio files, or Excel, Access, SAS, or SPSS files containing original data) - see Multimedia Appendix
- References - see References
- Abbreviations - see Abbreviations

Please use subheadings within the main "Introduction," "Methods," "Results," and "Discussion" sections. For example, if you describe three different methods, use three subheadings within the "Methods" section. Also, use matching subheadings in the "Results" section if you report the results from each of the described methods.

Randomized controlled trials (RCTs) are highly welcome and should be reported in accordance with the CONSORT statement. A diagram illustrating the flow of participants through the trial is required.

JMIR is now pilot-testing a **CONSORT-EHEALTH checklist** - please download the checklist from http://www.jmir.org/ojs/public/journals/1/CONSORT-EHEALTH-v1-6.pdf . Although this is primarily intended for randomized trials, the section of the checklist describing how an intervention should be reported is also relevant for manuscripts with other evaluation designs.

Before submission, authors of RCTs must **fill in the electronic CONSORT-EHEALTH questionnaire at http://tinyurl.com/consort-ehealth-v1-6** with quotes from their manuscript (if you wish to comment on the importance of the items from the checklist for reporting, please also rate each item on a scale between 1-5). BEFORE you press submit, please generate a pdf of the form with your responses and upload this file as supplementary file entitled CONSORT-EHEALTH V1.6.

A CONSORT-flowdiagram and a attrition diagram are also strongly recommended (as figures).

In accordance with ICMJE recommendations, **RCTs must have been registered in a WHO accredited trial registry**. Please mention the ClinicalTrials.gov registration identifier, the International Standard Randomized Controlled Trial Number (ISRCTN), or a comparable trial identifier at the end of the abstract ("Trial Registration: ClinicalTrials.gov NCT123456"), as well as when you first mention the trial in the manuscript. When mentioning related trials (e.g. in the Introduction or Methods section) the trial registration number should also be added in brackets. **ICMJE member journals require, as a condition of consideration for publication, registration in a public trials registry at or before the onset of patient enrollment. This policy applies to any trial which started enrollment after July 1, 2005. JMIR authors must add an explanation to the methods section of their manuscript if a RCT meeting these criteria has not been registered.** The JMIR editor reserves the right to reject any paper without trial registration without any further consideration or peer-review.

Meta-analyses and systematic reviews are also highly welcome and should be reported in accordance with the QUORUM statement.

Sample Template

A Word-template of an article compatible with journals from JMIR Publications can be downloaded from http://jmir.org/ojs/public/journals/1/InstructionsForAuthorsOfJMIR.docx. Note that the references can be in any format, as long as the in-text citations are sequentially numbered in the manuscript with square brackets and as long as the reference at the end has a PMID in the format PMID:123456.

Abstract Format

The abstract for an original paper, systematic review, or consensus paper must not exceed 450 words and must be **structured,** using the following sections:

- Background
- Objective
- Methods
- Results (make sure to include relevant statistics here, such as sample sizes, response rates, P-values or Confidence Intervals. Do not just say "there were differences between the groups")
- Conclusions
- (Trial ID number, e.g. ISRCTN, for RCTs)

For further details on structured abstracts, see http://jama.ama-assn.org/info/auinst_abs.html.

Proposals, comments, tutorials, reviews, and other types of papers may contain an unstructured abstract (max. 500 words).

Keywords

Below the abstract, authors should provide 3 to 10 keywords or short phrases that will assist indexers in cross-indexing the article and that may be published with the abstract. Terms from the medical subject headings (MeSH) list of Index Medicus should be used (see http://www.nlm.nih.gov/mesh/MBrowser.html). As well, keywords from ACM's Computing Classification System may be used if suitable MeSH terms are not available.

References

- Include a **reference list** (numbered 1., 2., 3. etc.) at the end of the paper. While in-text references are in square brackets [1], the bibliography at the end of the text must be numbered 1., 2., 3. etc (no square brackets).
- Do not use the footnote or endnote tool of your word processor to generate the reference list. Articles which contain footnotes as references may be returned without peer review.
- Cite **only published or accepted** ("in print") work as reference. *Submitted* papers (not yet accepted for publication), documents not widely available (personal emails, letters), or oral communications (unless they are published as abstract) should *not be cited as reference*, but instead must be cited in the main body of text as "personal communication by NAME, DATE". Obtain the permission of the communicator to quote his communication.
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Please remove any OLE elements from your manuscript before submission (keep the original file and create a copy with field codes removed). To convert references added by Reference Manager or Endnote to plain text, you can use the program itself to remove the OLE codes (for RefMan the menu point is Tools -> RefMan -> Remove Field Codes).

- Make sure that your references are correct by using the PubMed Citation Matcher.
- New (12/2010): **For Medline indexed references, we now ask that you append the PubMed Identifier (PMID) after each reference**, e.g. "PMID:1234567" (where 1234567 is the pubmed identifier) at the end of a reference. Alternatively (as per our old instructions) you could append a [Medline] link after each reference, linking to the PubMed abstract of the article you are citing. Alternatively, just Information on how to do this can be found in the document How to insert Medline Links [PDF document]. *During copyediting, we now use a web-based reference checking software (OrangeX) which will match your references to references in Medline and automatically correct them. If you have a PMID or Medline link after each reference, this process will work smoothly and formatting errors of references will be automatically corrected.*
- **If references are not listed in PubMed, please try to identify the DOI** (digital object identifier) and add the DOI at the end of the reference (e.g. doi:10.1136/bmj.331.7529.1391). The DOI is a unique identifier which is published by most journals somewhere within the article. You may check whether a DOI is correct using the DOI resolver at http://dx.doi.org/.
- **For books, please add the ISBN, if known** (no blanks). See e.g. http://isbndb.com/
- Number references in the order they appear in the text; do not alphabetize.
- Identify references within the body of the paper with Arabic numerals **enclosed in square brackets** (eg, [1,2]). Do **not** use superscripts.
- References must comply with JMIR style (see examples below).
- **Websites and Web articles (URLs)** should be cited as "webcited®" references *in the reference section at the end of the manuscript* - do **not** include links to websites in the text. To webcite® a web reference means to take a snapshot of the cited document and to **cite the archived copy (WebCite link) in addition to the original URL**. JMIR now *requires* that authors use the WebCite ® technology (www.webcitation.org) to archive cited web references first before they cite them. Do **not** cite uncached "live" webpages and websites in the article or reference section, unless archiving with WebCite has failed. Provide the original URL, the WebCite link, and an access date, which should be the date you cached the web reference (see **Web references archived with WebCite** below).
- Use Medline abbreviations for journal titles (see PubMed Journal Browser).

Journal Articles:

Preferred format since 12/2010 (including the PMID leads to better results as during production our RefCheck script will clean up and autocorrect the references):

Westberg EE, Miller RA. The basis for using the Internet to support the information needs of primary care. J Am Med Inform Assoc 1999 Jan-Feb;6(1):6-25. PMID:9925225

International Committee of Medical Journal Editors. Uniform requirements for manuscripts submitted to biomedical journals. JAMA 1997;277:927-934. PMID:9062335

(old format with link to Pubmed handing over the PMID, now discouraged)

Westberg EE, Miller RA. The basis for using the Internet to support the information needs of primary care. J Am Med Inform Assoc 1999 Jan-Feb;6(1):6-25. [Medline]

International Committee of Medical Journal Editors. Uniform requirements for manuscripts submitted to biomedical journals. JAMA 1997;277:927-934. [Medline]

Books:

Iverson CL, Flanagin A, Fontanarosa PB, et al. American Medical Association Manual of Style: A Guide for Authors and Editors. 9th edition. Baltimore, Md: Williams & Wilkins; 1998. ISBN:0195176332

Conference proceedings:

Kimura J, Shibasaki H, editors. Recent advances in clinical neurophysiology. Proceedings of the 10th International Congress of EMG and Clinical Neurophysiology; 1995 Oct 15-19; Kyoto, Japan. Amsterdam: Elsevier; 1996.

Note: If conference proceedings are available through Medline, please use the Medline citation rather than the style above - for example in case of AMIA proceedings or IMIA proceedings (=Medinfo) the citation is as follows:

Mandl KD, Kohane IS. Healthconnect: clinical grade patient-physician communication. Proc AMIA Symp 1999;(1-2):849-53. PMID: 10566480

Hachem F, Bellet J, Flory A, Leverve X. A generic model for Internet-accessed databases in epidemiology: a nutritional application. Medinfo 1998;9 Pt 2:1310-3.

Chapter in a Book:

Phillips SJ, Whisnant JP. Hypertension and stroke. In: Laragh JH, Brenner BM, editors. Hypertension: pathophysiology, diagnosis, and management. 2nd ed. New York: Raven Press; 1995. p. 465-78.

Web references (webpages, grey/government reports available on the web as PDFs, etc.)

See below: all webreferences (webpages, PDF reports) must be archived with WebCite. And both the original URL and the WebCite URL must be provided. If you cite reports (such as Pew Internet reports, government reports, etc.), try to locate a free PDF on the web and cite/webcite the PDF version.

Journal article in electronic format:

Morse SS. Factors in the emergence of infectious diseases. Emerg Infect Dis 1995 Jan-Mar; 1(1):[24 screens]. http://www.cdc.gov/ncidod/EID/eid.htm

[do NOT add WebCite links to journal articles]

Web References archived with WebCite ®

As cited URLs tend to disappear months or years after citing online material, JMIR now *requires* that (instead of citing "live" webpages and websites in the article) authors use the WebCite ® technology (www.webcitation.org) to archive cited web references first before they cite them. Please go to www.webcitation.org and enter the URL you want to cite. The system will take a "snapshot" of the webpage or online document (e.g. pdf) so that it will remain available for future readers. WebCite will also give you detailed instructions on how to cite the web reference. *Electronic journal articles SHOULD NOT be archived with WebCite if they can be expected to be "stable" e.g. available in libraries and/or carry a DOI*, but all other material which might disappear in the future should be archived first by the citing author. For further information on WebCite see also the article Going, Going, Still There: Using the WebCite Service to Permanently Archive Cited Web Pages, *J Med Internet Res 2005, 12, 30; 7(5):e60.*

Example for Citing a Web Reference

Preferred format for submissions to JMIR (note that the access/archiving date does not need to be provided because it can be retrieved by the reader when clicking on the WebCite link:

Fox S, Fallows D. 2003. Internet Health Resources. http://www.pewinternet.org/pdfs/PIP_Health_Report_July_2003.pdf . Archived at: http://www.webcitation.org/5I2STSU61

The access date will be automatically added during copyediting.

Abbreviations

All acronyms/abbreviations (including common ones such as WWW and HTML) must be explained in parenthesis after their first occurrence. If many unfamiliar acronyms/abbreviations are used, please compile them in an **"Abbreviations"** section at the end of the paper.

Multimedia Appendix

We strongly encourage to append multimedia appendices, for example research instruments (questionnaires), movie files including screencasts, a Powerpoint file containing additional screenshots or slides from a talk about the study, a Word, RTF, or PDF document showing the original instrument(s) used, a video, or the original data (SAS/SPSS files, Excel files, Access Db files etc.). Do not include copyrighted material unless you obtained writte permission from the copyright holder, which should be faxed to the editorial office in case of acceptance together with your Publication Agreement form.

Multimedia Appendices intended for publication must be numbered and referred to in the manuscript. Provide in-text citations (for example "see Multimedia Appendix 1") as well as a section with the heading "Multimedia Appendix" before the "References" section. Here, list all Multimedia Appendices and include a brief caption line for each Mutlimedia Appendix describing its contents.

Multimedia Appendices must be uploaded as "supplementary files" during the submission process. In the submission form, carefully enter the caption of the Appendix in a publishable format (using the correct case and avoiding typos and abbreviations), as this will be used in the final publication.

Supplementary files for editor/reviewer eyes only (e.g. related publications) can also be uploaded as "other supplementary file") - these are NOT referred to as "Mutlimedia Appendix".

Figures and Tables

Include all figures and tables in the manuscript at the location where they should appear in the final manuscript.

Screenshots of the intervention/website as a figure or a movie file of the intervention (as Multimedia Appendix, see above) are highly encouraged.

Figures and captions remain in the manuscript during peer-review, but will be removed during production, using the files and captions uploaded separately from the manuscript. Please also upload each of your final **figure** (and multimedia appendix) as **supplementary file** (hi-resolution png or jpg files with minimal compression). DO NOT upload .doc files with lineart or other file formats as figure. **Movie files (.m4v, .avi etc.), powerpoint files (.ppt), or documents (pdf/.doc) should be uploaded and referred to as Multimedia Appendix (see above), not figures**. Please name your files so that it becomes clear what version/revision the figure refers to, e.g. fig1_rev20090130.png. Enter the caption (which will appear underneath the figure) online, omitting the figure label ("Figure 1"), as this will be added automatically. Remove figure label and captions from the image file, if present. Note that for the final publication, the caption will be pulled from the metadata, NOT the caption provided in the manuscript.

IMPORTANT (and new since Aug 2011): During production, FIGURE AND MULTIMEDIA APPENDIX CAPTIONS FOR THE FINAL PUBLICATION ARE NO LONGER PULLED FROM THE MANUSCRIPT, INSTEAD, THEY ARE GENERATED

FROM OUR DATABASE (what you enter in the field "caption" when you upload a figure or appendix).

When preparing **tables,** please make sure that for each row you create a new table row, rather than writing multiple rows into one cell. Example:

Correct:

		n (%)
Age	30-40	23 (43%)
	40-50	27 (23%)
Gender	Female	80 (40%)
	Male	120 (60%)

Wrong:

		n (%)
Age	30-40 40-50	23 (43%) 27 (23%)
Gender	Female Male	80 (40%) 120 (60%)

It is technically not possible to generate different table headers for the same column in the course of the same table (e.g. switching from "%" to "mean") - the original table header will be automatically repeated on new pages. If the meaning of the column changes, then this constitutes a new table with a separate label and caption. If you report different metrics for different kinds of data (e.g. % for dichotomous outcomes, means and SD for continuous outcomes), write "(mean, SD)" or "(%)" after the category headings, or find alternative ways to present the information (e.g. footnotes).

Use portrait format and 10-12 pt fonts for tables. Do *not* use landscape paper formats for tables or smaller fonts to squeeze more information (more columns) into a table. If you have too many columns and the table becomes too wide so that you would have to use a smaller font, consider breaking the table into multiple tables. We will *always* typeset tables in normal font and in portrait orientation. Tables with too many columns will have very narrow columns and look squeezed.
Footnotes for tables must always be a-z (superscript). Do not use symbols such as * or ** (AMA styleguide has recently been revised to that effect - older JMIR articles still use symbols).

Also, please do not submit tables as separate (supplementary) files - always include them in the manuscript file.

Table of Contents Image

Please upload an "illustrative" figure or photo to be used for our homepage and the table-of-contents (we call this a "TOC image"). The TOC image should be at least 800px by 600px (4:3 ratio), with no excessive white space and no border.

Important Notes on Reporting *P* values

The actual *P* value should be expressed (*P* = .04) rather than expressing a statement of inequality (*P* < .05), unless *P* < .001. The *P* value should be expressed to 2 digits whether or not it is significant. When rounding, 3 digits is acceptable if rounding would change the significance of a value (eg, *P* = .049 rounded to .05). If *P* < .01, it should be expressed to 3 digits.

P values less than .001 should be reported as *P* < .001. Expressing *P* to more than 3 significant digits does not add useful information since precise *P* values with extreme results are sensitive to biases or departures from the statistical model.

The traditional reporting of *P* values (indicating only that *P* < 0.05) simply indicated whether the results were "statistically significant" or not. But *P* values of 0.051 and 0.049 should be interpreted similarly despite the fact that the 0.051 is greater than 0.05 and is therefore not "significant" and that the 0.049 is less than 0.05 and thus is "significant." Reporting actual *P* values avoids this problem of interpretation. *P* values should not be listed as not significant (NS) since, for meta-analysis, the actual values are important and not providing exact *P* values is a form of incomplete reporting.

Do not use 0 before the decimal point for statistical values *P*, alpha, and beta because they cannot equal 1. For some statistical values (eg, kappa) even if they cannot ever equal 1, use 0 if they are used infrequently.

***P* is always italicized and capitalized.**

Novel Paper Components: Original Data, Animations, HypER Papers

As a journal covering innovative methods to disseminate knowledge on the Internet, we want to be innovative in our style and format and take advantage of the possibilites available by publishing online. We do not want, as many online journals do, to reproduce an exact version of a traditional printed journal.

We therefore encourage you to experiment with novel methods of presentation whenever you feel it is appropriate and helps the reader, for example,

- animated gifs
- other media (movies)
- attachment or link to a database (Access) or spreadsheet (Excel) file containing original or additional data
- JAVA applets

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- **JMIR uses an online submission and manuscript tracking system. To submit your paper, please register as an author (in your user profile) and go the author home page.**
- You will have to register as an author and will then be guided through the submission process. You may upload your manuscript as an .rtf (rich text) or .doc (WinWord) file, as well as supplementary files such as figures.
- Email submissions are not accepted.
- This system allows you to check the status of your manuscript at any time. *Please refrain from sending emails to the editor or journal staff inquiring about the status of your manuscript.*
- Upon submission, you will receive an automatic email acknowledging receipt of your paper. If you do not receive a response within 24 hours, please verify that the paper has been submitted (using the manuscript tracking system).

Title Page

The first page of your manuscript should be a title page containing the type of paper; the title; all authors' names, degrees, and affiliations; and the corresponding author's contact address (including phone and fax numbers) and email address.

Acceptable Languages

Except for supplements covering special topics of regional interest or containing papers having been presented at non-English speaking meetings, manuscripts must be English.

Non-native speakers are advised to seek help from a native speaker or a professional copyeditor before submission. Although accepted JMIR manuscripts are also edited for language, a poorly written manuscript has lower chances to be accepted, and multiple typos and grammatical errors often reflect poorly on the author.

Final Checklist

Before you submit your manuscript to JMIR, make sure that you avoid the following common formatting / editorial problems:

A. ( ) all in-text references must be numbers in square brackets like this [1]. Do not use the author-year system. Do not use round brackets. Do not use superscript.

B. ( ) JMIR does not use footnotes or endnotes. If you have footnotes, please delete them or incorporate them into the text

C. ( ) URLs must be cited as references and should be archived using WebCite (www.webcitation.org)

D. ( ) in addition to the WebCite URL, please also mention the original URL in the references

E. ( ) please list only one corresponding author with full address, including phone, fax, and email address

F. ( ) Major headings for ALL original papers must be Introduction - Methods - Results - Discussion

G. ( ) Please add subheadings under Introduction/Methods/Results/Discussion (if you use WinWord, apply the style "Heading 2" to IMRD headings, and the styles "Heading 3" to subsequent subheadings). DO NOT USE italics or bold keywords or sentences in paragraphs in lieu of subheadings / sub-subheadings.

H. ( ) You must have more than one subheadings in each section, otherwise please remove the subheading

I. ( ) Your subheadings in the methods section should usually mirror the subeadings in the results section (i.e. for each result type there must be an explanation in the methods on how these results were obtained)

J. ( ) please check our Instructions for Authors on how P-values should be reported

K. ( ) If you want to include a multimedia appendix, please insert a reference ("Multimedia Appendix 1: [caption]") with a caption in the manuscript (before "References"), but make sure to also upload the Appendix as supplementary file. Each appendix must be uploaded as separate file.

L. ( ) End your introduction with a clear statement of what the aim of this paper or study is, or what the hypotheses are.

M. ( ) Start your discussion with a short summary of what the main finding(s) of this study was/were

N. ( ) Shorten the paper, in particular the section: ...

O. ( ) Abstract must be structured (Background-Objectives-Methods-Results-Conclusions)

P. ( ) Please include more quantitative results in the abstract (sample size, P-values, odds ratios with confidence-intervals etc.)

Q. ( ) Please clean up your references, following our instructions for authors. Do not use et al. to abbreviate authors. Do not use "and" between author names. For each author, provide lastname and initial - in that order - without punctuation (e.g. Eysenbach G). Do not use quotation marks for the titles. If you can, provide Medline-links or PMIDs in the format PMID:1234567

R. ( ) For all results for which you provide a relative result (percentage), you should also provide the absolute number, e.g. "132 out of 264 participants (50%) said that...". If n < 100, there is no decimal point in your percentages. If n is 100 to 999, 1 decimal point is reported. If n ≥ 1000, 2 decimal points are reported.

S. ( ) Do not number your headings

T. ( ) Tables should appear in the main manuscript file where they should appear in the final manuscript (rather than being at the end of the manuscript or in a separate file). Figures should remain (during the review process) in the main file but must also be uploaded under "supplementary files". Note that after acceptance, figures should be removed from the main manuscript and the figure/caption entered online (as metadata for the supplementary file) will be used, thus please fill in this section carefully.

U. ( ) Cite a reasonable and appropriate number of scholarly references. Make sure to include the most recent pertinent/related articles - a reference list where the last published reference is over 1-2 years old raises some red flags. Do a Pubmed search to cite previously published papers on the same topic immediately before submission to make sure the most recent related research is cited.

V. ( ) remove ALL field codes before submitting an electronic manuscript. Field codes are used in Microsoft Word if you use bibliographic software to create your references. Before re-submitting your revised manuscript, open your document in Word, select Tools -- Endnote (or Reference Manager) -- Remove Field Codes, and save the manuscript under a new name. Then resubmit that version.

W. ( ) avoid author-invented abbreviations and acronyms

X. ( ) For RCTs only: Starting in 2008, JMIR will routinely publish trial identifiers in the abstract. Please add the trial registration number to the ABSTRACT, after the section "Conclusions: ..." (e.g. "Registration: Clinicaltrials.gov NCT00102401, http://clinicaltrials.gov/ct2/show/NCT00102401)

If for any reason the trial was not registered, please provide an explanation (e.g. in the methods section and/or a cover letter to the editor).

Y. ( ) Please report the trial in accordance with the CONSORT-EHEALTH checklist - for details see CONSORT-EHEALTH: Improving and Standardizing Evaluation Reports of Web-based and Mobile Health Interventions, J Med Internet Res 2011;13(4):e126. Please download the checklist from http://www.jmir.org/ojs/public/journals/1/CONSORT-EHEALTH-v1-6.pdf . We then need you to **fill in the electronic version at http://tinyurl.com/consort-ehealth-v1-6** with quotes from your (revised) paper (if you wish to comment on the importance of the items from the checklist for reporting, please also rate each item on a scale between 1-5). BEFORE you press submit, please generate a pdf of the form with your responses and upload this file as supplementary file entitled CONSORT-EHEALTH V1.6. Mention in your article and/or cover letter that the trial is reported in accordance with CONSORT-EHEALTH.

A CONSORT-flowdiagram and a attrition diagram are also strongly recommended (as figures).

Z. ( ) For online surveys only: Please report the online survey in accordance with the CHERRIES checklist

AA. ( ) Tables must be designed in line with Instructions for Authors (http://www.jmir.org/cms/view/Instructions_for_Authors:Instructions_for_Authors_of_JMIR#figures) - do NOT use a soft line break within a table cell to separate different categories/subcategories. For each category, create a new table row.

DO NOT USE LANDSCAPE FOR TABLES OR SMALLER FONTS. WE WILL TYPESET TABLES IN NORMAL FONT AND IN PORTRAIT ORIENTATION. TABLES WITH TOO MANY COLUMNS WILL HAVE VERY NARROW COLUMNS AND LOOK SQUEEZED.

FOOTNOTES FOR TABLES must always be a-z (superscript). Do not use symbols such as * or **

AB. ( ) Please also upload each of your final figure (e.g. 1-2 screenshots of the intervention) as supplementary file (hi-resolution png or jpg files with minimal compression). DO NOT upload .doc files with lineart or other fileformats. Please name your files so that it becomes clear what revision the figure refers to, e.g. fig1_rev20090130.png. Enter the caption (which will appear underneath the figure) online, omitting the figure label ("Figure 1"), as this will be added automatically. Remove figure label and captions from the image file, if present. Note that for the final publication, the caption will be pulled from the metadata, NOT the caption provided in the manuscript.

Cover Letter

The online submission process allows you to enter a comment for the editor into a "comments field." Here you may briefly explain why you think your article is innovative and important. Please also mention if you opt-in into our Open Peer Review experiment. Finally, we ask that you mention that you either agree to pay the APF (Article Processing Fee, see below) in case of acceptance, or if you think that the APF should be waived due to institutional membership of the corresponding author.

Peer Reviewer Nominations

During the submission process, authors are asked to **nominate 2 to 4 external referees** to review their manuscript (please provide at least their name and email address). The best reviewers are authors of publications on which your research builds and which you cite. Peer reviewers must have a publishing track in the area the manuscript deals with, however, avoid nominating overly senior (and busy) individuals.

When suggesting peer reviewers, conflicts of interests should be avoided, that is, suggested referees should **not**

- be from the same department or division as one of the authors (the same university should also be avoided);
- have been a research supervisor or graduate student of one of the authors within the past six years;
- have collaborated with one of the authors within the past six years or have plans to collaborate in the immediate future;
- be employees of non-academic organizations with which one of the authors has collaborated within the past six years; or
- be in any other kind of potential conflict of interest situation (eg, personal, financial).

We ask applicants not to contact suggested referees in advance. The editor reserves the right to send the manuscript to other referees.

You may request, in the cover letter, that some researchers not be involved in the review of your paper.

Fast-Track Review and Premium Publishing

Authors sometimes have to meet publication deadlines, e.g. for promotion & tenure or thesis defense, grant proposals, spending of research funds before a certain deadline, publication of follow-up papers, or because the findings are deemed important.

To facilitate a speedy turn-around when a rapid decision is required, JMIR offers a review model in which selected peer reviewers may be *paid* to deliver high-quality and speedy peer-review reports. This is entirely optional - if you do not wish to pay for a fast-track peer review and premium publishing process, just submit your paper normally as described above.

If you opt for fast-track review and premium publishing, you are guaranteed

- **a rapid editorial decision and peer-review comments within 3 weeks (plus any additional holidays within that period)*** after submission and payment of the fee, and

- if the final paper is accepted, **publication of your paper within 4 weeks**** after acceptance and payment of the fee.

In order to take advantage of this, authors must pay a non-refundable fast-track fee (FTF). This should be done within 24 hours after submission. The FTF can be paid immediately after submission using the manuscript submission system. For further information see Pay Fast-Track Fee. We now also allow authors to expedite the submission *at any time during the peer-review process.*

We reserve the right to refund the fast-track fee and process the manuscript in the regular submission track if we are unable to meet the deadline due to a delayed peer-review report or other issues beyond our control.

* Canadian, US and European bank holidays, and excluding the days in the period between Dec 23rd - Jan 1st (of each year).

** not including the period between Dec 23rd-Jan 1st. Days where we wait for a response of the author(s) to copyediting or proofreading requests are also not counted

Editorial Processes

When JMIR receives a manuscript, the Editor and/or Assistant Editor will first decide whether the manuscript meets the formal criteria specified in the Instructions for Authors and whether it fits within the scope of the journal. When in doubt and before rejecting a manuscript on the basis of initial review, the editor will consult other members of the Editorial Board. The editor may assign a section editor to the manuscript, who will guide the manuscript through the peer-review process.

Manuscripts are then sent to an external expert for peer review. The number of peer-reviewers depends on the complexity of the manuscript, but we typically approach 4 peer-reviewers, expecting 1-2 peer-reviews back before we make a decision. Authors are required to suggest 2 peer reviewers during the submission process, but it is at the discretion of the editor whether or not these reviewers will be approached.

JMIR reviewers will not be anonymous (unless they explicitely request this). Names of reviewers will be stated below the article when it is published. Authors and reviewers should not directly contact each other to enter into disputes on manuscripts or reviews.

After peer review, the editor will contact the author. If the author is invited to submit a revised version, **the revised version has to be submitted by the author within 3 months.** Otherwise, the manuscript will be removed from the manuscript submission queue and will be considered rejected.

Speed of Peer Review

Internet research is a fast-moving field, and we acknowledge the need of our authors to communicate their findings rapidly. We therefore aim to be extremely fast (but still thorough and rigorous) in our peer-review process. For example, the paper "Factors

Associated with Intended Use of a Web Site Among Family Practice Patients" (J Med Internet Res 2001;3(2):e17) was **reviewed, edited, typeset, and published within only 16 days.** Including the two weeks' time authors needed for revision, less than 1 month passed from first submission to final publication. (Please note that actual times to review and edit papers vary and primarily depend on the quality of the paper upon first submission.)

We can not provide any guarantees on the speed of peer review or publication - except if a paper has been submitted under the fast-track option, in which case, we guarantee an initial editorial decision within a certain number of days and publication of the article within a certain number of weeks after acceptance.

Criteria for Selection of Manuscripts

Manuscripts should meet the following criteria: the study conducted is ethical (see below); the material is original; the writing is clear; the study methods are appropriate; the data are valid; the conclusions are reasonable and supported by the data; the information is important; and the topic is interesting to our readership.

It is recognized that many submissions will describe websites and other Internet-based services. The Editorial Board strongly recommends that authors of such submissions make efforts to **evaluate** and, if possible, quantify the impact of these services. Submissions containing evaluations are more likely to be accepted than those containing descriptions of services alone, unless the service includes significant innovation.

Ethical Issues

Internet-based research raises novel questions of ethics and human dignity. If human subjects are involved, informed consent, protection of privacy, and other human rights are further criteria against which the manuscript will be judged. Papers describing investigations on human subjects must include a statement that the study was approved by the institutional review board, in accordance with all applicable regulations, and that informed consent was obtained after the nature and possible consequences of the study were explained.

JMIR also encourages articles devoted to the ethics of Internet-based research. In addition, as mentioned above, we will ask authors to disclose any competing interests in relation to their work.

Recommended Reading:

- World Medical Association. Declaration of Helsinki: ethical principles for medical research involving human subjects (last amended Oct 2000). URL: http://www.wma.net/e/policy/17-c_e.html
- Eysenbach G, Till JE. Ethical issues in qualitative research on internet communities. BMJ 2001;323:1103-1105. (PDF reprint: http://bmj.com/cgi/reprint/323/7321/1103.pdf)

- Frankel MS, Siang S. Ethical and legal issues of human subjects research on the Internet - report of an AAAS workshop. Washington, DC; 1999. http://www.aaas.org/spp/dspp/sfrl/projects/intres/report.pdf
- Cho H, LaRose R. Privacy issues in internet surveys. Social Science Computer Review 1999;17(4):421-434.
- Burmeister OK. Usability testing: revisiting informed consent procedures for testing Internet sites. Proc AiCE2000, 2000. http://www.aice.swin.edu.au/events/AICE2000/papers/AiCE2000_Intro.pdf

Plagiarism

JMIR is dedicated to the fight against plagiarism and "cyberplagiarism," the stealing of paragraphs and ideas from articles and websites without appropriate references. We are the first scholarly journal which checks submitted manuscripts against the Web, using turnitin.com, to see whether significant portions of submissions have been taken from websites without appropriate credit.

It is perfectly acceptable to take direct quotes from websites, but the reference (URL) must be given and the citation must be included in quotation marks. If portions of the manuscript have already been published by the author on other websites, this does not necessarily exclude the material from publication in JMIR; however, the JMIR Editorial Board does need to know which portions of the manuscript have been previously published and where. The author should include a note in the cover letter indicating which portions have been published elsewhere.

Should possible scientific misconduct or dishonesty in research submitted for review be suspected or alleged, this journal reserves the right to forward any submitted manuscript to the sponsoring or funding institution or other appropriate authority for investigation. This journal recognizes the responsibility to ensure that the issue is appropriately pursued but does not undertake the actual investigation or make determinations of misconduct.

Open Access Model, Fee Schedule

"Open access" means that the content of JMIR is freely available. The definition, according to the Budapest Open Access Initiative, is as follows:

> "By 'open access' to this literature, we mean its free availability on the public internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. The only constraint on reproduction and distribution, and the only role for copyright in this domain, should be to give authors control over the integrity of their work and the right to be properly acknowledged and cited." (Budapest Open Access Initiative - Definition of Open Access)

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Anaesthetists' use of medically related mobile device applications and the evaluation of those most commonly used

Garth Bartlett, BSc, MBBCh, DA(SA)

Juan Scribante, M Cur

Helen Perrie, MSc

Department of Anaesthesiology, Faculty of Health Sciences, University of the Witwatersrand, South Africa

Corresponding author:

Garth Bartlett

+27 83 469 4699

drgarthbartlett@yahoo.com.

ABSTRACT

Background: The use of mobile devices and medical software applications (apps) for mobile devices have been increasing amongst medical professionals. Medical apps can be used for a variety of functions and clinical decisions may be made based on the information provided by these apps. However these apps do not need to have a medical professional involved in the development before being made available for use. Little data could be found regarding app use amongst anaesthetists.

Objectives: To describe anaesthetists in the Department of Anaesthesiology at the University of the Witwatersrand's use of medically related mobile device applications and the assessment of the credibility of those most commonly used.

Methods: Anonymous and self-administered questionnaires, requesting demographic data and information regarding apps used, were distributed among anaesthetists. From the participants list of apps the five most commonly used were assessed against a credibility template.

Results: A total of 127 questionnaires (61% of the department) were distributed with 117 (92.1%) being returned. All participants owned a mobile device, the most popular brand being Apple. There were 99 (84.6%) participants who have used a medical app in their practice. Differences in app use were seen between different age groups, 88.0% in those less than 40 years vs 58.8% in those 40 years or older. More females than males (35.1% vs 22.0%) and more participants younger than 40 years (31.8% vs 10.0%) used an app daily. Daily use of apps varied from 0% to 33.3% among participants with different years of experience. The most commonly used apps were Medscape (61.6%), ECG Guide (10.1%), Qx Calculate (10.1%), The Oxford Handbook of Anaesthesiology (9.1%) and Pedistat (9.1%). Recommendation by a colleague influenced the choice of app in 40.9% of participants. The five most commonly used apps in the department all appeared credible.

Conclusions: Mobile devices were owned by all participants and 84.6% made use of medical apps in their practice. The majority of participants used an app at least once a week with the older participants making less use of them. Medscape was the most frequently used app. The five most commonly used apps in the department all appear credible.

KEYWORDS

- Mobile devices
- Smartphones
- Tablets
- Use of medically related apps
- Credibility of medically related apps

Introduction

The use of mobile devices, that is smartphones and tablet computers (tablets) as well as their related software applications (apps), have been increasing in the last few years. With this, medically related programs that can be used by both clinicians and patients alike have been developed. Within the medical field, mobile device use is popular and appears to be increasing. For example in the United Kingdom, between 74 to 87% of junior doctors owned a smartphone between 2011 and 2012 [1-3] increasing to almost 100% in 2013 [4] and 2014 [5]. App use is also increasing. Only 15.3% of interns used an app daily in a 2012 study [1], compared with 50% in 2014 [5].

Concern exists as to whether the apps available are trustworthy sources for clinical practice [3, 6]. Studies [7-15] from various disciplines have revealed poor levels of medical professional involvement (MPI), defined as whether a named clinician or a medically affiliated institution was involved in the development of the app.

Regulatory bodies, such as the Food and Drug Administration (FDA) are becoming involved with the assessment of medical apps. They have divided medically related apps into three groups; those not considered a medical device, those that the FDA “intend to exercise enforcement discretion ‘over’ and those in which the FDA will become fully involved in regulating. Despite these regulations coming into play, concern still exists as to whether the three FDA groupings are “ambiguous and open to interpretation” [16].

Other methods to improve credibility surrounding apps have been attempted. The Apple App Store™ have started removing certain drug reference apps which have not cited the source of their data [17]. No similar policy could be found for the other commonly used app stores. Websites have also been developed in an attempt to offer guidance as to the use of these apps. iMedicalApps.com is an example of such a site and is considered a trusted source by the Cochrane Collaboration [18]. However, these are not regulating bodies and they only offer advice on the available medical apps.

Independent studies [6, 8, 9, 19-28] have been performed to validate the use of specific apps such as medical calculators, screening tools and clinical tools. Difficulty in assessing these studies is due to the fact that many of them have evaluated selected apps from certain categories and different apps have been discussed in different studies. No comparison can be inferred. In some, the study did not include the names of the apps reviewed [29].

These studies reveal that of the apps available, the possibility exists that the app has not been validated for use in a clinical setting. The aim of this study was to describe anaesthetists' in the Department of Anaesthesiology at the University of the Witwatersrand (Wits) use of medically related mobile device apps and the assessment of the credibility of the most commonly used apps.

Methods

Approval to conduct the study was obtained from the Human Research Ethics Committee (Medical) (M150111) and other relevant authorities. The study population consisted of all 208 anaesthetists' in the department. A sample size of approximately 60% of the department would be considered an adequate sample size. Convenience sampling was used.

An anonymous, voluntary and self-administered questionnaire (see Multimedia Appendix 1) was compiled following a review of the literature and input from an information technology expert with a medical background. The questionnaire included the following information; demographic data (gender, professional designation, age group, years of experience and mobile device brand), data on medical apps used (the number of apps owned, frequency of use, factors influencing choice of app) and how the participant would rank their apps. A mobile device includes both smartphones and tablets. Tablets were included as they make use of the same apps that smartphones are capable of using.

The questionnaire was distributed during weekly academic meetings. After completion, questionnaires were placed into a sealed collection box. Return of questionnaires implied consent. Questionnaires were analysed and the top five most commonly used apps the in the department were identified and then assessed against a demographic and credibility template.

At the time of release of this study, no formal assessment of an app could be found. A demographic and credibility template was developed after discussion with the same expert previously referred to. The template was divided into two sections: app demographics and credibility criteria and is shown in Table 1.

Table 1 App demographic and credibility template

Name of app
Availability in app stores
Cost
Category (medical, health, lifestyle)
Primary function (reference, calculator, etc.)
Target population (doctors, patient, both)
Is there MPI?
• **If yes, is medical professional named?**
• **If no, does it cite source of information?**
User ratings in app stores
• **Number of reviews**
• **Ratings**
Last update
Independent reviews
Independent validation

iMedicalApps.com was used to determine if any independent reviews had been conducted on the five most commonly used apps.

Data was entered and analysed on a Microsoft Excel spreadsheet. Descriptive statistics were used. Categorical variables were summarized using frequencies and percentages rounded to one decimal point. Missing data was recorded as "not specified."

Results

A total of 127 questionnaires were distributed among anaesthetists at academic meetings between April and September 2015, with the return of 117 (92.1%). Therefore 56.3% participated in this study. Incomplete questionnaires were included in the sample. In one returned questionnaire, no demographic information was given but did however include two apps owned and therefore the questionnaire was included for the study. Three participants did not include their years of experience. This missing data was excluded from the specific analysis.

The demographics of participants are shown in Table 2.

Table 2 Participant demographics

Demographic	Number (%)
Gender	
Male	48 (41.0)
Female	68 (58.1)
Not specified	1 (0.9)
Age group	
< 40 years	100 (85.5)
≥ 40 years	16 (13.7)
Not specified	1 (0.9)
Designation	
Medical officer	18 (15.4)
Registrar	53 (45.3)
Consultant	45 (38.5)
Not specified	1 (0.9)
Years of experience	
≤ 5 years	71 (60.7)
6 – 10 years	27 (23.1)
1 – 15 years	4 (3.4)
16 – 20 years	5 (4.3)
> 20 years	6 (5.1)
Not specified	4 (3.4)

The brand of smartphones and tablets owned by participants is shown in Table 3. All 117 (100%) participants owned a smartphone and 100 (85.5%) participants owned a tablet as well.

Table 3 Smartphone and tablet brands ownership

Brand of smartphone	Number (%)
Apple	71 (60.7)
Samsung	36 (30.8)
Sony	3 (2.6)
Blackberry	2 (1.7)
Nokia	2 (1.7)
LG	1 (1)
Other / not specified	2 (1.7)
Tablet brand	**Number (%)**
Apple	77 (77.0)
Samsung	16 (16.0)
Asus	1 (1.0)
Microsoft	1 (1.0)
Other/not specified	5 (5.0)

Of the 117 participants, 99 (84.6%) used a medically related app. App use according to participants demographics is shown in Table 4.

Table 4 Use of apps according to demographics

Demographic	Number (%)
Gender (number)	
Male (49)	41 (83.7)
Female (68)	57 (83.8)
Age group (number)	
< 40 Years (100)	88 (88.0)
≥ 40 years (17)	10 (58.8)
Designation (number)	
Medical officer (18)	15 (83.3)
Registrar (53)	46 (86.8)
Consultant (46)	37 (80.4)
Years of experience (number)	
≤ 5 years (71)	61 (85.9)
6 – 10 years (27)	24 (88.8)
11 – 15 years (4)	3 (75.0)
16 – 20 years (5)	3 (60.0)
> 20 years (7)	4 (57.1)

The frequency of app use: daily use, use of at least a few times per week, less than weekly and never using the apps they own according to demographics is shown in Table 5.

Table 5 Frequency of app use

Demographic	Daily	< Daily, <Weekly	<Weekly	Never
No.	No. (%)	No. (%)	No. (%)	No. (%)
Total (99)	29 (29.3)	39 (39.4)	29 (29.3)	2 (2.0)
Gender				
Male (41)	9 (21.9)	20 (48.8)	12 (29.3)	0 (0)
Female (57)	20 (35.1)	19 (33.3)	17 (29.8)	1 (1.8)
Age group				
< 40 years (88)	28 (31.8)	34 (38.6)	25 (28.4)	1 (1.1)
≥ 40 years (10)	1 (10.0)	5 (50.0)	4 (40.0)	0 (0)
Designation				
Medical officer (15)	6 (40.0)	5 (33.3)	4 (26.7)	0 (0)
Registrar (46)	14 (30.4)	20 (43.5)	11 (23.9)	1 (2.2)
Consultant (37)	9 (24.3)	14 (37.8)	14 (37.8)	0 (0)
Years of experience				
≤ 5 years (61)	19 (31.1)	25 (41.0)	16 (26.2)	1 (1.6)
6 – 10 (24)	6 (25.0)	9 (37.5)	9 (37.5)	0 (0)
11 – 15 (3)	1 (33.3)	0 (0)	2 (66.7)	0 (0)
16 – 20 (3)	0 (0)	1 (33.3)	2 (66.7)	0 (0)
> 20 (4)	1 (25.0)	3 (75.0)	0 (0)	0 (0)

A total of 76 different apps were listed by participants. The 5 most commonly used apps were Medscape, ECG Guide, Qx Calculate, The Oxford Handbook of Anaesthesia and Pedistat and are shown, by participant demographics, in Table 6.

Table 6 Commonly used apps

Demographic	Medscape	ECG Guide	Qx Calculate	Oxford Handbook	Pedistat
No.	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Total (99)	61 (61.6)	10 (10.1)	10 (10.1)	9 (9.1)	9 (9.1)
Gender					
Male (41)	25 (61.0)	4 (9.8)	5 (12.2)	5 (12.2)	6 (14.6)
Female (57)	36 (63.2)	6 (10.5)	5 (8.8)	4 (7.0)	3 (5.3)
Age group					
< 40 years (88)	55 (62.5)	10 (11.4)	10 (11.4)	9 (10.2)	9 (10.2)
≥ 40 years (10)	6 (60.0)	0 (0)	0 (0)	0 (0)	0 (0)
Designation					
Medical officer (15)	13 (86.7)	1 (6.7)	2 (13.3)	2 (13.3)	4 (26.7)
Registrar (46)	23 (50.0)	2 (4.3)	5 (10.8)	4 (8.7)	4 (8.7)
Consultant (37)	25 (67.6)	6 (16.2)	3 (8.1)	3 (8.1)	1 (2.7)
Years of experience					
≤ 5 years (61)	38 (62.3)	5 (8.2)	7 (11.5)	7 (11.5)	8 (13.1)
6 – 10 (24)	15 (62.5)	4 (16.7)	2 (8.3)	2 (8.3)	1 (4.7)
11 – 15 (3)	3 (100)	0 (0)	1 (33.3)	0 (0)	0 (0)
16 – 20 (3)	1 (33.3)	0 (0)	0 (0)	0 (0)	0 (0)
> 20 (4)	2 (50.0)	0 (0)	0 (0)	0 (0)	0 (0)

Of the 99 participants who used apps in their practice, only 9 made mention of which factors had influenced their choice in downloading particular apps. These participants listed factors for 21 different apps. One app was chosen by a participant for two reasons and therefore 22 influencing factors are given as shown in Table 7.

Table 7 Factors influencing choice of apps

Factor	No. (%)
Recommended by colleagues	9 (40.9)
Cost reasons	4 (18.2)
Own search conducted on relevant store	7 (31.8)
Saw others using it	1 (4.5)
Ease of use	1 (4.5)

Data of the five most commonly used apps were included in the demographic and credibility template, the details of which are given in Table 8.

Table 8 App demographic and credibility data of the most commonly used apps

	Medscape	ECG Guide	Qx Calculate	Oxford Handbook	Pedistat
Availability					
iStore	Yes	Yes	Yes	Yes	Yes
Google Play	Yes	Yes	Yes	Yes	Yes
Cost					
iStore	Free [a]	R13.99 [a]	Free [a]	R879.99 [a]	R39.99 [a]
Google Play	Free [a]	R46,26 [a]	Free [a]	R751.62 [a]	R77.91 [a]
App category in store	Medical	Medical	Medical	Medical	Medical
Primary function	Reference, Calculator	Reference	Calculator	Reference	Reference
Target population	Medical professionals	Medical professionals	Medical professionals	Medical professionals	Medical professionals
MPI	Yes	Yes	Yes	Yes	Yes
If yes, is MPI named	No [b]	Yes	Yes	Yes	Yes
If no, is source cited?	Yes	-	-	Yes	-
User rating					
iStore					
Number of reviews	All versions 74	Not enough ratings to give an average	All versions: 23	Not enough ratings to give an average	Not enough ratings to give an average
Rating	All versions: 4.5/5	-	All versions: 4.5/5		
Google Play					
Number of reviews	42024	123	7285	Not rated	110
Rating	4.4/5	4.3/5	4.6/5		4.5/5
Last update	23-May-16	3 Dec 2013	16-April-16	07-April-16	25-Feb-15
Independent reviews	Yes	Yes	Yes	Yes	Yes
Independent validation	ACCME accreditation	No	No	No	No

[a] Price at the time of submission of the research report.
[b] Only Medscape did not specifically state the main contributors in the development, due to multiple contributors for the various topics. It is also continually being peer reviewed. The remaining four apps named the medical professionals involved in the development of the app.

Discussion

It was difficult to make comparisons with most other studies as they included mainly medical students or interns [1, 4, 5] and not anaesthetists. The study by Franko [2] included app use by different disciplines but again no specific mention of use in anaesthetists. No studies were found that reported findings according to participant's demographics. In our study 88% of participants using apps were younger than 40 years. This is also reflected by the years of anaesthetic experience whereby those with less years of experience use apps more frequently. This may be explained that they are younger and more exposed to technology but also may need to access information more frequently.

Previous studies with junior doctors showed an increase in smartphone ownership from 2012 through to 2014 [1, 3-5]. Nason et al [30] in 2014 showed that all urology registrars in their hospital owned a smartphone. Our study is consistent with that of Nason et al [30] as all participants did own a mobile device. Tablets were included as the larger screen may make them more user friendly and encourage app use. Our study found that Apple was the most popular brand of both smartphone and tablet and this is in keeping with previous studies [1, 2, 4, 5].

The use of apps has also increased, as shown amongst junior doctors [3, 4]. This could be due to the increasing ownership of a mobile device and the availability of medically related apps. Comparing the use amongst anaesthetists however could not be done as no prior studies in this population group could be identified. Nason's [30] study with urology registrars in 2014 showed that 77% owned at least one medical app. In our study 85% of anaesthetists owned at least one medically related app. The increase in app use between Nason's [30] and our study may be due to our study being conducted more recently and the fact that app use has been rapidly increasing. The increase in app use can also be attributed to the fact that a cellphone or tablet is more convenient to carry compared to textbooks or notes

Daily use of apps increased from the study by Payne [1] in 2012, (29.6%) compared with those of O'Reilly [4], (43.6%), in 2013 and O'Connor [5], (50%), also in 2013 while the use of an app a few times per week decreased between these two studies [4, 5]. The majority of participants, (39.4%), in our study used their apps less than daily but more than weekly while daily use was only 29.3%. Daily use in previous studies [1, 4, 5] was higher than in our study, however they used interns and junior doctors whereas in our study more experienced doctors; medical officers, registrars and consultants, were used.

Apps can be used by the medical fraternity for a variety of functions, which can be broadly defined into five categories; administration, health record and maintenance, communication, reference and information gathering, and lastly medical education and patient management [31]. Only the last two categories were considered in our study. These two categories were chosen as medical information obtained from these apps may have clinical implications for patients. Apps for communication, such as What's App, may achieve a similar goal, however the source of information is a colleague and not information from the app itself.

The commonly used apps appear to differ between different institutions [4, 5]. These could possibly reflect differences in those recommended by colleagues, preferences by particular institutions, cost or other factors discussed later. The study on urology registrars by Nason [30] showed the most popular app was a logbook, followed by the Oxford Handbook on Urology. O'Connor et al [5] showed that the British National Formulary was the most popular app in their study. The five most commonly used apps in our study were Medscape (61.6%), ECG Guide (10.1%), Qx Calculate (10.1%), the Oxford Handbook of Anaesthesiology (9.1%) and Pedistat (9.1%). Medscape was the most popular app used among all the demographic categories used. The remaining four apps commonly used were only used those participants with less than 15 years of experience. Medscape is a reference source, drug dosing reference and medical calculator and these multiple functions may possibly be the reason for its popularity.

Participants in our study were asked to give reasons for choosing their particular apps. The reasons given included recommended by a colleague (40.9%), cost (18.2%), their own search conducted (31.8%), saw others using it (4.5%) and ease of use (4.5%). Cost appeared to play a larger role in in the study by Nason [30] where only 30.6% of urology trainees reported paying for an app. However, O'Reilly [4] in 2013 found that the most commonly downloaded app by interns was the Oxford Handbook of Clinical Medicine, an app that cost €44.99 at the time. Our study also showed that cost was less important a factor as most of the commonly used apps were paid for.

Despite app regulations coming into play, individual apps still appear to have shortcomings. One study [25] showed an overall accuracy of 98.6% amongst calculator apps used, with two of 14 apps having errors. The errors were related to the Child-Pugh and Model for End-Stage Liver Disease scores. Another study on calculator apps looked at fluid calculations for burns resuscitation, where two apps were compared to a simple calculator and all using the Parkland formula. There was no significant difference found between the time taken to calculation or accuracy [19]. Apps may also function as screening tools, such as that those for pain [32], depression [23], skin lesions [6], cognitive dysfunction [28].

Drug dosing apps have also been reviewed. One such study involved using the British National Formulary for Children and comparing it to an ICU dose calculator with respect to adrenaline and dopamine infusions in clinical scenarios. All the participants, from student to consultant, were able to calculate correct adrenaline and dopamine doses using the app as opposed to only 28.6% using the British National Formulary for Children. [33]

Other apps developed utilise features built into the mobile device, such as the light emitting diode flashlight, which has been used to measure heart rate [20, 21, 27, 29], although most showed poor accuracy. The accelerometer, which is able to measure the tilt and positioning of the mobile device has been used to measure the degree of scoliosis [26] or range of motion of joints [22]. The screen of the mobile device may be used for any number of visually related functions, and has been reviewed as a monitor for devices such as a pulse oximeter [34] or glucometer [24]. These are features not marketed for medical use by the mobile device manufacturers but which app manufacturers have utilised in the design of their apps.

In the credibility assessment in our study, a template was developed to give an overview as to whether the information in the five most commonly used apps is reasonable for clinical use. Criteria based on limitations from previous studies were considered.

All five of the most commonly used apps were found under the medical category in the app stores, and designed for use by medical professionals. In addition, they all had at least one named medical professional involved in their development. These apps were also independently reviewed by iMedicalapps.com. With regard to user ratings, ECG Guide, the Oxford Handbook and Pedistat did not have enough reviews to give an average rating on the South African iStore, although Google Play had averages for all the commonly used apps except for the Oxford Handbook. Where a rating was available, the lowest was 4.3/5 for ECG Guide. ECG Guide in addition has not been updated recently, the last update being December of 2013. Only ECG Guide and Pedistat did not have a recent update within the last few months. In addition to its high rating, Medscape is used as a platform for continuing education points, and thus is a requirement for up to date information. However, none of the apps had any independent studies conducted to test their content. These apps therefore do have a reasonable degree of safety for use in clinical practice.

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CONFLICTS OF INTEREST

None declared.

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ABBREVIATIONS

App: Application

MPI: Medical Professional Involvement

Wits: University of the Witwatersrand

Section 4: Appendices

4.1) Ethics approval

R14/49 Dr Garth Bartlett

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M150111

NAME: (Principal Investigator)	Dr Garth Bartlett
DEPARTMENT:	Anaesthesiology Chris Hani Baragwanath Academic Hospital
PROJECT TITLE:	Anaesthetists Use of Medically Related Smartphone Applications and the Evaluation of those most Commonly Used
DATE CONSIDERED:	30/01/2015
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Juan Scribante and Helen Perrie
APPROVED BY:	Professor P Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	20/03/2015

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor, Senate House, University.
I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**.

Principal Investigator Signature   Date 22-03-2015

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

4.2) Post graduate approval

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Ms Thokozile Nhlapo
E-mail: thokozile.nhlapo@wits.ac.za

28 January 2015
Person No: 0200064J
PAG

Dr G Bartlett
Suite 318
Private Bag X09
Weltevreden Park
1715
South Africa

Dear Dr Bartlett

Master of Medicine: Approval of Title

We have pleasure in advising that your proposal entitled *Anaesthetists use of medically related mobile device applications and the evaluation of those most commonly used* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

Annexure: Proposal

Anaesthetists' use of medically related mobile device applications and the evaluation of those most commonly used

Garth Bartlett

0200064J

Supervisor	Juan Scribante
	Department of Anaesthesiology
Co-Supervisor	Helen Perrie
	Department of Anaesthesiology

1. Introduction

The use of mobile devices, that is smartphones and tablet computers (tablets) as well as their related software applications (apps) has been increasing in the last few years. With this, medically related programs that can be used by both clinicians and patients alike have been developed. Within the medical field, mobile device use is popular and appears to be increasing, for example in the United Kingdom, between 74 to 87% of junior doctors owned a smartphone in 2011 and 2012 (1, 4, 5) to almost 100% reported in 2013 (2) and 2014 (3). Among different specialties in a 2012 study in the United States of America, ownership ranged from 77.3% in radiologists to 98.1% in surgeons (5), whilst a study in Ireland reported 100% of urology trainees owning some form of smartphone (6).

App use is also increasing. Only 15.3% of interns used an app daily in a 2012 study (1), compared with 50% in 2014 (3). The apps used depend on the speciality and possibly the institute. In two studies conducted in Ireland amongst junior doctors, one showed that the most commonly used app was the Oxford Handbook of Clinical Medicine (2), whilst the other showed the British National Formulary being the more popular (3). Specialists tend to utilise apps that are more relevant to their respective specialty (6). Another factor that may influence the apps used would be the cost. In these studies, approximately half of smartphone owners had apps that were paid for. (2, 6)

Apps can be used by the medical fraternity for a variety of functions, which can be broadly defined into five categories; administration, health record and maintenance, communication, reference and information gathering, and lastly medical education and patient management (7).

Concern exists as to whether the apps available are trustworthy sources for clinical practice (4). Studies from various disciplines have revealed poor levels of medical professional involvement (MPI), whether a named clinician or a medically affiliated institution. In a review of apps related to breast health, MPI was as low as 12.8% (11). Most reviews of health app groups, revealed MPI of between 21-37% (8, 9, 12, 14-16), although reviews looking at viral hepatitis and neurosurgery showed MPI of 56.5% and

66% respectively (10, 13). In a review of apps used for the conversion of opioids, the developer of one of the apps was found to be a “training grade doctor” (14) .

Regulatory bodies, such as the Food and Drug Administration (FDA) are becoming involved with the assessment of medical apps. They have divided medically related apps into three groups; those not considered a medical device, those that the FDA “intend to exercise enforcement discretion” over and those in which the FDA will become fully involved in regulating. The latter two are referred to as a “medical device” (17). The European Commission and the South African Medicines Control have not specifically included apps in their guidelines and so they fall under the current heading of “software” (18, 19).

Other methods to improve credibility surrounding apps have been attempted. The Apple App Store™ have started removing certain drug reference apps which have not cited the source of their data (24). No similar policy could be found for the other commonly used app stores. Websites have also been developed in an attempt to offer guidance as to the use of these apps. iMedicalApps.com is an example of such a site and is considered a trusted source by the Cochrane Collaboration (21). However, these are not regulating bodies and they only offer advice on the available medical apps.

Despite these regulations coming into play, concern still exists as to whether the three FDA groupings are “ambiguous and open to interpretation” (20). Independent studies have been performed to validate the use of specific apps such as medical calculators, programs that can perform common clinical calculations (such as glomerular filtration rate) or calculate a value in a scoring system. One study (25) showed an overall accuracy of 98.6% amongst calculator apps used, with only two of the 14 apps having errors. The errors were related to the Child-Pugh and Model for End-Stage Liver Disease scores. Another study on calculator apps looked at fluid calculations for burns resuscitation, where two apps were compared to a simple calculator and all using the Parkland formula. There was no significant difference found between the time taken to calculation or accuracy (26). Apps may also function as screening tools, such as those for pain (31), depression (29), skin lesions (28), cognitive dysfunction (30).

Drug dosing apps have also been reviewed. One such study involved using the British National Formulary for Children and comparing it to an ICU dose calculator with respect to adrenaline and dopamine infusions in clinical scenarios. All the participants, from student to consultant, were able to calculate correct adrenaline and dopamine doses using the app and only 28.6% using the British National Formulary for Children. (27)

Other apps developed utilise features built into the mobile device, such as the light emitting diode flashlight, which has been used to measure heart rate (32-35), although most showed poor accuracy. The accelerometer, which is able to measure the tilt and positioning of the mobile device has been used to measure the degree of scoliosis (36) or range of motion of joints (37). The screen of the mobile device may be used for any number of visually related functions, and has been reviewed as a monitor for devices such as a pulse oximeter (38) or glucometer (39). These are features not marketed for medical use by the mobile device manufacturers but which app manufacturers have utilised in the design of their apps.

Difficulty in assessing these studies is due to the fact that they have evaluated individual apps and no similar studies were done with the same apps. No comparison can be inferred. In some, the study did not include the names of the apps reviewed (33).

These studies reveal that of the apps available, the possibility exists that the app has not been validated for use in a clinical setting. The aim of this study was to describe anaesthetists’’ in the Department of Anaesthesiology at the University of the Witwatersrand (Wits) use of medically related mobile device applications and the assessment of the most commonly used apps credibility.

2. Problem statement

Mobile devices and their related apps are increasing in number and popularity with the medical community being no exception (1-6). Apps for a wide range of possible functions have already been developed for use in the medical field (7, 26-39). However, many of these apps have no MPI, being a named healthcare worker, institution or manufacturer of medical equipment (8-16). Regulation of apps has recently been incorporated into guidelines (17) or are still in the process of having a set of guidelines drafted, where apps currently fall under the auspices of "software" (18, 19). However, regulation will only involve a certain subset of apps (17).

In an attempt to improve safety surrounding the use of medical apps, certain websites have been developed by independent individuals that offer guidance but do not regulate apps (21). With the vast amount of possible functions, varying degree of MPI and low levels of regulation, safety remains a concern with the use of medical apps (20). Within the Department of Anaesthesiology at the University of the Witwatersrand (Wits), it is not known which apps are commonly used and what factors were involved in the decision to use those particular apps, whether financial constraints, recommendations from colleagues or other factors.

3. Aim

The aim of this study is to describe anaesthetists in the Department of Anaesthesiology at Wits use of medically related mobile device applications and the assessment of those apps most commonly used.

4. Objectives

The objectives of this study are to:

- describe the use of apps by anaesthetists
- describe what may influence anaesthetists choice of apps
- assess the demographics and credibility of the five most commonly used apps in department.

5. Research assumptions

The following definitions will be used in this study.

Anaesthetist: in this study, is any qualified doctor working in the Department of Anaesthesiology, including medical officers, registrars and consultants.

Medical officer: is a qualified doctor practising in the Department of Anaesthesiology under specialist supervision. Medical officers with more than 10 years of experience are regarded as career medical officers.

Registrar: is a qualified doctor that is registered with the Health Professions Council of South Africa as a trainee specialist.

Consultant: is a qualified doctor who is registered as a specialist anaesthesiologist with the Health Professions Council of South Africa or career medical officers.

Mobile device: a portable computing device such as a smartphone or tablet.

Smartphone: a mobile device that has the functionality of a computer, having access to the internet and capable of running apps on its operating system in addition to being a mobile phone.

Tablet computer: a wireless portable personal computer with a touchscreen interface. A tablet computer will be referred to as a tablet in this study.

Medically related app: software application that can be executed/run on a mobile device that is used for a medical purpose; e.g. reference material, diagnosis, scoring, monitoring.

Demographic and credibility assessment template: a template checklist designed by the researcher as a basic assessment of the apps.

6. Demarcation of study field

The study will be conducted in the Department of Anaesthesiology, affiliated to the Faculty of Health Sciences at Wits. The staff complement of the department is 27 medical officers, 107 registrars and 74 consultants. The following hospitals are affiliated to the university.

- Charlotte Maxeke Johannesburg Academic Hospital, a 1200 bed central hospital
- Chris Hani Baragwanath Academic Hospital a 2888 bed central hospital
- Helen Joseph Hospital, a 500 bed tertiary hospital
- Rahima Moosa Mother and Child Hospital, a 388 bed regional hospital
- Wits Donald Gordon Medical Centre, a 190 bed public-private hospital.

7. Ethical considerations

Approval to conduct the study will be obtained from the Human Research Ethics Committee (Medical) and the Postgraduate Committee at Wits.

Anaesthetists will be invited to participate in the study at departmental academic meetings. Those who agree will receive an information letter (Appendix 1) and a self-administered questionnaire (Appendix 2). Implied consent will be assumed on return of the questionnaire.

Anonymity will be ensured as data will be collected without identifying information. A study number will be allocated to each questionnaire to assess response rate. Confidentiality will be ensured as only researcher and supervisors will have access to the raw data.

At the end of the study, the demographic and credibility assessment template will be made available to all anaesthetists in the department.

Data will be stored securely for six years after completion of the study.

This study will be conducted according to the principles of the Declaration of Helsinki (41) and the Guidelines for Good Practice in the Conduct of Clinical Trials with Human Participants (42).

8. Research methodology

8.1. Research design

A prospective, descriptive, contextual, research design will be followed in this study.

A prospective study is one where data about a presumed case are first collected, and then the effect or outcome is measured (43). Data will be collected in the form of a questionnaire and the results evaluated thereafter.

Descriptive designs are concerned with gathering information from a representative sample of the population (43). This study will collect data regarding mobile device app use from anaesthetists in the Department of Anaesthesiology.

A contextual is defined as a study with a focus on particular contexts or a "small scale world". It takes a small group or specific area and contextualises it to the overall population. (44). This study will be incorporating a small group of anaesthetists in one academic institution.

8.2. Study population

The study population consists of all the anaesthetists in the Department of Anaesthesiology at Wits.

8.3. Study sample

Sample method

Convenience sampling will be used in this study. This involves the choice of readily available subjects or objects for the study (43). Data will be collected during academic meetings when the majority of the department is available.

Sample size

The questionnaire will be administered to the entire accessible population. The sample size will be realised by the response rate. Approximately 124 (60%) of the departments members are available at any one time due to theatre commitments, outreach rotations and leave.

Inclusion criteria

The inclusion criteria for this study are:

- anaesthetists (medical officers, registrars and consultants) employed by the department
- who are willing to participate.

8.4. Data collection

Development of questionnaire

Following a review of the literature a draft questionnaire was developed by the researcher with guidance from the supervisors. The draft questionnaire was reviewed by an information technology expert with a medical and the suggestions were incorporated. This ensured content and face validity of the questionnaire.

The questionnaire (Appendix 2) will include the following information:

- demographic data (gender, professional designation, age group, years of experience and mobile device ownership and brand)
- medically related apps (the number of apps, frequency of use, factors influencing choice of app)
- the ranking of the apps.

Development of demographic and credibility assessment template

A review of the literature did not reveal a template for the assessment of the demographics and credibility of medically related apps.

As such, a draft template was developed by the researcher and reviewed by an information technology expert with a medical background and the suggestions incorporated into the template. This template is to describe factors that could influence the credibility of an app and will be used by the researcher to assess whether an app has been developed by a credible source.

The template (Appendix 3) will include the following information:

- app demographics (available in both iTunes and Google Play, price, app category, app function)
- credibility assessment (MPI, MPI named, source of information cited, user ratings, last update, independent reviews, independent validation)

Data collection process

Before departmental academic meetings, the convenor of the meeting will be approached and asked if the researcher can address the meeting. The researcher will explain the topic, after which anaesthetists will be invited to join in the study. It will be mentioned that even if potential participants do not own a smartphone or tablet, they are still eligible to participate. Individuals will be informed that participation is voluntary and anonymous. Those agreeing to participate will be given an information letter and a questionnaire. Questionnaires will be handed out and collected by the researcher. The researcher will be available to answer any questions. After completion, questionnaires will be placed into a sealed collection box.

Questionnaires will be analysed and the five most commonly used apps the in the department will be ascertained. The researcher will then assess these apps using the demographic and credibility assessment template.

A search for reviews of alternate sites for credibility (iMedicalApps.com) will then be conducted to ascertain if medical peer review of the specific app has occurred.

8.5. Data analysis

Data was entered and analysed on a Microsoft Excel spreadsheet. Descriptive statistics were used. Categorical variables were summarized using frequencies and percentages rounded to one decimal point. Missing data was recorded as "not specified."

9. Significance of the study

Mobile device apps are in common use within the medical fraternity and use is increasing. They can be used for a multitude of purposes in the workplace which includes administration, communication, health records, referencing and education (7). Regulating bodies will not incorporate all medically related apps (17-19), despite many of these apps with a medical theme not having any form of MPI (8-16). Most studies evaluating apps have either taken a group of related apps and reviewed them or have taken a specific app to validate it for use (25-39). The results from this study will give an understanding of medically related app use in the department and whether the more commonly used apps are credible.

10. Validity and reliability of the study

Validity is defined as “that which indicates whether the conclusions of the study are justified based on the design and interpretation” and reliability “is an indication of the extent of random error in the measurement method” (45)

Reliability and validity in this study will be ensured by:

- the appropriate study design
- questionnaire developed following the literature review
- experts reviewed the questionnaire ensuring face validity

- a standardised demographic and credibility assessment template was used to assess the credibility of the apps
- checking 10% of data entries to confirm accuracy.

11. Potential limitations of the study

This study is contextual in nature and reflects the smartphone and tablet ownership, in addition to their respective use of apps, within the Department of Anaesthesiology at Wits. It does not necessarily reflect that occurring within or Departments of Anaesthesiology or amongst anaesthetists in general.

The possibility exists with convenience sampling that individuals who do not have a mobile device or use apps may not complete the questionnaire, giving a falsely high ownership of mobile devices in the department.

12. Project outline

A Gantt chart outlining the timeline of the project

Activity	Nov	Dec	Jan 2015	Sep	Oct	Nov	Dec	Mar 2016	April
Proposal Preparation	X								
Proposal Submission	X								
Ethics Approval		X							
Postgrad. Approval			X						
Data Collection				X	X	X			
Data Analysis						X	X		
Research report								X	X
Submission of work									X

13. Financial plan

The Department of Anaesthesiology will incur the cost of printing and paper for the proposal, ethics and post graduate approvals.

Item	Cost	Number	Total
Paper	R1.00 per page	1200 pages	R1200.00
Binding	R150.00 per book	3 books	R450.00
TOTAL			R1650.00

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Appendices

Appendix 1: Participants information letter

Dear colleague,

Hi, my name is Garth Bartlett and I am a registrar in the Department of Anaesthesiology at Wits.

I would like to invite you to participate in my MMed research topic entitled: Anaesthetists Use of Medically Related Mobile Device Applications and the Evaluation of Those Most Commonly Used. The aim of this study is two-fold. The first part aims is to determine the commonly used smartphone and tablet applications (apps) within the Department of Anaesthesiology at Wits. Apps are becoming widely used as a reference source and tool in the medical field, yet many do not mention the source of the information that they contain. The second part is to determine if those apps commonly used by the department are credible for use in a medical setting.

The study is approved by the Human Research Ethics Committee (Medical) (M150111)

Participation in this this study is voluntary and consent to participate will be implied on return of a completed questionnaire. Information will be anonymous as no personal information will be required, questionnaires will be numbered for practical reasons. No numbers will be used to identify participants. Confidentiality will be ensured as only my supervisors and I will have access to the raw data. There will be no penalty for not participating or withdrawing from the study. If you do not own a smartphone or tablet but still wish to participate in the study, please complete the questionnaire up to question 5. If you own a smartphone and/or a tablet but do not use medically related apps and you wish to participate, please answer up to question 8.

The questionnaire should not take more than 10 minutes to complete. Before completion of the questionnaire, please ensure you understand the above information. All returned questionnaires should be placed into the sealed box provided.

Your time is greatly appreciated. Any questions regarding this study may be directed to me on 083-469-4699 or the Chairman, Human Research Ethics Committee (Medical) on (011) 717-1234

Sincerely, Garth Bartlett

Appendix 2: Questionnaire

Study Number:

Mobile device app use in the Department of Anaesthesiology

1) What is your gender?	M	F

2) What is your designation? (MO, registrar, consultant)	

3) Age group	< 40 years	≥ 40 years

4) Years of experience	

5) Do you own a smartphone or tablet?	Y	N

6) If you own a smartphone, what brand is it? (Apple, Blackberry, Samsung, other)	

7) If you own a tablet, what brand is it? (Apple, Samsung other)	

8) Do you use medically related apps in your practice / study?	Y	N

9) How many medically related smartphone applications do you own?	

10) How often do you use one or more of your medically related apps?	At least once daily
	Few times per week
	Less than weekly
	Never

11) Please rank your top five most commonly used medical apps, from most common to least and what factor made you decide on that particular app If you own less apps, please rank those you do from most to least	1) ____________________ 2) ____________________ 3) ____________________ 4) ____________________ 5) ____________________

Appendix 3: Demographic and credibility assessment template of the five most commonly used apps

Name of app		
Availability	iTunes	Google Play

Cost	

Category (medical, health, lifestyle)	

Primary Function (reference, calculator etc.)	

Target population (patient, doctor, both)	

Is there documented MPI?	

If MPI, is MPI named	

If no MPI, does it cite source of information?	

User Ratings	

Last update	

Independent reviews	

Independent validation	