THE USE OF MEDICAL APPS AMONGST DOCTORS WORKING IN THE DEPARTMENT OF PAEDIATRICS AND CHILD HEALTH OF THE UNIVERSITY OF THE WITWATERSRAND, IN JOHANNESBURG SOUTH AFRICA

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

Johannesburg, 2019

DECLARATION

I, Shahid Mahmood, student number 1595984, declare that this research report is my own, unaided work. It is being submitted for the degree of Master of Medicine in Paediatrics at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

DEDICATION

I dedicate this research to my beloved parents.

ABSTRACT

Background: Use of medical apps by healthcare professionals is common in their day to day practice. Doctors use medical apps for gathering reference information, patient management, clinical decision making, communication, counselling, data and information management, medical education and training as well. The rapid proliferation of medical apps raises concerns about quality, efficacy, security, safety and reliability of applying these apps in clinical practice. There should be regulatory bodies with oversight on the medical apps.

Aim: The purpose of this study was to look at the number of doctors using medical apps, types of medical apps being used, the frequency of usage, and their trends while choosing these apps, in the Department of Paediatrics in the School of Medicine at the University of the Witwatersrand, Johannesburg. To also determine their knowledge regarding any regulations around medical app development.

Method: A cross-sectional study design using a questionnaire was used to collect data in this study. This was done via an online survey. The questionnaire was sent to medical practitioners in selected hospitals.

Results: A total of 150 medical doctors participated in this study and 73.2% reported using clinical apps several times a day. Registrars, consultants, interns and medical officers reported using the mobile app 81.7%, 54%, 85.7% and 84.2% respectively several times a day. Reference tools (81.7%), diagnostic tools (58.17%) and clinical decision-making support tools (43.79%) were the three most common medical apps used in clinical practice. Peer recommendation (75.8%), app credibility (66%), functionality (65.4%), usability (64.7%) and used or recommended by a senior (60.1) are the common criteria used in evaluating a potential app for use in clinical practice.

Updated regularly (73.2%), scientifically evaluated (71.2%), peer-reviewed (64.1%) and approved by a regulatory body (59.5%) are the most common requirements identified in recognizing a high-quality application.

Conclusion: Medical apps are being increasingly used by medical doctors of all ranks, supporting them in their clinical decision making, improving patient management and making better communication amongst the health professionals at different levels. However, they need more training and support regarding selection, usability and dealing with potential hazards. Improved awareness of the regulations surrounding medical apps amongst doctors is required.

ACKNOWLEDGEMENTS

Special thanks to all my fellow registrars for cooperation and support

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1. CHAPTER ONE: INTRODUCTION

1.1. Background

In the last few decades, advancements in information and mobile technology has led healthcare professionals accessing medical information to move from desktops computers and laptops to handheld devices such as Personal Digital Assistants (PDAs like the Palmtop), to the use of smartphones (Boulos et al., 2011, Baig et al., 2015). Mobile health applications have been used to guide medical practitioners in diagnosis (Patterson et al., 2018) and drug prescription (Tuon et al., 2017). Apart from healthcare practitioners, mobile health applications have also been used to assist with self-management among patients (Lee and Moon, 2016, McKay et al., 2018).

With the high levels of smartphone ownership and the rapid growth of medical apps , smartphones have now become part of day to day lives of healthcare professionals (Larkin, 2011). They use them as gadgets in their pockets with a purpose to improve their practice by getting quick, comprehensive and up-to-date information on current clinical guidelines and other reference material (Nolan, 2011).

Apps are software programs that have been developed to run on a computer or mobile device to accomplish a specific purpose (Wallace et al., 2012). Faster processors, improved memories, smaller batteries and highly efficient operating systems have led to the development of a huge number of medical apps for both professional and personal use (Ozdalga et al., 2012). The ability to download medical apps on mobile devices has made a wealth of mobile clinical resources available to healthcare professionals (Payne et al., 2012). Medical apps are accessible to both patients and healthcare providers that offer health-related information and services via smartphones and tablets anywhere, at any time.

There are a variety of medical apps available in the application stores which are either free or for purchase. Some of them are designed for patients' use, whilst others are aimed at healthcare

providers for multiple purposes. It was~~is~~ estimated that by 2015, 500 million smartphone users ~~will~~ would be using a healthcare application and by 2018, more than 50% of the world smartphone users would have downloaded a mobile health application (Research2Guidance, 2013).

A survey conducted by the General Medical Council, UK demonstrated that this number would rise in 2012, where it was predicted that 83% of doctors would be using smartphones by 2012 (Baumgart, 2011, Larkin, 2011). Healthcare professionals can use medical apps to accomplish many vital tasks, such as;

- information and time management
- health record maintenance and access
- communication and consulting
- reference and information gathering
- patient management
- clinical decision making
- medical education and training

Despite the benefits, medial apps offer there are concerns regarding;

- their reliability for making clinical decisions (Moodley et al., 2013)
- protection of patient data concerning privacy (Nolan, 2011)
- impact on the doctor-patient relationship
- proper integration into the workplace (Misra et al., 2013)
- Standards and accuracy of contents, especially for apps involved in patient management (Moodley et al., 2013).
- important medico-legal and ethical implications (Divall et al., 2013)

- medical application regulations and the limits of regulatory bodies (Barton, 2012, Jogova et al., 2019)

1.2.Apps for Healthcare Providers

Smartphone-based apps for healthcare providers are grouped based on their functional purpose, as shown in Figure 1.1 and are discussed in the following sections.

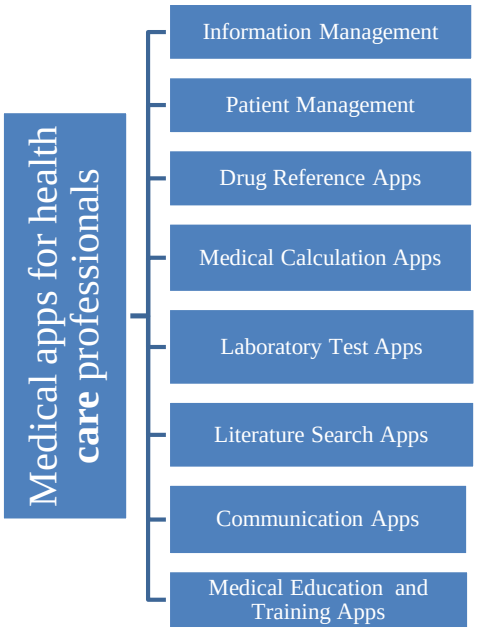

Figure 1.1: Medical applications for healthcare professionals

1.2.1. Information Management Apps

One of the most frequent uses of smartphones or tablets by healthcare professionals is for information management (Wallace et al., 2012). They use their devices to;

- write notes

- dictate notes
- record audio
- take photographs
- organize information and images
- use e-book readers
- access cloud services

There are several information management apps; popular ones include:

- *Evernote* and *Notability*; These enable users to write or dictate notes, record audio, store photographs and organize material into a searchable database (O'Neill et al., 2013)
- E-book reader apps, such as *GoodReader* and *iannotate* allow the users to view, underline, highlight, enlarge and annotate text in PDF files (Aungst, 2013, Yoo, 2013).
- Cloud-based storage and file-sharing apps; These apps allow users to store, update and share documents or photographs with others without exchanging a flash drive or CD. The additional advantage is that information can be accessed instantaneously from multiple devices. *Dropbox*, *Google Drive*, *SkyDrive* and *Box* are popular cloud-based storage apps (Aungst, 2013, Yoo, 2013, O'Neill et al., 2013).

An additional advantage provided by information management apps is that they can be used in combination. For example, *GoodReader* can connect to cloud services, allowing PDF files to be downloaded from the cloud into the reader app (Yoo, 2013).

1.2.2. Disease Information and Decision- Making Apps

Medical apps provide healthcare professionals with convenient and rapid access to evidence-based information, supporting clinical decision- making (Divall et al., 2013). The increased reliance of healthcare professionals on electronic resources was identified in the Manhattan Research/Physician Channel Adoption Study, which reported that physicians spend (64%) of

their online time looking for information to make or support clinical decisions, double the time spent reviewing print sources (Chase, 2013).

Printed medical references often used in disease diagnosis are now available as mobile device apps that provide information on (Mosa et al., 2012):

- diagnosis treatment,
- differential diagnosis,
- the disease process and pathogenesis
- other related topics.

Examples of such apps are (Mosa et al., 2012, Aungst, 2013):

- *UpToDate®*
- *5-Minute Clinical Consult*
- *Medscape*
- *Epocrates®*
- *Dynamed*
- *Skyscape*
- *Diagnosaurus*
- *Pocket Guide to Diagnostic Tests*

Smartphone apps can also assist healthcare professionals in identifying the appropriate scans or tests to order, thus reducing unnecessary procedures and reducing the cost of care (Mosa et al., 2012). Apps on lab tests provide information such as reference values and interpretations, causes for abnormal values and laboratory unit conversion (Mosa et al., 2012).

Examples of these lab tests apps are:

- *Pocket Lab Values*

- *Lab Pro Values*
- *Lab 360*
- *Normal Lab Values*
- *Pocket Guide to Diagnostic Tests*
- *Lab Unit Converter*

1.2.3. Drug Reference Application

Drug reference apps are generally used to access information including, drug names, indications, dosages, side effects, pharmacology, interactions, contra-indications, costs, formulary status and dose per weight calculator (Mosa et al., 2012, Baumgart, 2011).

Most frequently used apps for drug references include (Mosa et al., 2012, Aungst, 2013, Ozdalga et al., 2012):

- *Epocrates*
- *DrugDoses*
- *FDA Drugs*
- *DrugDoses.net*
- *Medscape*

1.2.4. Medical Calculation Apps

These are apps that are aimed at providing a convenient way to perform several medical calculations needed in medical practice. These apps use standard formulae that require several input parameters to determine measurements like body mass index (BMI), body surface area (BSA) and proper drug doses (Mosa et al., 2012, Ozdalga et al., 2012). Healthcare workers do not necessarily need to know the formulae for calculating a clinical score or index manually; they simply need to enter the parameters to produce reliable results quickly. So, the use of these apps is time-saving and without potential errors encountered in manual calculations (Mosa et

al., 2012). In our daily practice, these apps can be used for assessment and calculations such as BMI, an APGAR score, delivery date estimates, the Glasgow coma scale (GCS) score, WHO growth curves, mean arterial pressure and many other metrics. Examples of such apps (Aungst, 2013, Kiser, 2011, Mosa et al., 2012) include:

- *MedMath*
- *MedCalc*
- *Qx Calculate*
- *Pediatric Calculator*
- *MQ Growth*
- *WHO Growth Charts*
- *Medical Calculator*
- *Paeds ED*
- *Delivery Date Estimator*

1.2.5. Literature Search Apps

Smartphone medical apps are critical tools for healthcare professionals to search for or access medical literature as well as other medical information sources (Wallace et al., 2012). A survey of medical school healthcare professionals and students found that mobile devices were often used to access medical journal websites (60%) (Wallace et al., 2012). Several medical journals such as the British Medical Journal, The Lancet and the New England Journal of Medicine provide apps that allow articles to be viewed on mobile devices. However, access to full-text references is not free for all journals (Yoo, 2013).

Some examples of such apps are (Aungst, 2013, Mosa et al., 2012)

- *PubMed on Tap*

- *MEDLINE on Tap*
- *PubSearch*
- *Read by QxMD*
- *Medscape*
- *Docphin*
- *Docwise*
- *Essie*
- *Google and Google Scholar*

1.2.6. Medical Education and Training Apps

With an increase in the use of medical technology, medical apps play an increasingly important role in medical education and training because healthcare professionals and students use them as a resource to learn anywhere and as a pocket resource for easy access to information they need in their work (Murfin, 2013, Payne et al., 2012, Wallace et al., 2012).

Healthcare students use apps in a variety of ways (Wallace et al., 2012):

- to log their experiences
- to access information about medical conditions and drug treatment
- to perform calculations
- to make basic notes

Also, many smartphone apps having study quizzes or tests and interactive case studies, can be used for knowledge assessment and help students for examination preparation. For example, healthcare professionals can participate in Continuing Medical Education (CME) activities that keep them informed about the most current evidence-based information and medical practices (Ozdalga et al., 2012, Kiser, 2011, Mosa et al., 2012). In a survey of medical school faculty, residents, and students, 75%, 95%, and 55%, respectively agreed that using a mobile device

permitted rapid access to educational resources (Wallace et al., 2012). Similarly, some examples of apps playing a role in education and training of healthcare professionals are (Low et al., 2011, Semeraro et al., 2011, Zolfo et al., 2010):

- *Touch Surgery* or *vCath* are apps available for simulated surgical training.
- *Medscape CME* that provides material for training in an evidence-based manner
- CPR manoeuvers that are based on International guidelines

1.2.7. Clinical communication apps

Healthcare facilities are highly dispersed. Clinics, inpatient wards, out-patient clinics, emergency departments, operating theatres, intensive care units and laboratories are located at different locations (Mosa et al., 2012). Therefore, there is a need for a collaborative communication system amongst all stakeholders for better and continued care of patients. Clinical communication apps are available on mobile devices that are specifically designed to simplify communications and clinicians are taking advantage of this (Mosa et al., 2012). These apps have been proven to improve contact between healthcare professionals and their colleagues (Wallace et al., 2012, Ozdalga et al., 2012). Popular mobile applications such as WhatsApp, Amcom mobile connect and mVisum have been used to enhance communications in healthcare, besides standard clinical communication applications (Ammenwerth et al., 2000, Soto et al., 2006, Wu et al., 2010).

1.2.8. Hospital Information System (His) Client Apps

Specialized apps are available that aid in data collection and retrieval, such as entering information into a patient *Electronic Health Record(HER) or Electronic Medical Record (EMR)* (Kiser, 2011, Mosa et al., 2012). These apps allow healthcare professionals for secure access to patient information (medical history, examinations, investigations, prescriptions,

consultations and discharge summaries) either on-site or remotely (Kiser, 2011, Mosa et al., 2012). Some examples of such apps are:

- *Electronic Health Record*
- *Electronic Medical Record*
- *Epic Systems* (Ozdalga et al., 2012)
- *PatientKeeper Mobile Clinical Results* provides physicians with access to patient clinical data with Apple or Android mobile devices (Mosa et al., 2012).
- *Teamviewer* is a general-purpose record maintenance and access app that can be installed on mobile devices, allowing remote access to desktop PCs (Yoo, 2013).
- *Mobile MIM* is a free app for IPad and iPhone, approved by the FDA, that allows remote viewing of x-rays and imaging scan when users cannot access imaging workstations. Images can be downloaded from the cloud and viewed with the *MIMViewer* paid app in any setting (Mickan et al., 2013, O'Neill et al., 2013).
- *Picture Archiving and Communication System (PACS*) (Choudhri and Radvany, 2011).

1.2.9. General Health Apps

These are the general health apps which do not fit into categories discussed above such as *Handheld Computer Smoking Intervention Tool (HCSIT)* and *Out- breaks Near Me* (Oehler et al., 2010, Strayer et al., 2006).

1.3. Potential dangers of using medical apps

Increasingly rapid growth and proliferation of the medical apps industry is not without risks such as in the following circumstances described below:

1. Unreliable apps, not evidence-based, not peer-reviewed, which will make them trivial and even more dangerous such as a rheumatology calculator app from Pfizer was recalled because it provided incorrect values for markers of disease activity (Pfizer, 2011). Most of the apps are downloaded and used as offline, therefore, if an app is recalled or removed, to correct an error or is not updated there is a risk that an outdated or even a recalled app is still being used because a developer can only remove from the apps store and not from a user's device. No protocols exist on how to recall a malfunctioning or a dangerous medical app to stop it being used. Thus, the use of poor quality and unreliable medical apps affect clinical decision making negatively which poses a risk to patients. Hospitals and doctors must make sure of proper education and use of information technology and use the apps which are clearly designated, peer-reviewed, evidence-based, reliable and up to date for use in daily clinical practice (Visser and Buijink, 2012).
2. Medical apps used in the interpretation of images such as x-rays pose a risk to patients because of their unique characteristics of the medium. For example, the interpretation of a chest radiograph on a smartphone could be negatively affected because of the small screen, low resolution and lack of comparison of films side by side (Food and Administration, 2011).
3. One of the biggest concerns today is the breach of patient confidentiality, especially apps used for protected health information. There may be some local regulations to maintain protected health information and to prevent a data breach. However, there are no international guidelines, which could deal with the issues regarding storage of protected health information in medical apps as different legal regulations apply for different countries. Necessary security measures installed in most smartphones are not sufficient to protect electronic health record systems or patient data stored. Passwords

for a device may not be activated or there may be very simple and easily discovered making all stored patient information accessible to others (Heider and Boll, 2011, Nolan, 2011, Bommisetty, 2020).

4. The use of mobile applications have been suggested to increase engagement between healthcare practitioners and the pharmaceutical companies and this could influence decision making (Digiteum, 2018).

1.4.Regulation of medical apps

There are regulations and guidelines in each country regarding the publication of drug promotion in scientific medical journals, or accepting money from a drug company. Similar rules should be applied to medical apps that are emerging at the moment and are far more complex. Due to potential consequences for clinical care of drug promotion in medical apps, regulators and manufacturers must share the responsibility for any oversight (Greene and Kesselheim, 2010, Husain, 2011).

Given these challenges with the use of medical applications, it would appear pertinent to have a system of regulating mobile medical applications. This is an almost impossible task for any authority, and so healthcare professionals have to look towards apps that may comply with any existing guidelines on this subject. The FDA outlined the medical application under their regulatory jurisdiction as to "be used as an accessory to a regulated medical device" or "transform a mobile platform into a regulated medical device (US Food and Drug Administration, 2019).

It argued that the intended use of mobile apps determines whether it meets the definition of a "medical device" (US Food and Drug Administration, 2019). Apps that are used as an accessory to medical device or that transform a smartphone into a regulated medical device will, therefore, face strict regulations by FDA, Other apps such as those sole copies of electronic textbooks or apps that do not require the input of patient-specific data to output a

patient-specific recommendation, a diagnosis, or treatment are not considered as mobile medical apps and therefore not regulated (US Food and Drug Administration, 2019).The EU regulatory framework for medical devices is as follows; There are two categories of health-related apps (the distinction is not always straightforward) which are broadly called mHealth apps,

a. Apps for prevention, diagnosis and treatment of disease (medical apps)
b. Apps relevant to lifestyle, fitness and wellbeing (non-medical apps)

In the EU, medical devices are regulated under the Medical Devices Directive (93/42/EEF) and In Vitro Diagnostic Medical Devices Directive (98/79/EEC), together called Directives. Neither the existing nor the proposed legislation specifies what type of mHealth apps were captured under the EU regulatory framework. Based on the general principles mHealth apps fall under the Directives if they have an intended medical purpose. "The manufacture's intended use is "medical "if the app is specially designed for a medical setting and for performing a medical task. Thus, apps intended for general and domestic purposes are not subject to Directives even though they might be used in healthcare settings or medical context. By contrast, apps that fulfil a medical purpose fall under the directives, even though they may be used domestically (European Commission, 2014).

In South Africa, the regulation of mobile health falls under the e-health principles and function of regulation is aimed at the protection of consumers' information, which is under the Protection of Personal Information (POPI) Act of 2013, and the Health Professions Council of South Africa (HPCSA) and South African Nursing Council (SANC) guide the healthcare professional conduct. Despite all the regulatory bodies' role in maintaining the standards of training and practice in South Africa, there is no clear guidance on the regulation around the use of mobile health applications (MEASURE Evaluation, 2016). ~~There is Consequently,~~

Tthere is a need to establish standards and policies for validating practices within healthcare institutions to ensure ethical and transparent conduct (Divall et al., 2013, Mosa et al., 2012).

Also, researchers developed the Mobile App Rating Scale (MARS) which provided them with a brief tool for assessing and classifying the quality of medical apps (Stoyanov et al., 2015). MARS includes 23 items, which do engagement, functionality, aesthetics, information quality and subjective quality. The MARS proved to be very significant for testing the quality of medical apps on well- being (Stoyanov et al., 2015) and mindfulness (Mani et al., 2015).

1.5. Justification of study in the South African Setting

The majority (83%) of digital health applications are developed in Europe and the United states with Africa and South America contributing a very small share of the digital health application development (Research 2 Guidance, 2018). A systematic review by (Lee et al., 2017) to evaluate the mhealth implemented in Sub Saharan Africa between 2006 and 2016 reported that only 487 mhealth applications have been implemented, this is small fraction of the estimated number of health applications available (The Medical Worklfow Company, 2019). A small survey of Emergency Physicians on the use of mobile applications to improve the diagnosis of pesticide poisonings in South Africa (Kabanda and Rother, 2019), 67% of the doctors use health related mobile applications in daily practise and the EM guidance is the most common applications used (Kabanda and Rother, 2019).

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In South Africa, there has been a steady increase in the number of internet mobile phone users and a recent report in 2019 showed that 27.989 million South Africans use internet mobile phone (Clement, 2020). Despite, the increasing utilization of mobile health applications in South Africa from both the health practitioners and the people generally (Seebregts et al., 2018, Lahti et al., 2020), there is still a dearth of literature on the mobile application used, the purpose of the mobile applications and the effectiveness of the applications in practice. An

understanding of the extent and use would assist in facilitating patient management. A recent study in Australia shows that despite the high usage of medical applications by medical practitioners, there is a reluctance to recommend them to patients (Byambasuren et al., 2019).

1.6. Study aim

The aim of this study was to evaluate the extent and nature of the use of medical apps by doctors working in the Department of Paediatrics and Child Health in the School of Clinical Medicine of the University of the Witwatersrand in Johannesburg.

1.7. Study objectives

1. To look at the use of apps amongst medical staff in paediatrics concerning the following:
    a. reported proportion amongst all staff who respond to this survey
    b. the types of apps used in clinical practice
    c. the frequency of their use
    d. any differences amongst the various categories of the paediatric team concerning their choice of apps
2. To evaluate the level of awareness/knowledge amongst the paediatric staff of any existing regulations about medical apps.
3. To determine what features of medical apps do paediatric staff regard as important in determining their choice of these.

2. CHAPTER TWO: METHODS

2.1. Study design

A cross-sectional survey study was conducted using a questionnaire that was modified from a previously published study. This was via an online survey and a hardcopy to fill where needed.

2.2. Study site

The study was conducted amongst doctors working in the Department of Paediatrics and Child Health of the University of the Witwatersrand located at the three central teaching hospitals; the Rahima Moosa Mother and Child Hospital (RMMCH), Chris Hani Baragwanath Academic Hospital (CHBAH), Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) and three satellite hospitals: Thelle Mogoerane hospital, Sebokeng and Klerksdorp hospital. At the satellite hospitals only the registrars and consultants were invited to participate in the study.

2.3. Inclusion criteria

All the medical practitioners in the Department of Paediatrics and Child Health ~~department~~ of the University of the Witwatersrand were approached to participate in the study including the joint staff at the satellite sites ie consultants and registrars only at these sites.

2.4. Exclusion criteria

Medical practitioners who were part of the Department of Paediatrics at the satellite sites but were not on joint staff with the university i.e Medical Officers and interns were not invited to participate.

2.5. Data collection procedure

All the medical doctors that work within the Department of Paediatrics and Child Health ~~department~~ of the University of the Witwatersrand were approached to participate in the study via e-mail. Of the 285 medical doctors in the department, 150 responded between February 2018 and August 2018 and reminders were sent severally during the period of data collection.

2.6. Questionnaire

The questionnaire used for this study was adapted from an existing questionnaire used to measure smartphone application use among medical students in the United Kingdom (Payne et al., 2012). The questionnaire was modified to suit the aim of this study. Neither the original questionnaire nor the one used in this study were validated.

2.7. Data analysis

A statistical package IBM SPSS 25 (R) employed in analysing the data. All categorical variables were summarized using frequency (percentages). Fischer's Exact Test used to determine the association between categorical variables. The Fischer's exact test is most appropriate for measure of association when the sample size is small (McDonald, 2009). It is assumed that the requirements needed to perform a Chi-Squared test will not be met (Garson, 2012) and therefore Fischer's exact test is justifiably the most appropriate test. Level of significance was set at $p<0.05$. Missing data were treated as missing.

2.8. Ethics

Permission to conduct the study was obtained from the Human Research Ethics Committee of the University of the Witwatersrand on 31/01/2018 with protocol number M171141. The

Postgraduate Protocol Review Committee (Department of Paediatrics and Child Health) approved the protocol.

3. CHAPTER THREE: RESULTS

3.1. Demographic characteristics of the participants

A total of 150 (53%) respondents out of 285 from six hospitals completed the online survey. The majority of the 150 respondents were registrars (40%) and consultants (33.3%), as shown in Table 3.1 below.

Table 3.1: Rank of the participants (n=150)

Position	**N**	**%**
Consultant	50	33.3
Registrar	60	40.0
Medical officer	19	12.7
Intern	21	14.0
Total	**150**	**100**

The majority (48.6%) of the participants were from the Chris Hani Baragwanath Academic Hospital (CHBAH) followed by the Rahima Moosa Mother and Child Hospital (RMMCH) (25%) and the Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) (20.9%) as shown in Figure 3.1.

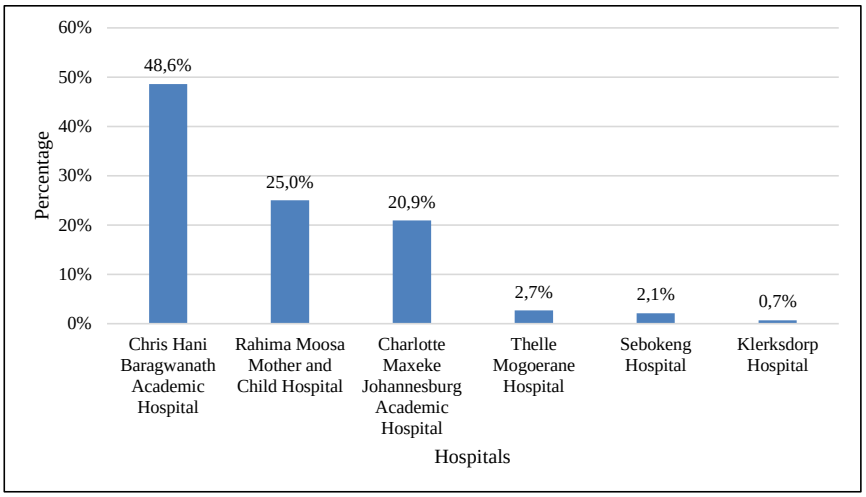

Figure 3.1: Participating hospital (n=148)

Table 3.2 below presents the frequency and percentages of the medical doctors according to the specific selected hospitals.

Table 3.2: Respondents distribution by rank within each hospital (n=148)

	Charlotte Maxeke Johannesburg Academic Hospital (n=31)		Chris Hani Baragwanath Academic Hospital (n=72)		Rahima Moosa Mother and Child Hospital (n=37)		Thelle Mogoerane Hospital (n=4)		Sebokeng Hospital (n=1)		Klerksdorp Hospital (n=3)		Total (N=148)	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**N**	**%**
Consultant	9	29.0	26	36.1	8	21.6	2	50	1	100	2	66.7	48	32.4
Registrars	16	51.6	30	41.7	11	29.7	2	50			1	33.3	60	40.5
Medical officers	4	12.9	6	8.3	9	24.3	-	-	-	-	-	-	19	12.8
Interns	2	6.5	10	13.9	9	24.3	-	-	-	-	-	-	21	14.2

As shown in Table 3.2, the majority of the participants in the top three participating hospitals were registrars. At CMJAH they comprised just over half of the respondents (51.6%) whilst at CHBAH they constituted 41.7% and at RMMCH they were 29.7% of the respondents. In the other three satellite hospitals, only consultants and registrars were invited to participate in the study.

3.2. Frequency of smartphone app use in everyday clinical practice

Of the 150 respondents, 73.3% use smartphone several times a day in everyday clinical practice and 16.7% use smartphone app once a day as shown in Figure 3.2.

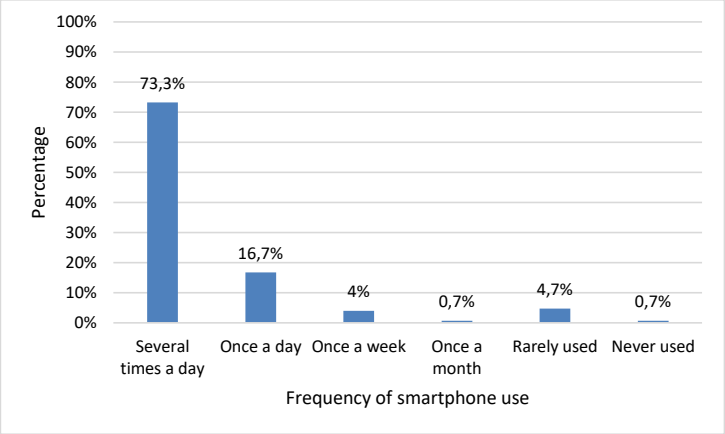

Figure 3.2: Extent of smartphone use in clinical practice (n=150)

Table 3.3 outlines the extent of smartphone use in everyday clinical practice to assist with patient management according to the rank of the participants. The result shows that 81.7% of the registrars use smartphones to assist with patient management several times a day. Only 54% of the consultants use the smartphone in clinical practice several times a day.

Table 3.3: Extent of smartphone use in assisting in clinical management (n=150)

Position	Frequency of use	N	%
Consultant (n= 50)	Never used	1	2
	Once a week	4	8
	Rarely used	4	8
	Once a day	13	26
	Once a month	1	2
	Several times a day	27	54
Registrar (n=60)	Once a week	2	3.3
	Rarely used	2	3.3
	Once a day	7	11.7
	Several times a day	49	81.7
Medical officer (n=19)	Once a day	3	15.8
	Several times a day	16	84.2
Intern (n=21)	Rarely used	1	4.8
	Once a day	2	9.5
	Several times a day	18	85.7

3.3. Association between medical doctor rank and the extent of smartphone use in everyday clinical practice

A determination of association using Fischer's exact test was used to determine the association between current position and extent of smartphone use in everyday clinical practice to assist with patient management. The Fischer's exact test showed no significant association, p=0.297.

3.4. Medical apps used in clinical practice

Table 3.4 presents the frequencies and percentages of the most commonly used medical apps by the participants in clinical practice. The most commonly used medical apps are reference tools (81.7%), diagnostic tools (58.17%) and clinical decision-making tools (43.79%). Table 3.5 and 3.6 below outlines the pattern of medical application use according to the current position of the participants.

Table 3.4: Medical apps used in clinical practice

	Total (N=150)		Consultant (n=50)		Registrar (n=60)		Medical officer (n=19)		Intern (n=21)	
Common medical apps used in clinical practice	**N**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Diagnostic tools	89	59.33	28	56	34	56.767	10	52.63	17	80.95
Electronic health record data capturing and viewing	37	24.767	13	26	15	25	5	26.32	4	19.05
Reference tools	125	83.33	35	70	53	88.33	18	94.74	16	76.219
Secure messaging	46	30.767	16	32	17	28.33	6	31.658	6	28.657
Clinical decision-making support tools	67	44.767	18	36	28	46.767	8	42.11	13	61.90
Patient engagement	14	9.33	8	16	4	6.767	2	10.53	0	0.00
Making notes and documentation tools	26	17.33	13	26	7	11.767	5	26.32	1	4.876
Not using apps for my clinical practice	8	5.33	5	10	3	5	0	0	0	0

Table 3.5: Medical apps used by senior (consultants) and junior doctors (Registrars, MOs, Interns)

Common medical apps used in clinical practice	Senior doctors		Junior doctors		Fischer's exact test
	n	%	n	%	p-value
Diagnostic tools	20	56.4	27	67.5	0.056
Electronic health record data capturing and viewing	28	25.5	9	22.5	0.954
Reference tools	88	80	34	85	0.055
Secure messaging	33	30	12	30	0.985
Clinical decision	46	41.8	21	52.5	0.174
Patient engagement	12	10.9	2	5	0.231
Making notes and documentation tools	20	18.2	6	15	0.095
Not using apps for my clinical practice	8	7.3	0	0	0.442

As shown in Tables 3.6, 80% and 85% of the senior doctors and junior doctors respectively used reference tools followed by diagnostic tools in 56.4% and 67.5% of the senior and junior doctors respectively. Further classification of the senior doctors showed that, 88.3% of the registrars use reference tools and 56.7% use diagnostic tools. Further classification of the junior doctors showed that 94.7% of the medical officers use reference tools and 52.6% use diagnostic tools.

3.5. Association between common medical apps and positions of the participants

Measure of association using Fischer's exact test was used to determine the association between the common medical apps used in clinical practice and the current position of the participants. The Fischer's exact test result showed no significant association in all the commonly used apps and the rank of the medical doctor ($p>0.05$) as shown in Table 3.6 below.

3.6. Criteria when evaluating a potential app for use in clinical practice

The most commonly reported criteria when evaluating a potential app among the respondents was peer recommendation (75.8%), app credibility (66%), functionality (65.4%) and usability (64.7%). Table 3.7 below outlines the criteria when evaluating a potential app for use in clinical practice.

Table 3.4 below outlines the criteria when evaluating an app for potential use according to the rank of the respondents.

Table 3.6: Criteria when evaluating a potential app for use in your clinical practice

	Total (N=150)		Consultant (n=50)		Registrar (n=60)		Medical officer (n=19)		Intern (n=21)		Fischer's exact test
Criteria when evaluating a potential app for use in your clinical practice	N	%	n	%	n	%	n	%	n	%	p-value
Peer recommendation	116	75.8	33	66	45	75	17	89.5	19	90.5	0.017*
App credibility	101	66	38	76	36	60	9	47.4	15	71.4	0.103
Functionality	100	65.4	33	66	39	65	14	73.7	13	61.9	0.441
Usability	99	64.7	35	70	35	58.3	12	63.2	14	66.7	1.000
Used or recommended by a senior	92	60.1	17	34	40	66.7	15	78.9	17	81	0.002*
Cost	90	58.8	33	66	33	55	10	52.6	12	57.1	0.581
Clinical impact	76	49.7	32	64	22	36.7	10	52.6	11	52.4	0.854
Security	31	20.3	16	32	8	13.3	4	21.1	3	14.3	0.653
Integration	14	9.2	3	6	9	15	19	100	2	9.5	0.355
Not sure	2	1.3	2	4	0	0	0	0	0	0	1

Consultants majorly reported app credibility (76%) and usability (70%) as the major criteria when evaluating a potential app for use in your clinical practice. Registrars on the other hand reported peer recommendation (75%) and used or recommended by a senior (66.7%) as the major criteria when evaluating a potential app. Medical officers reported app integration (100%) and peer recommendation (89.5%) as the major criteria when evaluating a potential app for use in your clinical practice.

3.7. Association between criteria for choosing apps, position and type of medical application used

Association between criteria for choosing apps, position and type of medical applications used was measured by using the Fischer's exact test. The results showed that there was a significant association between the rank of the medical doctor and the following - Peer Recommendation (p=0.017) and Used or recommended by a senior (p=0.002) as shown in Table 3.6.

3.8. Concerns about using medical apps in your practice

App credibility (standards and content accuracy) (72.5%) and data usage (56.9%) were the two most common concerns about using medical apps as shown in Table 3.10.

Table 3.7: Concerns about using medical apps in your practice (n=150)

Criteria when evaluating a potential app for use in your clinical practice	Total		Consultant (n=50)		Registrar (n=60)		Medical officer (n=19)		Intern (n=21)		Fischer's exact test
	N	%	n	%	n	%	n	%	n	%	p-value
App credibility (standards and content accuracy)	111	72.5	32	64	45	75	15	78.9	17	81	0.513
Internet and data Usage	87	56.9	32	64	37	61.7	9	47.4	8	38.1	0.184
Cost	60	39.2	27	54	20	33.3	5	26.3	7	33.3	0.121
Privacy and security	39	25.5	16	32	14	23.3	4	21.1	5	23.8	0.763
Ongoing maintenance	33	21.6	9	18	11	18.3	5	26.3	8	38.1	0.312
Integration into your practice	23	15	6	12	6	10	5	26.3	6	28.6	0.154
None/Do not know	6	3.9	3	6	1	1.7	0	0	1	4.8	0.117

The results showed that the app's credibility (standards and content accuracy) and internet and data usage were the major concern in all the doctors. Consultants (64%), registrars (75%), medical officers (78.9%) and interns (81%) reported the app's credibility (standards and content accuracy) as a major concern. Internet and data usage was also a major concern reported by the medical doctors, 64% of the consultants, 61.7% of the registrars, 47.4% of the medical officers and 38.1% of the interns all reported internet and data usage as a concern

Fischer's exact test was used to determine the association between concerns about using medical apps in your practice and current position. The result showed that all the potential concerns about using medical apps in practice was not significantly associated with the position of the medical doctor, $p>0.05$ as shown in Table 3.7. Using Fischer's Exact Test to measure association between two categorical variables, there was no significant association between the concerns of the participants and their current rank (Table 3.7).

3.9. How to recognize a high- quality app?

Table 3.8~~13~~ shows the frequency and percentages reported by the medical doctors on how to recognize a high-quality app.

Table 3.8: How to recognize a high-quality app (n=150)

	n	%
Is updated regularly	112	73.2
Has been scientifically evaluated	109	71.2
Has been peer reviewed	98	64.1
Approved by a regulatory body	91	59.5
Password protected	37	24.2
Developed by a not-for-profit organization	22	14.4

The medical doctors reported regular update of the app (73.2%), scientific evaluation (71.2%) and peer review of the apps (64.1%) as the important criteria for identifying a high-quality app.

3.10. Regulations

The majority of the participants (95%) were unaware of any regulatory bodies for controlling medically related apps on smartphones.

3.11. Internet accessibility

The majority of the participants (86%) do not have access to free Wi-Fi at work and majority (86.1%) would use the medical apps if there was free Wi-Fi.

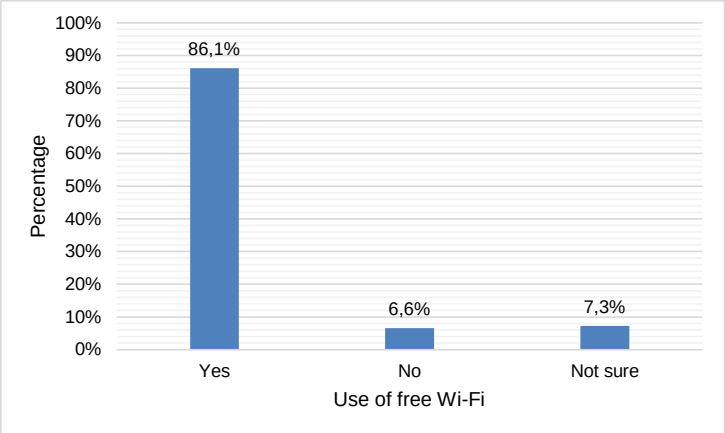

Figure 3.3: Would use apps if free Wi-Fi available (n=150)

3.12. Common Apps Used

Medscape (n=93), *EM guidance* (n=62) and *Paeds Calc* (n=55) were the most commonly used medical apps as shown in Figure 3.6 below

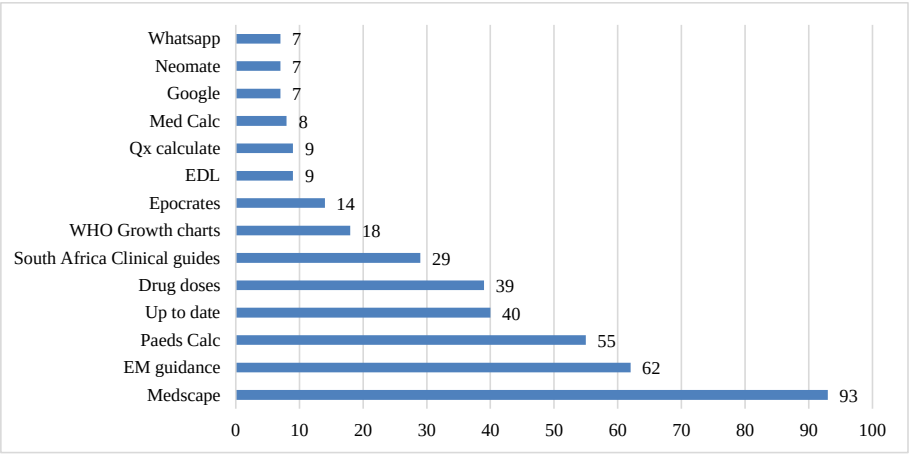

Figure 3.4: Commonly used apps (n=150)

Table 3.14 presents the frequency of use of the medical apps in clinical practice. The result show that *Medscape* (n=37), *EM guidance* (n=25), *Paeds Calc* (n=25) and *Drug Doses* (n=22) were commonly used several times a day.

Table 3.9: Frequency of use of specific medical apps in clinical practice (n=150)

	Once a month		Once a week		Several times a week		Once a day		Several times a day	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Medscape	4	13.33	7	18.07.95	19	20.43	24	32.43	37	26.106
EM Guidance	3	10.00	4	10.026	15	16.13	14	18.92	25	17.61
Paeds Calc	4	13.33	1	2.656	14	15.105	11	14.86	25	17.61
Drug doses	1	3.33	4	10.326	6	6.545	5	6.876	22	15.549
Up to date	5	16.767	8	20.51	10	10.875	6	8.11	11	7.875
Growth Charts	0	0.00	4	10.326	4	4.30	2	2.70	8	5.63
Med Calc	0	0.00	2	5.13	1	1.108	0	0.00	5	3.52
Clinical guides	8	26.767	6	15.438	9	9.768	3	4.105	3	2.11
EDL	1	3.33	1	2.656	4	4.30	0	0.00	3	2.11
Neomate	3	10.00	0	0.00	2	2.215	1	1.435	1	0.70
Qx calculate	1	3.33	1	2.656	4	4.30	2	2.70	1	0.70
Epocrates	0	0.00	1	2.656	5	5.38	6	8.11	1	0.70
Denominator	30		39		93		74		142	

4. CHAPTER FOUR: DISCUSSION AND CONCLUSION

This study aimed to evaluate the use of medical apps in everyday clinical practice in selected hospitals in South Africa. The various sections of the study are discussed below.

4.1. Discussion

Frequency of smartphone use in everyday clinical practice

In our study, 73.2% of the medical doctors in this study reported using clinical apps several times a day. This is not surprising; currently, the use of mobile apps for various daily activities is common regardless of the profession, rank and age group. It was shown in our study that, the use of mobile app cuts across all the ranks. Although, junior doctors reported a higher usage compared to senior doctors. Our study corroborates recent studies that have reported an increasing mobile application usage in medical practice (Payne et al., 2012, Ganasegeran et al., 2017, Buabbas et al., 2019). Similarly, a rising trend was predicted in a survey conducted by the General Medical Council UK, where it estimated 83% of doctors would be using smartphones by 2012 (Payne et al., 2012).

The numbers of doctors using these apps are comparable to numbers published in other studies (Alkhateeb and Doucette, 2009, Byambasuren et al., 2019, Patel et al., 2015). However, numbers using other apps like communication and counselling, data and information management, medical education and training are lesser as compared to other studies. Doctors of all ranks use medical apps; however, younger doctors (registrars and interns) use apps more frequently than senior doctors (consultants) which are perhaps due to the reason that they are more familiar with the technology. Other studies have also assessed the relationship between seniority and age and the results have shown that despite the increasing use by younger people, the influence of age on the usage of mobile applications is not entirely clear and that perceived usefulness and perceived ease of use are predictors of mobile medical applications (Veríssimo,

2018). Although it has also been reported that older doctors are less likely to adopt the use of mobile medical applications compared to younger doctors (Alkhateeb and Doucette, 2009, Patel et al., 2015).

Medical apps used in clinical practice

In our study, reference tools (81.7%), diagnostic tools (58.17%) and clinical decision-making support tools (43.79%) were the three most commonly used medical apps in clinical practice. The interns most commonly used the diagnostic tools 19.1% (n=17) and decision making 61.9% (n=13) while the registrars 42.4% (n=53), consultants 28% (n=35) and medical officers 14.4% (n=18) used the reference tools the most in their clinical practice. There was no significant association between the use of the medical application in clinical practice and the rank of the doctor. The increased reliance of healthcare professionals on electronic resources was identified in the Manhattan Research/Physician Channel Adoption study which reported that physicians spend (64%) of their online time looking for information to make or support clinical decisions, double the time spent reviewing print sources (Chase, 2013). Examples of such apps are: UpToDate®, 5-Minute Clinical Consult, Medscape, Epocrates · Dynamed, Skyscape, Diagnosaurus, Pocket Guide to Diagnostic Tests (Mosa et al., 2012, Aungst, 2013).

There are currently more than 165000 medical apps being used globally (Aitken and Lyle, 2015), providing resources around the clock regarding evidence-based disease information, patient management and other purposes. Not all these apps are scrutinised by regulatory bodies for assessing their quality of information (Pagoto and Bennett, 2013). There are also concerns about quality, efficacy, security and reliability of the use of these apps. This also raised concern regarding the safety of applying the information gathered from these apps in clinical practice (Chan et al., 2015, Andersson et al., 2014). Meta-analytic studies have demonstrated the

efficacy of some medical apps, but also the evidence base of other types is poor at best (Fiordelli et al., 2013, Heffner et al., 2015).

Criteria when evaluating a potential app for use in your clinical practice

Peer recommendation (75.8%), app credibility (66%), functionality (65.4%), and usability (64.7%) and used or recommended by a senior (60.1%) are the common criteria used in evaluating a potential app for use in clinical practice. For the cConsultants, the most significant factorstop reported when evaluating trends werean application for clinical practice were credibility (n=38), usability (n=35), peer recommendation (n=33), functionality (n=33), cost (n=33) and clinical impact (n=32) as the most common criteria when evaluating a potential application for use in clinical practice. Registrars citing these factors,reported peer recommendation (n=45), recommended by a senior (n=40), functionality (n=39), application credibility (n=36) and usability (n=35) as the most common criteria when evaluating a potential application for use in clinical practice.

Concerns about using medical apps in your practice

App credibility (standards and content accuracy) (72.5%), data usage (56.9%) and cost (39.2%) were the most common concerns about using medical apps. Other studies have also identified other concerns about the use of medical applications in your practice, concerns such as trust, security and verifiability have also been reported (Meulendijk et al., 2014). Privacy and security concerns about the consumer have been identified as well (Plachkinova et al., 2015).

How to recognize a high- quality app?

Updated regularly (73.2%), scientifically evaluated (71.2%), peer-reviewed (64.1%) and approved by a regulatory body (59.5%) are the most common requirements identified in recognizing a high-quality application. According to the findings of our study, most of the variable regarding selection criteria, concerns about the use of apps in clinical practice, and recognizing high quality are well established in the current literature. However, still, the

knowledge was not up to mark as explained in previous studies. The practice of quality oversight is identified as a criteria in a systemic review of criteria for assessing the quality of mHealth apps by Nouri et al. (2018).

Researchers developed the Mobile App Rating Scale (MARS) which provided them with a brief tool for assessing and classifying the quality of medical apps (Stoyanov et al., 2015). MARS includes 23 items, which do engagement, functionality, aesthetics, information quality and subjective quality. The MARS proved to be very significant for testing the quality of medical apps on well- being (Stoyanov et al., 2015) and mindfulness (Mani et al., 2015). In South Africa, the uMARS can be adopted in identifying the use of mobile medical applications in regular clinical practice.

Regulation

The majority of the doctors are not aware of regulatory bodies for controlling medically related apps on smartphones as reported in the literature. Two most common are the FDA and the EU regulatory framework (Greene and Kesselheim, 2010, US Food and Drug Administration, 2019). Although the framework of the regulation is not entirely clear, several authors have complained about the limits and scope of the regulatory agencies (McNiel and Binder, 2018, Schoenfeld et al., 2016).

4.2. Limitations

Participants were enrolled voluntarily. This could have resulted in a selection bias whereby respondents would have been more technologically literate than non-responders. Despite the fact that these limitations, data received from our convenience survey provide a base for further studies.

4.3. Recommendations

~~We recommend that, as medical apps are increasing more and more doctors are adopting them in their daily clinical practice, so we suggest that:~~ Given the results of this study we can make the following set of recommendations :

- ~~Most of the applications reported are not South African or African based and it would be important to explore the opportunity of modifying the apps to suit local needs.~~
- t~~T~~here should be a ~~regulatory body at~~ national ~~level~~ regulatory authority most suitably under the umbrella of the Health Professions Council of South Africa (HPCSA)~~A~~ that should ~~. The regulatory body should monitor~~advise on the criteria of ~~use of~~ apps in terms of quality of contents, cost, confidentiality and ethical issues related to the use of medical apps in practice
- there is great scope for both adaptation of existing medical apps to local needs as well as the development of local apps for the South African context.
- ~~We also recommend that medical apps should be incorporated into clinical practice based on their frequency of use; instead,~~ all the medical apps should undergo a trial of uMARS to assess their quality.

4.4. Conclusion

Medical apps are being increasingly used by pediatric medical staff of all ranks, supporting them in their clinical decision-making, improving patient management and making better communication amongst the health professionals at different levels. These apps are used to support the staff in their clinical decision- making and to improve patient management and communication amongst the health professionals. Amongst the medical staff in paediatrics, junior doctors, registrars and interns, used apps more frequently than senior doctors such as the consultants. The senior doctors mostly used apps for disease information, where juniors used the apps for the purpose of patient management. There was no difference in their trend of

choosing a particular application; however, peer recommendation was a major factor. Both senior and junior doctors did not have knowledge about the regulatory bodied regarding the medical apps.

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APPENDIX 1: ETHICS CLEARANCE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Office of the Deputy Vice-Chancellor (Research & Post Graduate Affairs)

TO: Dr S Mahmood
School of Clinical Medicine
Department of Paediatrics and Child Care
University

E-mail: drshahid185@gmail.com

CC: Supervisor: Professor A Coovadia <Ashraf.Coovadia@wits.ac.za>
and <HREC-Medical.ResearchOffice@wits.ac.za>

FROM: Iain Burns
Human Research Ethics Committee (Medical)
Tel: 011 717 1252

E-mail: Iain.Burns@wits.ac.za

DATE: 31/01/2018

REF: *R14/49*

PROTOCOL NO: **M171141** *(This is your ethics application study reference number. Please quote this reference number in all correspondence relating to this study)*

PROJECT TITLE: *The use of medical apps amongst doctors working in the Department of Paediatrics of the University of the Witwatersrand, in Johannesburg, South Africa*

Please find attached the Clearance Certificate for the above project. I hope it goes well and that an article in a recognized publication comes out of it. This will reflect well on your professional standing and contribute to the Government funding of the University.

MSWorks2000/Iain0007/Clearscan.wps

APPENDIX 2: QUESTIONNAIRE

Use of Medical Apps amongst Paediatric Staff

By completing this survey you are providing your consent for your information provided to be used as part of a research project in an anonymous fashion.

1. Please state your current position

- ○ Consultant
- ○ Intern
- ○ Registrar
- ○ Research staff
- ○ MO (including Community Medical Officer)

2. To what extent do you use your smartphone in your everyday clinical practice to assist with patient management?

- ○ Never used
- ○ Once a week
- ○ Rarely used
- ○ Once a day
- ○ Once a month
- ○ Several times a day

3. What type of medical apps are you using in your clinical practice? Tick all that apply

- ☐ Diagnostic Tools
- ☐ Electronic Health Record Data Capturing and Viewing
- ☐ Reference Tools
- ☐ Secure Messaging
- ☐ Clinical Decision-Making Support Tools
- ☐ Patient Engagement
- ☐ Making Notes and Documentation Tools
- ☐ Not using apps for my clinical practice

Other (please specify)

4. What are your top five criteria when evaluating a potential app for use in your clinical practice?

- ☐ App Credibility
- ☐ Functionality
- ☐ Peer Recommendation
- ☐ Cost
- ☐ Used or recommended by a senior
- ☐ Security
- ☐ Usability
- ☐ Integration
- ☐ Clinical Impact
- ☐ Not Sure

Other (please specify)

5. What are your biggest concerns about using medical apps in your practice? (please comment too)

- [ ] Cost
- [ ] Apps Credibility (Standards and Content Accuracy
- [ ] Privacy and Security
- [ ] Integration into Your Practice
- [ ] Internet and Data Usage
- [ ] Ongoing Maintenance
- [ ] None/Do Not Know

Please comment on any of these or any other concerns you have

6. Please list the top five medical apps you employ in your clinical practice (list the most commonly used first and the least of these last)

App 1	
App 2	
App 3	
App 4	
App 5	
N/A	

7. Please indicate the frequency of use of these top five medical apps in your clinical practice

	Once a month	Once a week	Several times a week	Once a day	Several times a day	N/A
App 1	○	○	○	○	○	○
App 2	○	○	○	○	○	○
App 3	○	○	○	○	○	○
App 4	○	○	○	○	○	○
App 5	○	○	○	○	○	○

8. How would do you determine whether a medical app is credible and reliable? Please select the options you believe are critical in making this determination and add any other if you feel its relevant.

- [ ] Developed by a not-for-profit organization
- [ ] Has been scientifically evaluated
- [ ] Is updated regularly
- [ ] Has been peer reviewed
- [ ] Password protected
- [ ] Approved by a regulatory body
- [ ] Other (please specify)

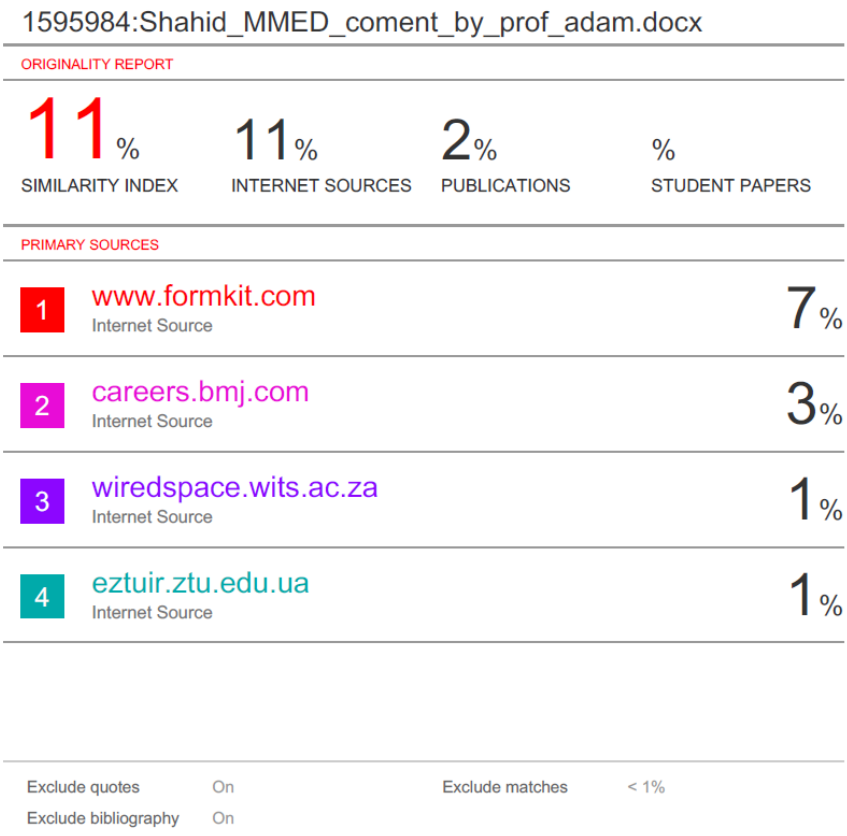
9. a) Do you have access to free WiFi at your place of work ?

10. Would you use mobile apps for clinical practice more frequently if WiFi was available at your place of work at no cost to you ?

11. Are you aware of any regulatory bodies for controlling medically related apps on smartphones ?

12. If you answered YES to question 10. please specify which regulatory authority/authorities you are aware of.

APPENDIX 3: TURN IT IN REPORT



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