Smartphone apps commonly used by doctors working in Orthopaedic Surgery at the University of the Witwatersrand in Johannesburg: Are they peer-reviewed?

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

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Declaration

I, Virsen Singh, declare that this Research Report is my own, unaided work. It is being submitted for the Degree of Master of Medicine in the branch of Orthopaedic Surgery at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

……
(Signature of candidate)

…29th…day of ……May…….2019……in……Johannesburg…

Presentations arising from research project

There are no presentations arising from this research report.

Publications arising from research project

There are no publications arising from this research report.

Abstract

Background: As the popularity of smartphones soar throughout the world, their usefulness within the workplace, and particularly the healthcare sector, has increased dramatically. Unfortunately, not all healthcare-related smartphone apps can be trusted in terms of the accuracy of their content. Just as articles in journals undergo a peer-review process to determine their accuracy, the medical world has begun to peer-review the contents of medical apps. In this study, we aim to determine the most commonly used orthopaedic smartphone apps in our population group as well as find out if the content of these apps has been peer-reviewed.

Methods: A prospective study was conducted in the Department of Orthopaedic Surgery at the University of the Witwatersrand, to determine the most commonly used healthcare-related apps. We then analysed the content of these apps, to see if it was peer-reviewed.

Results: Of the 87 doctors surveyed (22 consultants; 49 registrars and 10 medical officers), 81 used their smartphones in their medical practice. The majority of doctors used apps which fell into the "reference" category, which allowed them to quickly access information regarding diagnosis, treatment and surgical approaches. Only seven doctors (8%) had checked to see if the apps they were using had been peer-reviewed. Twelve doctors (14%) felt that it was not important to peer-review these apps, while the majority (68 doctors, 78%) felt that it was important, but had not specifically checked.

Discussion: Regarding the content of the apps, only eight of the thirteen apps included in the survey (62%) had been peer-reviewed by an expert in the field of orthopaedic surgery. The other five apps (38%) had never been reviewed in terms of their content. Some of the apps did not even have a medical expert on their development team.

Conclusion: Our recommendation is that apps intended for use by clinicians should all undergo a peer-review process before being made available for download. Furthermore, these apps should provide a concise summary of the development process in the app description, which the user can peruse before downloading and

using the app. Lastly, we believe that the onus lies with the clinician to ensure the accuracy of the content of these apps before using them in the healthcare setting.

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Nomenclature

- Smartphone - A mobile phone which performs many of the functions of a computer; typically having an operating system capable of running downloaded applications; a touchscreen interface and internet access
- Smartphone Application (App) - A platform-specific, self-contained piece of software, developed to fulfill a particular purpose; usually downloaded for use on a smartphone
- Apple (Apple, Incorporated) - Smartphone developer (iPhone) based in Cupertino, California
- Samsung (Samsung Electronics, Incorporated) - Smartphone developer (various models) based in Suwon, South Korea
- iOS (iPhone Operating System) - A smartphone firmware developed by Apple and used on Apple devices
- Android - A smartphone firmware developed by Google (Mountain View, California) and used on the majority of Samsung devices and many other brands of devices
- Apple App Store - A digital distribution platform for mobile apps on iOS firmware; developed and maintained by Apple Inc.
- Android Market - A digital distribution platform for mobile apps on Android firmware; developed and maintained by Google

- Jailbroken - An iPhone in which the firmware has been modified to allow the user to access applications which they would not usually be able to access due to developer restrictions on the device

- Orthopaedic Surgeons - Medical Officers, Registrars and Consultants employed in the field of Orthopaedic Surgery

- HIPAA Compliant - Health Insurance Portability and Accountability Act compliant, which is a standard for collecting sensitive patient data when performing patient-based studies in the USA

- SurveyMonkey - SurveyMonkey, San Mateo, CA, USA, founded 1999. A web-based survey website

- WhatsApp - WhatsApp Inc., Mountain View, CA, USA, founded 2009. An online, instant messaging application, available on smartphones and computers

- iMedicalApps.com - iMedicalApps is the leading online publication for medical professionals, patients, and analysts interested in mobile medical technology and healthcare apps

List of Abbreviations

CHAPTER 1

1.Introduction and Literature Review

1.1. Background

As smartphones begin to have more memory and better processing power, they are able to run bigger and more complex smartphone applications (apps). Over the years, smartphones have evolved from expensive, bulky devices with pixelated screens to the thinner, more user-friendly smartphones that most of us have in our pockets today (1). This, combined with the popularity of these devices, results in more and more clinicians using the apps on their smartphones to aid their clinical practice (2). The aim of this study was to identify the healthcare-related apps most commonly used by doctors working in the Department of Orthopaedic Surgery at the University of the Witwatersrand, and to establish whether or not they are peer-reviewed. By increasing awareness regarding the need for apps to be evidence-based, we hope to encourage doctors to be judicious when downloading these apps and using them in a clinical setting.

1.2. Literature Review

The first smartphones appeared as early as 1992, but only performed basic functions such as keeping an address book; receiving email headings and storing text files (3). It was not until the early 2000's that the first smartphones capable of web browsing came about from developers Palm and Blackberry (4). It was at this stage that smartphone use in the US began to soar.

It was not until 2007, when the Apple iPhone first appeared, that the concept of "smartphone apps" was born (5). This concept was a revolution in the functionality of smartphones. The devices were no longer limited to the functions that they came with on the day of purchase. Users were now able to download third-party apps which increased the functionality of the device (5). The benefits of apps are two-fold: they allow more convenient and quicker access to information and they increase the longevity of the devices by constantly increasing functionality without any hardware upgrades (5).

Currently, there are just over 6 billion active SIM-cards worldwide (6) with the estimated number of smartphone users sitting between 1.5 and 1.85 billion (6, 7). If we look at the latest data for global smartphone sales in the first quarter of 2016, the market is dominated by Apple accounting for 40.2% of all sales. They are followed by Samsung at 23.2% and Chinese brand, Huawei, at 6% (see Figure 1.1) (8).

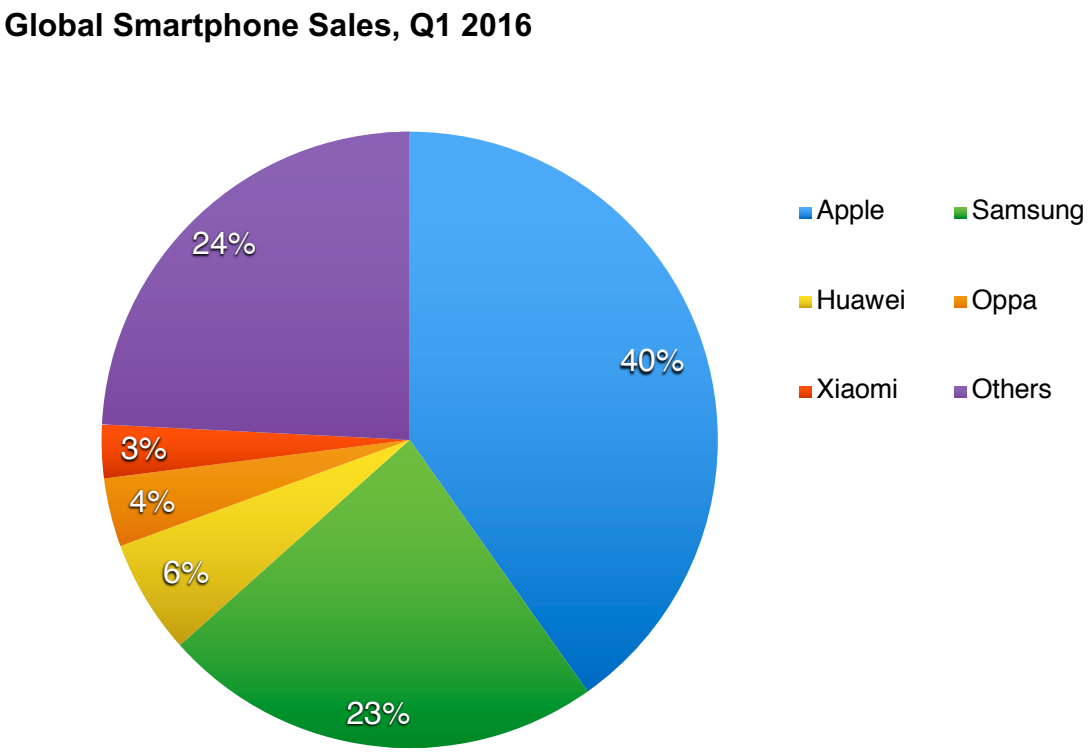

Figure 1.1: A pie chart showing the global smartphone sales in the 1st quarter of 2016 (8).

When it comes to smartphone ownership, most of the data available are US-based. Once again it is evident that Apple dominates this market. Eighty six percent of US broadband households now own a smartphone. The vast majority of these individuals use Apple devices (40%), followed by Samsung (31%) and LG (10%). The remaining 19% is made up by Motorola, HTC and some lesser known brands (9).

Despite the high prevalence of Apple devices, the operating system usage figures paint a very different picture. Global statistics from 2015 show that the majority of users (80%) use an Android platform, 16% use Apple's iOS; 3% Windows and 1% use lesser known operating systems (see Figure 1.2) (10).

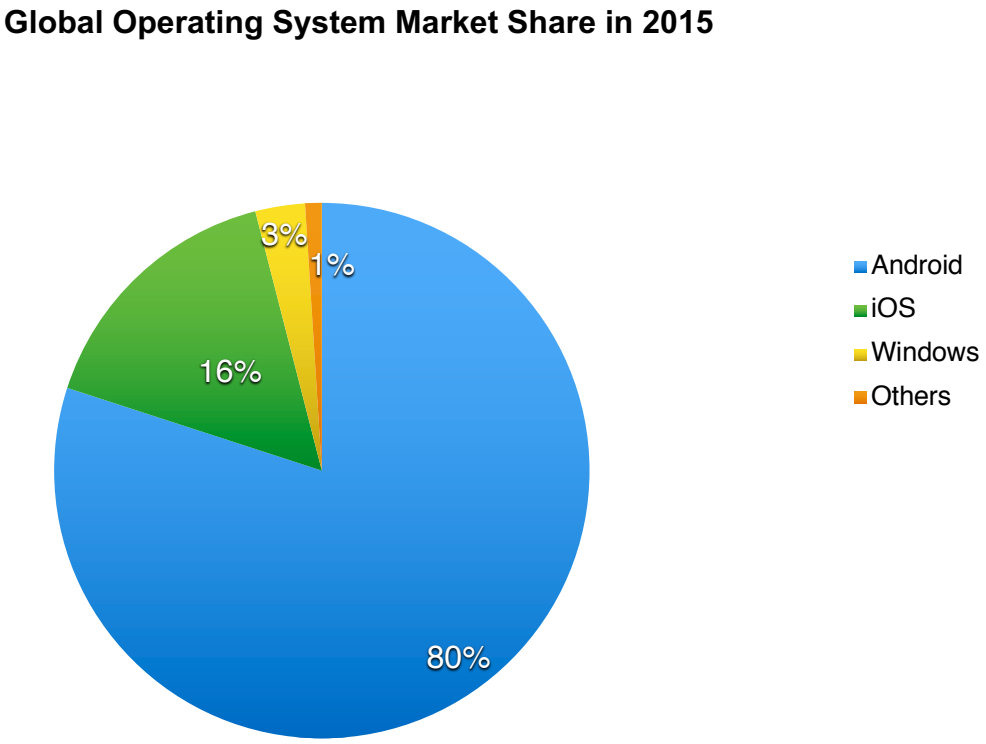

Figure 1.2: A pie chart showing the global operating system market in 2015 (10).

The reason for Android's dominance in this area is due to the fact that the Google-developed operating system is used by multiple brands, as opposed to Apple's iOS, which is used only by Apple devices.

With the large number of apps available on these app stores, one simply needs to perform a keyword search, and there will be multiple apps available on the desired subject matter. As of June 2016, the Apple App Store had 2 million apps available for download, and the Android Market surpassed this with 2.2 million apps available for download (11). In June 2015, the Apple App Store reported surpassing 100 billion downloads in just under 7 years (12).

When it comes to apps in healthcare, there is no shortage of apps on the app stores. In 2012, Obiodu reviewed the top 500 ‘medical apps’ available on the Italian Android Market (13). She found that the majority of these apps were developed for use by healthcare professionals. Furthermore, each app had undergone an average of 3000 downloads (13).

Despite these readily available healthcare apps, the medical community has been relatively slow in integrating these into their daily practice. Kijsanayotin et al. looked at the adoption of health information technology in healthcare centres in Thailand and found that social influence was a large contributing factor to how quickly healthcare workers started using information technology in their clinics (14). These trends come back to the Technology Adoption Cycle described by Bohlen in 1957, a concept which is still relevant today (see Figure 1.3) (15). According to his model, the majority of users of technology are the early and late adopters. This large group is comprised of the individuals who rely on social influence and the experiences of their peers, before deciding to try something new (15).

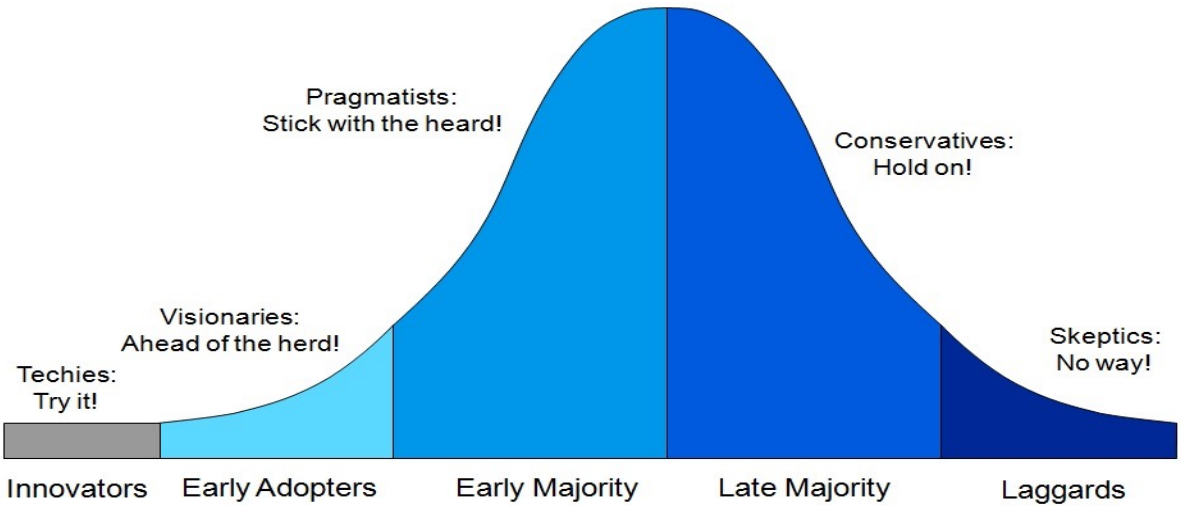

Figure 1.3: The Technology Adoption Cycle (15).

Apps in healthcare can have a wide range of uses. Aungst described four main groups of clinical uses of smartphone apps in healthcare i.e. reference; clinician-centred apps; patient-centred apps and education (see Figure 1.4) (16). Each of these categories contains four minor subgroups of the commonly used apps. Personnel working in different avenues of healthcare seem to favour different groups of apps. For example, Aungst found that those individuals working in pharmacy practice, favoured the use of apps in the reference category, specifically drug reference (16). Furthermore, he found that clinicians mainly used apps that were categorised as clinician-centred and patient-centred. Those clinicians involved in the teaching of medical or nursing students fell within the group that used education-based apps.

Clinical Uses for a Medical App

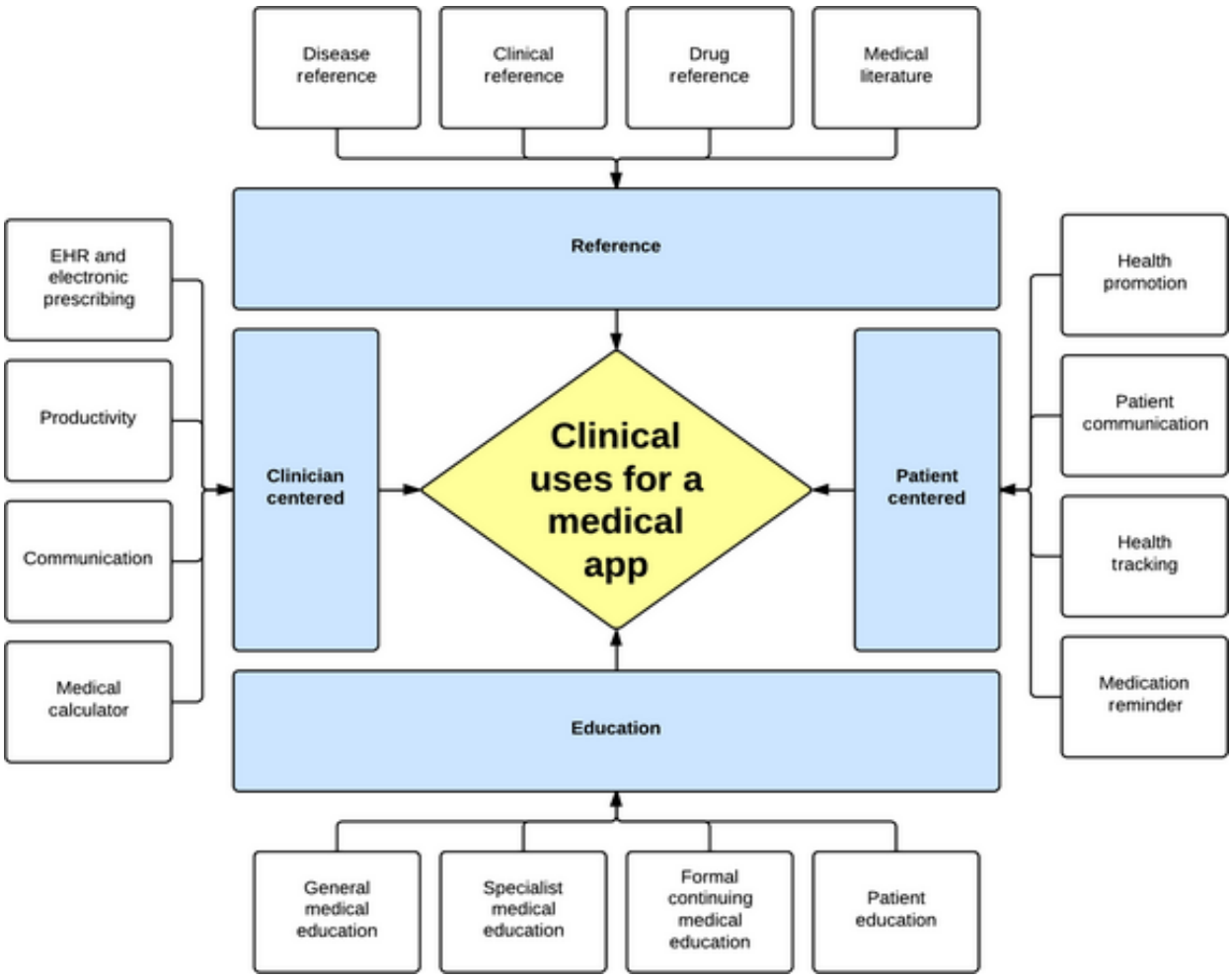

Figure 1.4: A flow chart showing "Clinical Uses for a Medical App" (16).

In the field of orthopaedics, apps are available for a wide range of uses, from providing 3-dimensional anatomy images to allowing you to take a photo of an X-ray and measure angles on your smartphone screen. There is paucity of data in the literature looking at which smartphone apps are favoured by orthopaedic surgeons.

Despite the large number of available healthcare apps and their widespread use in clinical practice, there still remains a poor evidence base for their content. One

study found that less that 35% of apps in the “Healthcare” section of the Apple App Store had a medical expert on their development panel (17).

Aungst et al. were the first to see a need to provide information and reviews on the vast number of healthcare apps. In doing so, they aimed to assist healthcare workers in choosing the most appropriate app for their need (16). His team decided to set up a website (iMedicalApps.com) which peer-reviews healthcare apps and make recommendations for download.

Visser found that the majority of the 17,000 medical apps surveyed were simply void of detailed content and did not fulfill the need for which the app was initially sought (18). The recommendation made was that a system be put in place for peer-reviewing apps, and that clinicians themselves critically assess apps before using them.

CHAPTER 2

2. Methodology

2.1. Research Question

Which healthcare-related smartphone apps are mostly used by doctors working in the Department of Orthopaedic Surgery at the University of the Witwatersrand and are these apps peer-reviewed?

2.2 Study Aim and Objectives

The aim of the study is:

To determine whether the healthcare-related apps most commonly used by doctors working in the Department of Orthopaedic Surgery at the University of the Witwatersrand are peer-reviewed.

The objectives of the study are:

- To identify the most commonly used healthcare-related smartphone apps used by doctors working in the Department of Orthopaedic Surgery at the University of the Witwatersrand, by means of an online questionnaire

- To review the top 10 apps on each platform and see if their content is peer-reviewed
- To identify if doctors in the Department of Orthopaedic Surgery at the University of the Witwatersrand believe that a peer-reviewed app is important
- To identify if doctors in the Department of Orthopaedic Surgery at the University of the Witwatersrand have checked if the apps they use in clinical practice are peer-reviewed

2.3 Research Design

A prospective, web-based survey was used to evaluate which apps were commonly used by the doctors in the sample and whether they were aware of the reputability of the app amongst their peers. Due to the spread of orthopaedic staff across six different academic hospitals in Johannesburg, and the difficulty in meeting due to call-roster and scheduling conflicts, an online survey was chosen. The platform chosen was SurveyMonkey (SurveyMonkey, San Mateo, CA, USA, founded 1999). This platform is commonly used for student surveys and allows the user to be Health Insurance Portability and Accountability Act (HIPAA) compliant, which is a standard for collecting sensitive patient data when performing patient-based studies in the USA. Furthermore, the data are encrypted, which provides an extra level of security within the company's server.

We chose to keep the survey anonymous. In addition, SurveyMonkey does not store any data relating to the participant's IP Address or Geodata. The website automatically ensures that each email link is only used once, to prevent the duplication of results.

2.4 Materials (Survey Design)

The first step to developing the survey was to find out the most popular orthopaedic smartphone apps available on each operating system. This was done in order to narrow down the number of options on the survey. Had this not been done, we would have had to include a large number of options on the survey, thereby increasing the time it would take to complete the survey, and thus risking a lower response rate. Furthermore, by adding a limited number of options, we were able to include a picture of the app icon, to assist participants to recall which app they use.

Smartphone apps relating to orthopaedic surgery were found by using keyword searches in both the South African Apple App Store and the South African Android Market Store. The keyword search was done on 1st March 2018. When searching using a keyword in these app stores, the search tool looks for the specified word in the title and description (provided by the developer). The keywords used were: “orthopaedic”, “orthopedic", “ortho medical” and “fracture”. The reason for including both the American and British spelling, is that that the description is not always adjusted by the developer when the app is introduced into a different country’s app store. The app store keyword search also does a partial-word search, which meant that apps with the words ‘orthopaedics’ and ‘orthopedics’ were also included in the results. The majority of results obtained during the search were the same with both the American and British spelling. The apps from each keyword search were then ranked in order of most downloaded, and duplicates were excluded. The ten apps with the highest number of downloads in each store were chosen to be included in the study.

In the group using Apple devices the specific apps included on the questionnaire were:

- **AO/OTA Reference App** - An application created by the Association of the Study of Internal Fixation and American Orthopaedic Trauma Association (AO/OTA). This app provides reference with regards to the diagnosis of fractures, treatment guidelines as well as surgical options and approaches.

- **Bullets App** - This app gathers its information directly from the orthobullets.com website. The website provides detailed information on orthopaedic conditions ranging from diagnosis to treatment.

- **Ortho Traumapedia** - An app which assists with fracture classification.

- **OrthoGuidelines** - An app created by the American Academy of Orthopaedic Surgeons with clinical practice guidelines and criteria for the use of different modalities of treatment.

- **Acta Orthopaedica** - An app which provides summaries of articles from a medical journal of the same name.

- **5-Minute Orthopaedic Consult** - A quick reference application with orthopaedic topics. A brief overview of each topic is provided.

- **LogBox** - An app mandated by the Colleges of Medicine of South Africa to record all procedures done during registrar training.

- **Arthrex Surgeon App** - An application created to assist with surgical techniques in orthopaedic surgery.

- **Vula Medical Referral** - A South African application created for the purpose of referring patients from lower level district hospitals to tertiary centers by sharing information regarding the patient's condition.

- **VuMedi** - An application highlighting various surgical procedures including videos and explained techniques.

In the Android group, the majority of the 'most popular apps' were the same. Three Apps were not included, namely: OrthoGuidelines; Acta Orthopaedica and 5-Minute Orthopaedic Consult. These were replaced by:

- **OrthoRef** - An app that assists in classifying patients with different orthopaedic pathologies.

- **Visible Body Human Anatomy** - An app which displays 3-dimensional images of human anatomy.

- **Tolerances** - An application which tells the user what amount of fracture displacement is acceptable when treating orthopaedic injuries.

2.5 Study Population

The study was conducted at the Department of Orthopaedic Surgery at the University of the Witwatersrand in Johannesburg, South Africa. The study included Orthopaedic Consultants, Registrars and Medical Officers employed at Charlotte Maxeke Johannesburg Academic Hospital; Chris Hani Baragwanath Academic Hospital; Helen Joseph Hospital; Klerksdorp Tshepong Hospital Complex; Sebokeng Hospital and Thelle Mogoerane Hospital.

2.6 Data Collection

Data were collected in English via a web-based survey on SurveyMonkey. The survey was developed by the primary investigator, and reviewed by the supervisors to ensure that the data obtained were relevant. The link for the survey was emailed to staff affiliated with the Department of Orthopaedic Surgery at the University of the Witwatersrand. The staff email addresses were obtained from the departmental secretary with permission from the Academic Head of Orthopaedic Surgery at the University of the Witwatersrand.

2.7 Data Analysis

Results were collated by SurveyMonkey and presented to the researchers in a tabulated format. Once the most commonly used apps were determined, we set out to find out if the content was peer-reviewed. For this we used the website iMedicalApps.com. The website was set up by a group of physicians who found that there was inaccurate medical information in a number of apps. They investigate the

content of medical apps to see the accuracy and then review the app on their website. Their team consists of specialists from a number of medical disciplines including orthopaedic surgery.

Certain apps in our survey were not reviewed on iMedicalApps.com. For these apps, we visited the developer's website to see if a medical expert was on the development team and how the information on the app was gathered.

2.8 Limitations

Multiple limitations were encountered in the execution of this study. The first, relates to a noted selection bias as a single university site was used during a set time period with no randomisation, as all participants who replied were included. The second limitation was that the survey participation could not be supervised, leaving room for error with regard to question interpretation and response. Although the study was done as a prospective trial, it was noted that due to the varying schedules of most participants an emailed electronic survey would allow for the greatest response. Due to call-roster obligations; vacation leave and other commitments, the entire population group was never available at a single location at a single point in time.

There was a concern that a very small sample size would be obtained and thus make the study statistically insignificant. We were able to increase the number of respondents by sending our regular reminders over electronic platforms, such as departmental WhatsApp groups, and email. Despite these limitations, all responses were collected within the anticipated data collection period.

CHAPTER 3

3.Results

The survey was emailed to all Consultants, Registrars and Medical Officers employed in the Department of Orthopaedic Surgery at the University of the Witwatersrand (see Table 3.1). The population group comprised of 105 doctors, all of whom were sent the survey link via email. The study response rate was 85.7% (90 doctors out of 105), from which three participants (2.86%) were excluded due to their use of non-compatible cellular devices (namely Blackberry and Windows Mobile devices). We excluded doctors who used these devices because they were unable to download apps from the Apple App Store or Google Android Market, and thus would not have had access to the apps included in the survey.

TABLE 3.1: DOCTORS SURVEYED IN THE DEPARTMENT OF ORTHOPAEDICS

Participant Group	No. of Responses	Excluded (Incompatible Device)	Smartphone Apps Used in Practice
Consultants	30 (out of 36)	2	22
Registrars	50 (out of 57)	1	49
Medical Officers	10 (out of 12)	0	10

The data from the completed surveys were sent back to the primary investigator in the form of a spreadsheet. The data from that spreadsheet were then imported into Numbers (Apple Inc., Cupertino, CA, USA) and then analysed. Tables and graphs were generated in Numbers and the color key was kept consistent throughout the write-up.

It was noted that, while all included registrars and medical officers that responded to the survey used a smartphone app of some kind to assist with their day to day work, only 78.5% of consultant orthopaedic surgeons (22 out of 28) had ever used a smartphone application in their clinical practice. Despite this, these six consultants were found to still be using a number of the apps included in the survey. We are unsure if this was an error in the response selected, or a misinterpretation of the phrase “used in clinical practice”. We decided to include the results of these individuals, because the fact remained that they still used these apps, regardless of whether or not they used them in “their clinical practice”. In total, 87 responses were included in the study from a total of 105 doctors in the department, which resulted in a 82.9% inclusion of responses from the department.

The department had slightly more Android users (43 devices which included Samsung, Sony and LG mobile smartphones) than Apple users (38 Apple devices). It was found that most registrars used Apple devices (55%), while both consultants and medical officers preferred Samsung devices (see Figure 3.1).

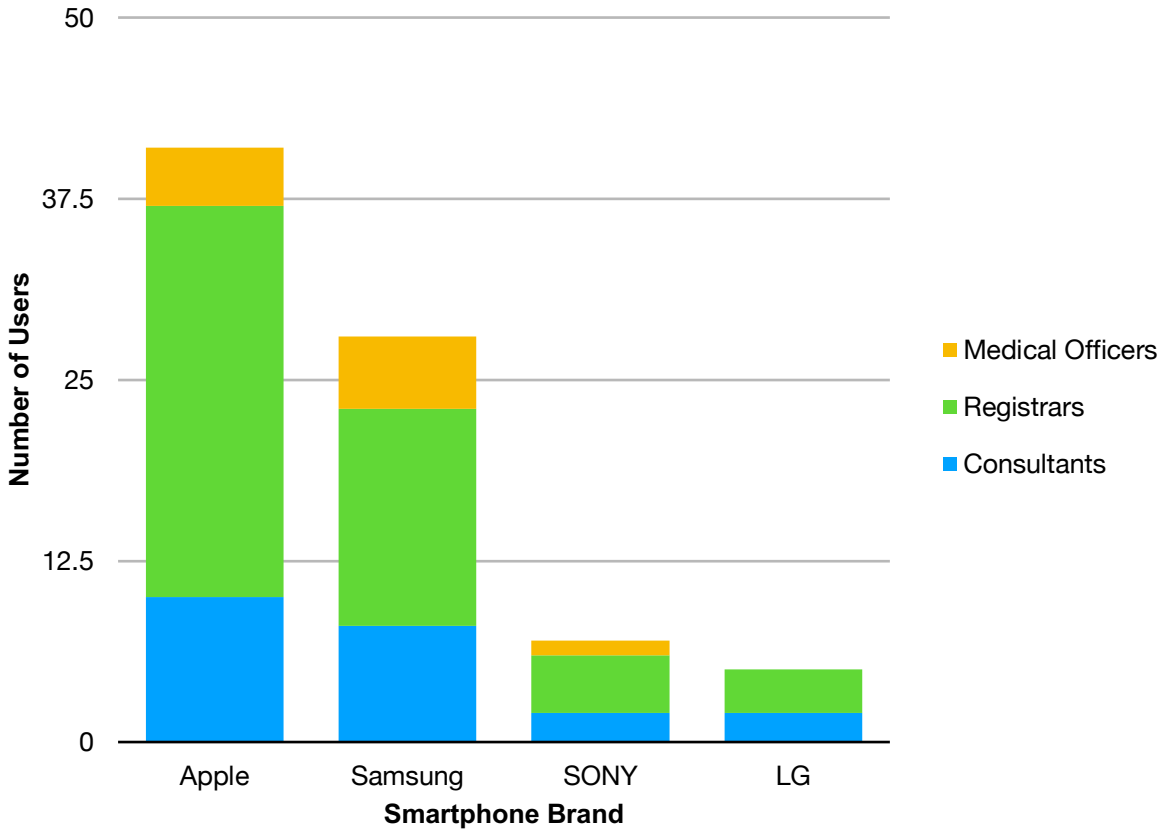

Figure 3.1: A bar graph showing the smartphone devices used in the Department of Orthopaedic Surgery

As per our original plan, we decided which apps to include in the survey by looking at the relevant “app stores” (Apple App Store and Google Android Market) and finding out which orthopaedic smartphone apps were the most popular. The reason for limiting the number of options in the survey, was to make the survey as brief as possible. This also allowed us to include the graphic icon for each app in the survey, since a limited number of apps were included.

Each app store has more than 100 medical apps which included words such as “orthopaedics” and “fracture” in their description. Including all of them in the survey would have resulted in a very long survey. Furthermore, some of the apps had as little as seven downloads from the app store, making it highly unlikely that the population group being surveyed would have downloaded the app. For the group using Apple devices the apps listed in the questionnaire included:

- AOSR
- Bullets
- Ortho Traumapedia
- OrthoGuidelines
- Acta Orthopaedica Journal
- 5-Minute Orthopaedic Consult
- Logbox
- Arthrex Surgeon App
- Vula Medical Referral
- VuMedi

For the Android group, most of the same apps were included except OrthoGuidelines, Acta Orthopaedica Journal and the 5-Minute Orthopaedic Consult. These were replaced by:

- OrthoRef

- Tolerances

- Visible Body Human Anatomy

The most popular app amongst Apple users was found to be the application created by the Association of the Study of Internal Fixation and American Orthopaedic Trauma Association (AO/OTA) - with a total of 34 users in the department (39.1% of included participants). The second most popular app was the Bullets app (31 users) and the Vula Medical Referral app (31 users). The latter was only used by registrars and medical officers. The most popular apps amongst consultants was the 5-Minute Orthopaedic Consult app (40.9%) and the VuMedi app (36.4%) (see Figure 3.2).

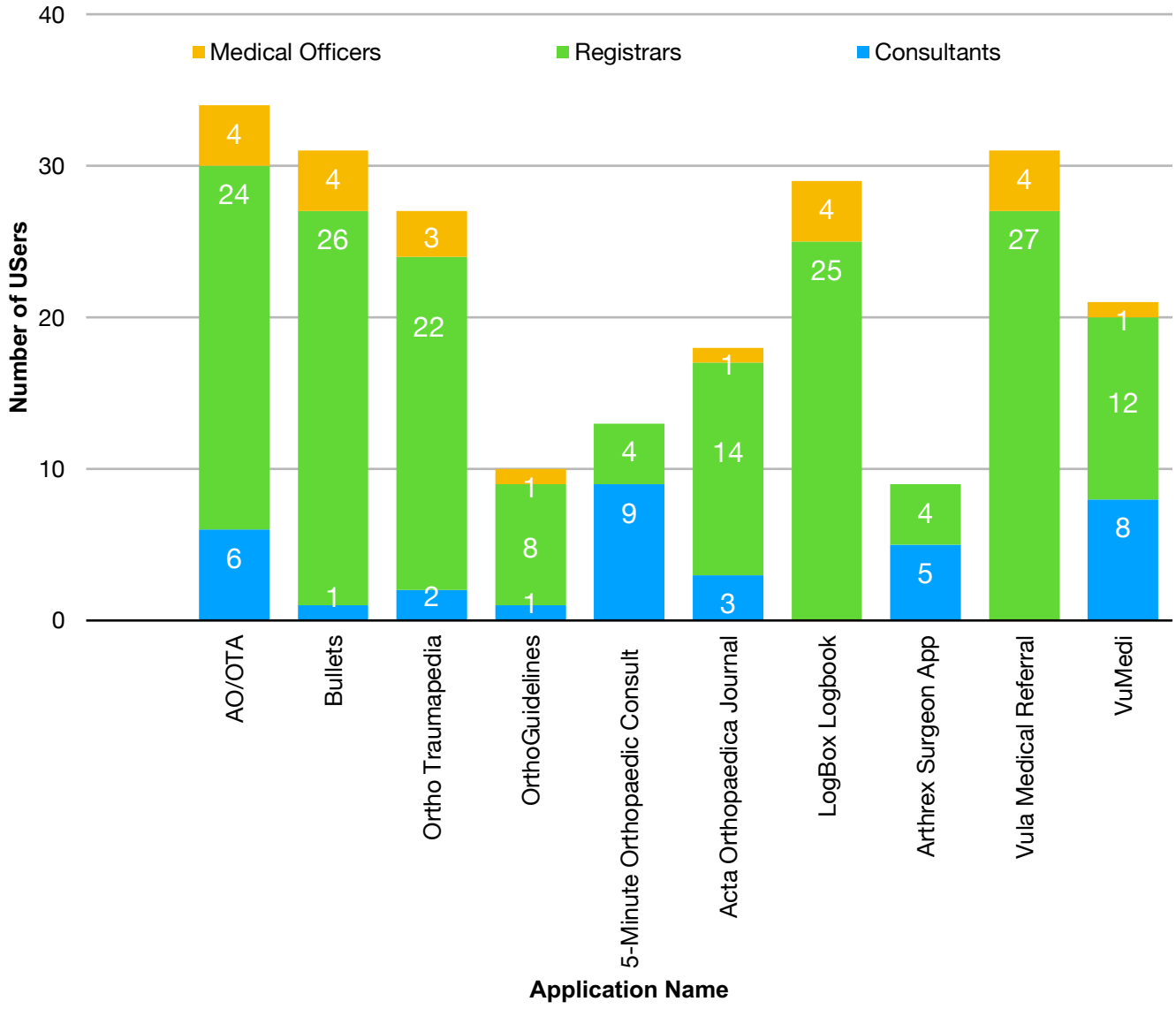

Figure 3.2: A bar graph showing Apple application use in the Department of Orthopaedic Surgery

The group of Android users, similar to the Apple group, used the application created by the Association of the Study of Internal Fixation and American Orthopaedic Trauma Association (AO/OTA) more than any other (74.4%) and similarly Bullets was the second most used app (69.8%). The least popular app used on the Android operating system was the Visible Body Human Anatomy, only used by 10 doctors out of the 43 (23.3%) (see Figure 3.3).

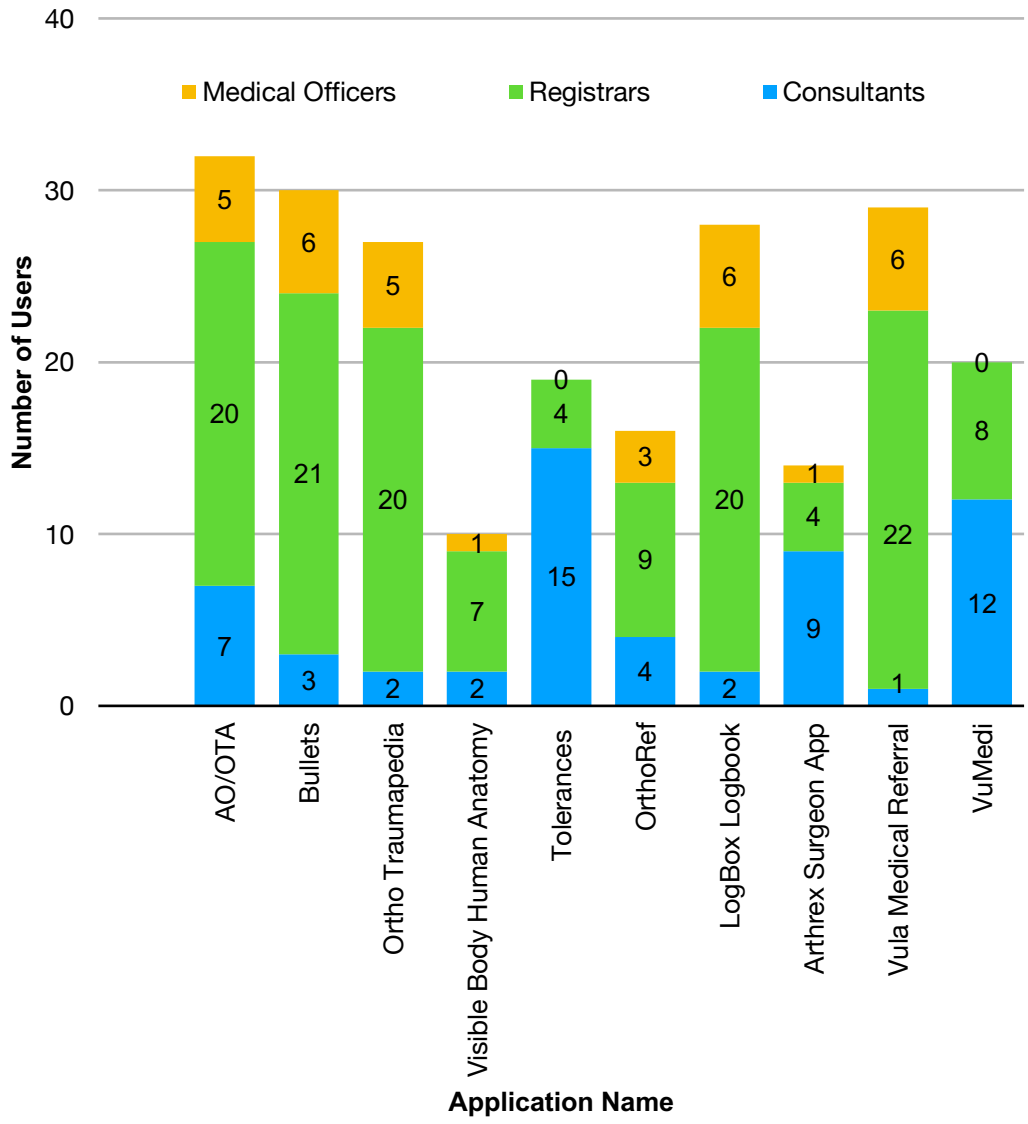

Figure 3.3: A bar graph showing Android application use in the Department of Orthopaedic Surgery

The last aspect of the survey reviewed the perspective of doctors in the department with regard to the importance of the applications being peer-reviewed. Out of the 81 included doctors, 75 (86.2%) believed that this was important however only 7 (8%) had actually checked if the apps they were using were actually peer-reviewed. The majority of consultants, registrars and medical officers had not previously checked if the applications they use were peer-reviewed, as evidenced by the Table 3.2 below.

TABLE 3.2: PARTICIPANT OPINION REGARDING PEER-REVIEW OF APPS

		Consultants	Registrars	Medical Officers	Total
Important to peer-review app	Apps Checked	2	4	1	7
	Apps Not Checked	19	42	7	68
Not Important to review app	Unnecessary to Check	7	3	2	12

CHAPTER 4

4.Discussion

The smartphone has become an integral asset in the lives of all modern individuals (3, 7). The addition of the “app” or “mobile phone application” has further broadened the use of these devices in our lives by the optimisation of a mobile device to perform specific functions (5). The further integration of this fast developing technology into not only our home lives, but also our occupations (in this case specifically the healthcare market) led to the development of dedicated healthcare apps (13) to assist in our basic day to day work environment.

Differing from the US based trend of an Apple dominated smartphone use, the devices used within the Department of Orthopaedics followed a more global picture with more Android users than Apple users (43 versus 38 smartphone devices respectively). Interestingly however, there was a noted dominance of Apple devices amongst registrars while Android remained more common in the consultant and medical officer groups. The use of Apple smartphones being greater in this cohort could be a matter of co-incidence or possibly due to the increased capabilities of Apple smartphones to integrate with other Apple devices used by the student population such as iPads and MacBooks (10).

As would be expected, most of the doctors in the Department of Orthopaedic Surgery utilised a healthcare-based smartphone app in their day to day work. It is unfortunate that a few members of the consultant group (6 out of a total of 28 responses) possibly misinterpreted the questionnaire by not properly identifying their use of the app in their medical practice. This was noted by their response in identifying different apps that they had on their smartphones and responding to the questions in spite of a negative response to the question of its use in their clinical practice. It can be assumed that this may be due to an oversight in the survey whereby doctors, in this case specifically consultant specialist orthopaedic surgeons - while having the apps available to them on their smartphones - do not actively employ them in their clinical practice and are therefore not fully aware of the peer-review process for each app.

A positive response of app use in clinical practice was identified in 77.1% of doctors within the department. This included the all responding registrars and medical officers. As noted in Kijsanayotin et al., doctors were slow to integrate the use of healthcare apps into their clinical practice unless influenced by their contemporaries around them (14). The consultant base at the Department of Orthopaedics comprises of a relatively older cohort than both registrar and medical officer groups - resulting in a longer previous period of practise where app use was unknown to them. Thus, their exposure to the use of apps in the workplace (and possibly in daily life) has been limited in their total lifespans, as opposed to a younger generation who have found technology integrated in their lives from early in their education (15). Using the Technology Adoption Cycle described by Bohlen, one could surmise that the registrars and medical officers in the Department of Orthopaedics were most

likely part of the “early adopters” of smartphone apps, while the consultants comprised more of the “late adopters”.

Upon looking into the background of the most commonly used apps, we found some interesting data regarding the development process and information contained within the app. We used this information to conclude as to whether or not the app was peer-reviewed.

The AOSR app gathered data directly from the AO/OTA website. According to the AO website, the app itself has multiple medical professionals on its development team, and the information contained on the AO/OTA website was compiled by medical experts in the field. The information contained in the AOSR app was peer-reviewed by a group of orthopaedic surgeons.

The Ortho Traumapedia app had a very different background. This app was initially developed by a group of App Developers without a medical specialist on the development team. The app simply contained information regarding orthopaedic classifications, which were taken directly from various orthopaedic textbooks and scanned into the app. As of 2017, a group or orthopaedic surgeons joined the design team and reviewed the content. Currently, the information provided by the Ortho Traumapedia app is peer-reviewed

The “Bullets” app is an orthopaedic reference app which gathers its data directly from the orthobullets.com website. The app was designed by the same team who set up the website and provides the user access to all the orthobullets.com features through the interface of an app. According to TopOrthoApps.com, the information on the orthobullets.com website was put together by a large group of orthopaedic surgeons. This same team was involved in the development of the Bullets app. The information contained in the app has been reviewed by experts in the field. The app even goes so far as to provide levels of evidence of its sources. According to the orthobullets.com website, the information contained on the website was initially put together by a single orthopaedic surgeon. Over time, as usage of the site increased, more experts were brought onboard, and the information on the site was reviewed. The information contained in the Bullets app is peer-reviewed.

The OrthoGuidelines app is a set of clinical practice guidelines provided by the American Academy of Orthopaedic Surgeons (AAOS). All data contained in the app are extracted from the AAOS Guidelines. These guidelines are evidence-based, having been developed by a renowned team or experts in the field. The orthoguidelines.org website divides the app contents by strength of evidence, also providing references for every piece of evidence in the app. The content of this app is peer-reviewed.

The “5-Minute Orthopaedic Consult” app is one of the few paid apps which appeared on our search of the most popular apps. Although the app itself is free, the content requires a payment of $94.99 to be fully enabled. Upon downloading the app, only

10% of the content is available before paying. The app gathers data from the book "5-Minute Orthopaedic Consult" written by F.J. Frassica. The app itself was developed by a company known as Skyscape Medpresso Inc. A look at the Skyscape Medpresso website reveals that the development team does have medical professionals on board, but no experts in field of orthopaedic surgery. The app simply extracts information from the textbook and groups it into different headings. The app has never been reviewed by a team of experts in the field of orthopaedic surgery. Our investigation revealed that this app had not undergone a peer-review process.

The "Acta Orthopaedica" app is an app that can be used to access journal articles from the Acta Orthopaedica Journal. This journal is a well-known Scandinavian orthopaedic journal. The app serves to give the user access to journal articles from the journal as well as summaries of recent articles. The full-text of certain articles are available, while the user is required to pay for access to all the journals. Research into the app revealed that it did not undergo a peer-review process.

The LogBox logbook app is a South African app which allows registrars to create a logbook of surgical procedures done. The app was developed by a Johannesburg-based orthopaedic surgeon. His team also included specialists from other fields of medicine. The app was accepted by the Colleges of Medicine of South Africa as the standard format for collecting data regarding procedures done for registrars starting after January 2018. The Health Professionals Council of South Africa approved the app for this purpose as well. In order for the app to be accepted by these two

medical governing bodies, it had to undergo a peer-review process. This was done in 2016, according to the developer's website.

The Arthrex Surgeon App was developed by an orthopaedic implant company called Arthrex. The app showcases the company's implants and provides surgical techniques for the use of the implants. The app was initially developed as a database of the surgical guides for the various implants. According to Arthrex, the app underwent a review in 2017 by a team consisting of "leading orthopaedic surgeons" who refined the content and made the app more user-friendly. TopOrthoApps.com has also reviewed the app and found the content to be evidence based.

The Vula Medical Referral app was developed by an ophthalmologist in Stellenbosch, South Africa. The app was initially developed to facilitate referral of eye cases between primary/secondary level facilities and tertiary facilities with an ophthalmology registrar on call. The referral system allows the referring clinician to enter patient data and clinical photos onto an app-based template, which is then sent to the registrar on call. The registrar can then either provide advice or accept the patient for referral. In 2015 the app was expanded to allow various other specialties to use the app, including orthopaedics. The developer's website confirms that the template was adjusted for orthopedics by the app development team, which does not include an orthopedic expert. The app itself has not been peer-reviewed by an expert in the field of orthopaedic surgery.

VuMedi is an app that links to the website VuMedi.com. This website serves to provide videos of surgical techniques for various orthopaedic procedures. There are also web-based lectures given by experts in the field. This app has surged in popularity in the past few years, and is highly rated by various online orthopaedic communities. This app has been extensively peer-reviewed.

OrthoRef is an orthopaedic reference app with a list-based system of orthopaedic references. The app compiles commonly used classification systems into an app format for ease-of-use. The app was developed by and IT specialist named Pieter Kubben. There were no medical experts on the app development team. The contents of this app have not been peer-reviewed by an orthopaedic expert.

Visible Body Human Anatomy is 3D graphics-based anatomy app. The app provides detailed 3D images of the human anatomy which can be rotated or moved by the user. This app has been extensively peer-reviewed by multiple experts in the field and found to be highly accurate. The app is also endorsed for use by multiple medical institutions in the United States.

The last app that we looked at was Tolerances: Orthopaedic Reference app. This app was only recently developed (in 2017) and is an orthopaedic reference app. The contents of the app come directly from a handbook called “Tolerances’. This

handbook is a collection of acceptable amounts of fracture displacement when it comes to treating orthopaedic injuries. The app was developed by a team of IT specialists who scanned the contents of the book into the app. This app has never been peer-reviewed by experts in the field.

A total of 13 different apps were included in our survey across the 2 platforms. From these 13, only 8 apps (62%) had undergone a peer-review process. The other 5 apps (38%) had never been reviewed by an expert in the field of orthopaedic surgery, despite being downloaded more than 200 times each, on the Apple App Store and Google Play Market. Upon researching these apps, we also found that a number of the apps did not even have a medical expert on the development panel. This was in keeping with previous literature.

CHAPTER 5

5.Conclusion

The doctors surveyed in our study use medical apps for a wide range of purposes. We were able to group these apps into those which provided detailed information on orthopaedic topics and those which allowed quick reference regarding orthopaedic diagnoses and surgical approaches. As expected, the majority or registrars and medical officers used the former, while consultants tended to use apps in the latter group. The reason for this is that registrars and medical offers are generally looking at topics with an aim to learn more about the topic in preparation for their exams, while consultants often use these apps to revise the surgical approach before surgery or simply to confirm small details regarding an orthopaedic condition.

Our recommendation, based on this study, is that there needs to be a more intensive peer-review process for healthcare-related smartphone apps that are intended for use by clinicians. Ideally, these apps should undergo a peer-review process before being released for download. Furthermore, a synopsis of the development and peer-review process should be provided in the app description. It is, in a way, irresponsible for these apps to be marketed to clinicians while possibly containing inaccurate information. Despite all these recommendations, the ultimate responsibility lies with the clinician to ensure that the information used to guide

patient care is accurate. It is of the utmost importance that all clinicians be judicious when downloading smartphone apps which they intend to use in clinical practice.

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7.Appendices

7.1. Human Research Ethics Approval Letter

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Dr Virsen Singh

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M171001

NAME: (Principal Investigator)	Dr Virsen Singh
DEPARTMENT:	Orthopaedic Surgery School of Clinical Medicine
PROJECT TITLE:	Smartphone Apps Commonly used by Doctors Working in Orthopaedic Surgery at the University of the Witwatersrand in Johannesburg: Are they Peer-Reviewed?
DATE CONSIDERED:	27/10/2017
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr Cynthia Sathekga
APPROVED BY:	Professor CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	05/07/2018

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 Research Office Secretary, Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. 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**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **October** and will therefore be due in the month of **October** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

Date 7/7/2018

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

7.2. Participant Informed Consent Form

INFORMED CONSENT FORM

Smartphone apps commonly used by doctors working in Orthopaedic Surgery at University of the Witwatersrand in Johannesburg: Are they peer-reviewed?

The aim of our research project is to find out whether or not the most commonly used orthopaedic smartphone apps are peer-reviewed. In order to determine this, we must first determine which smartphone apps are most commonly used. We intend to gather this information through our survey.

We invite you to participate in this study by taking part in our survey. It is a brief survey, which should take no longer than 2 minutes. The questions revolve around which smartphone apps are used in your clinical practise.

The survey will be offered to all Consultants, Registrars and Medical Officers in the Department of Orthopaedic Surgery at the University of the Witwatersrand.

Participation is voluntary, and participants may choose to exit the survey at any time. All data collected is anonymous.

Participation in the survey will pose no risk to the participant.

The benefit of being in the study is that all participants will be informed of the final outcome. This will enable participants to know if the apps used by them are peer-reviewed or not. Furthermore, participants will learn which apps are commonly used by other doctors, thereby giving them an opportunity to use these apps in their own clinical practise.

There are no re-imbursements for participating in this study.

Please choose an option below:

☐ **Yes, I agree to participate**

☐ **No, I do not want to participate**

7.3. Patient Information Sheet

Dear participant,

My name is Dr Virsen Singh and I am a Registrar in the Department of Orthopaedic Surgery at the University of The Witwatersrand. I am performing this survey as part of my MMed Research Study, together with my supervisors Dr Tatolo Sefeane and Dr Cynthia Sathekga.

Our qualifications are below:

Dr V. Singh MBChB(UCT)
Dr T. Sefeane MBChB, FCOrth(SA), MMed(Orth)
Dr C. Sathekga: MBChB(UCT), FCOrth(SA)

The survey aims to find out which Orthopaedic Smartphone Apps are most commonly used by Orthopaedic Surgeons (this includes Medical Officers; Registrars and Consultants) in the University of the Witwatersrand Circuit. After collecting the relevant data and determining which apps are the most commonly used, I will look into whether or not those apps have been peer-reviewed.

There are **5 questions** in the form of checkboxes.
The average time to complete the survey is **2 minutes**.
I ask that you please answer all the questions, although you are free to omit questions which you do not wish to answer.

The survey is completely anonymous. You are not required to identify yourself and SurveyMonkey does not store any data relating to your IP Address or Geodata. The website only ensures that the survey is completed no more than once, via the email link. There is no risk to the participants and there is no payment or other forms of compensation made to the participants.

SurveyMonkey is a world-renowned data collection tool. The information gained is stored on a secure server in the United States of America. The website allows the user to be HIPAA (Health Insurance Portability and Accountability Act) compliant, which is a standard for collecting sensitive patient data when performing medical studies in the USA. Furthermore, the data is encrypted by SurveyMonkey, which provides an extra level of security within their server.

Please note that you may only participate in this survey if your smartphone runs one of the following mobile platforms:

iOS (eg. Apple Devices)
Android (eg. Samsung Galaxy Devices; Sony Xperia; LG; HTC; Motorola)

The HREC Office can be contacted in the case of any queries or complaints related to the research process:
Chairperson: Prof. Clement Penny (clement.penny@wits.ac.za)
Administrators: Ms Zanele Ndlovu / Mr Rhulani Mkansi / Mr Lebo Moeng (Tel: 011 717 2700/2656/1234/1252)

Thank You

7.4. Survey

Smartphone Apps in Orthopaedic Surgery

1. Have you ever used smartphone apps in clinical practice (e.g. reference apps; surgical approaches; classifications etc.)?

- ◯ Yes
- ◯ No

2. I currently use the following brand of smartphone:

- ◯ Apple (iPhone)
- ◯ Samsung (Galaxy; Note etc.)
- ◯ Sony (Xperia)
- ◯ LG
- ◯ HTC
- ◯ Motorola
- ◯ Other (please specify)

3. iPhone Users: I currently use/have used the following medical apps:

- ☐ AO/OTA Fracture and Dislocation Classification AO Foundation

4. Android Users: I currently use/have used the following medical apps:

- ○ 

AO Surgery Referen
AO Foundation

5. My view regarding a peer-review process for orthopaedic smartphone apps is:

- ○ It is important and **I have checked** to see if the apps I use are peer-reviewed
- ○ It is important but **I have never checked** to see if the apps I use are peer-reviewed
- ○ I do not believe it is necessary to peer-review apps

7.5 Survey Results - SurveyMonkey.com

Survey Results

		Consultants (28)	Reg's (49)	MO's (10)				
		Consultants (28)	Reg's (49)	MO's (10)		Totals:	Responded	Excluded d/t OS:
1	Yes	22	49	10		Consultants:	28 of 36	2 (Blackberry)
	No	6	0	0		Reg's:	49 of 57	1 (Windows Mobile)
2	Apple	10	27	4		MO's:	10 of 12	0
	Samsung	13	15	5				
	SONY	2	4	1				
	LG	3	3	0				
3 (Apple)		(10)	(27)	(4)				
	AO/OTA	6	24	4				
	Bullets	1	26	4				
	Ortho Traumapedia	2	22	3				
	OrthoGuidelines	1	8	1				
	5-Minute Orthopaedic Consult	9	4	0				
	Acta Orthopaedica Journal	3	14	1				
	LogBox Logbook	0	25	4				
	Arthrex Surgeon App	5	4	0				
	Vula Medical Referral	0	27	4				
	VuMedi	8	12	1				
4 (Android)		(18)	(22)	(6)				
	AO/OTA	7	20	5				
	Bullets	3	21	6				
	Ortho Traumapedia	2	20	5				
	Visible Body Human Anatomy	2	7	1				
	Tolerances: Orthopaedic Reference	15	4	0				
	OrthoRef	4	9	3				
	LogBox Logbook	2	20	6				
	Arthrex Surgeon App	9	4	1				
	Vula Medical Referral	1	22	6				
	VuMedi	12	8	0				
5	have checked	2	4	1		7		
	have never checked	19	42	7				
	do not believe	7	3	2				