**CHAPTER TWO**

**LITERATURE REVIEW**

**2.0 INTRODUCTION**

Adherence has been defined as the extent to which individuals follow the instructions they are given for prescribed treatments (Haynes et al, 2002). Thus, if a person is prescribed an antibiotic to be taken as one tablet four times a day for a week for an infection, but takes only two tablets a day for five days, their adherence would be (10/28=) 36 %. The term adherence is intended to be nonjudgmental – a statement of fact rather than of blame of the individual, the prescriber, or the treatment. Compliance and concordance are synonyms for adherence. Adherence to treatment is a complex health behavior. Problems identified include the individual’s failing to initiate therapy, underusing or overusing a treatment, stopping a treatment too soon, and mistiming or skipping doses.

**2.1 Factors Affecting Non-Adherence In Patients With Diabetes Mellitus**

“Drugs don’t work in patients who don’t take them”. It is clear that full benefit of many of the effective medications that are available will be achieved only if patients follow prescribed treatment regimen reasonably closely. Some of the factors that cause non-adherence in patients with diabetes mellitus are

1. Forgetfulness: 88% of type 2 DM patients forget to take their drugs as recommended by their physician (Haynes et al, 2002).
2. Carelessness about taking medication
3. Feeling better
4. Feeling worse
5. Cost of purchasing medication
6. Not aware of the consequences of missing the doses

Poor medication adherence seems to be a significant barrier to attainment of positive clinical outcome among type 2 diabetes patients. Studies show that most deviations in medication taken by patients occur as omission of the doses (Paes *et al.,* 1997). Fear of inconvenience of daily ingestion of too many drugs has been observed to constitute hindrance to medication adherence among patients with chronic diseases in general and diabetes patients in particular.

**2.2 Current Trends in Electronic Medication Reminders for Self Care**

A recent popular strategy to tackle non-adherence has been the use of technology-based interventions to improve medication adherence. These interventions are generally realized through the use of information and communications technology-driven electronic reminders to inform patients of the time to take their medication, and sometimes also the dosage. Electronic reminders are defined as automatically generated or sent reminders, without personal human contact between the healthcare provider and the patient. These reminders may occur independently of the actual medication or may be associated with various medication storage and handling devices.

Below are some reviews on electronic medication reminders used for medication adherence in order to identify the current and future trends.

**2.2.1. Mobile phone reminders**

Mobile phones are devices that can support electronic reminder systems, as they allow constant access to communication and information and can perform many computational tasks. Their popularity has grown exponentially over the past few years so it can be assumed that they are now widely available and used across the population. Mobile phones provide ubiquity, accessibility and familiarity for users, which in turn has the ability to make their long-term use more sustainable over other electronic devices (Wise and Operario, 2008), and as such can be used as very convenient reminder devices that allow various degrees of personalization based on preferences (Feder, 2010). One study has shown that a mobile-phone based medication reminder system contributed positively to im33proving medication adherence (Patel *et al.*, 2013). Recent mobile phone contributions in the field of interest have focused on usage with internet connectivity. There are 3 types of reminding services that can be used with mobile phones: phone call/SMS services, reminder apps, and built-in alarms.

**2.2.1.1 Phone Call/SMS Services**

Phone calls and SMS (Short Message Service) reminder services were widely used even before mobile phones became popular. They are typically done by calling or texting the patients to remind them to take their medications, often automatically from a service provider (Shet *et al.,* 2010). SMS reminding is currently increasingly being implemented in interventions aimed at improving medication adherence, due to high mobile device penetration and cheap cost (Vervloet *et al.,* 2012). One study on the effectiveness of SMS reminders shows that the rate of missed dose was decreased by 90.1% for participants in an intervention group that received SMS medication reminders (Huang *et al.,* 2013).

Various studies targeting a variety of health situations have shown that SMS interventions help to improve medication adherence and behaviour and can be useful in measuring adherence. Studies on the effects of SMS reminder on medication adherence for patients with chronic diseases, such as diabetes, Parkinson and mental illness have shown to improve medication adherence (Mall *et al.*, 2013)( Keränen and Liikkanen, 2013)( Vervloet *et al.,* 2012). One study focused on the effects of daily SMS reminder on patients with asthma, and the result shows that daily text message reminders are associated with increased adherence to anti-asthmatic medication (Strandbygaard *et al.*, 2010). A study on automated telecommunication-based reminders with once-daily glaucoma medication show that daily text or voice message improve adherence rate from 53% to 64% (Boland *et al.,* 2014). SMS is considered personal, socially acceptable, inexpensive and is accessible to patients irrespective of their geographical or socioeconomic barriers (Miloh, and Annunziato, 2010).

**2.2.1.2 Mobile Phone Apps**

Mobile phone apps are a novel approach to improving medication adherence and behaviour, as they are constantly accessible, easy to use and learn, and have the ability to educate patients and provide medication specific information. Apps are downloaded into a mobile phone, so patients do not need to carry a separate reminder device to remind them to take their medication (Laffer and Feldman, 2014). The apps can be obtained with little to no cost, and have been proven to be very useful for patients with complex medication regimens (Dayer *et al.,* 2013). The number of such adherence apps is increasing across platforms such as iOS and Android, and the most popular features are medication reminders, refill reminders, data logs that record adherence which can be uploaded to healthcare professionals, and medication information. One study on the effectiveness of an iPhone app showed that most participants were comfortable sharing information via the app with a health professional, and deemed it useful in reminding and managing their medications (Wickham *et al.,* 2013).

Sometimes users will use only the built-in alarm features of a mobile phone to remind them to take their medication. However this does not work very well for patients who need to take a number of different drugs and doses every day, as they can get confused over which medication to take and how much to take, when the alarm rings. One systematic review paper concluded that all studies in the review suggest that reminder systems such as text messages, automated phone calls and audio-visual reminder devices help to increase patient medication adherence (Tran *et al.***,** 2014).

**2.2.2. In-home electronic reminder devices**

Reminder services can be built into a home environment, such as smart homes, for health management and monitoring purposes. It can be beneficial to both the patients and healthcare providers, and especially useful for elderly patients who live alone and have difficulty managing their medications. For the providers, an automatic monitoring system with sensors will free up labour from 24/7 physical monitoring, thus reducing labour costs and increasing health service efficiency. In-home sensors and wearable sensors can monitor changes in the environment and patient’s vital signals such as heart rate and blood oxygen levels, which human carers might overlook. The data collected from the sensors can be stored and integrated into a patient’s health records for use by healthcare professionals to adjust diagnoses and treatments (Granger and Bosworth, 2011).

The Home Automated Telemanagement system was developed for the computer guided management of patients with ulcerative colitis to monitor their symptoms, medication compliance, quality of life, and educating them on their disease. The system can also be adapted for other diseases such as hypertension, where the same principles can be applied to aid patient adherence in self-care. The response of patients to the system within the pilot tests has been positive as it is easy to use and convenient (Frankelstein *et al.,* 2011). Recent advances in telehealth technologies have enabled the development of connected devices that can be used in home settings in order to assist with medication management and monitoring (Reeder *et al.,* 2013). Automatic pill dispensers are sophisticated, computer based monitoring systems that can be programmed to perform a variety of functions, such as emitting audible or visual alarms, separating medications into compartments and dispensing the correct medication dosage. Some can contact a caregiver by telephone if a medication dosage was not taken within a predefined period. By using an automatic pill dispenser, the medication is locked away so the patient cannot accidentally overdose (Wakefield *et al.,* 2008). One major disadvantage of this device is that it can cost up to $1000, which is expensive compared to other type of reminder devices. (Wakefield *et al.,* 2008). In a randomized controlled trial of 61 elder patients with chronic illness, an automatic pill dispensing device with an audible medication-taking prompt was found to be superior in enhancing medication adherence in comparison with pre-filled pillboxes after a 6 months trial (Wakefield *et al.,* 2008). An example of such device is the MD.2 medication dispenser, a device that automatically dispenses the pre-loaded medication and gives alerts to patients when it is time to take their medication(Sather et al., 2006) (Winland-Brown *et al., 1999* ). A study has shown that dose-dispensing aids, including automated dose dispensing with monitoring system, help to improve adherence in polymerization (Hersberger *et al., 2013*).

Two-way interactive video technology can also be used to monitor medication compliance. Such technology brings virtual medication monitors into people’s homes.

The virtual caregivers can help to increase social interactions, thus adding to the quality of life. A study of the use of such technology over a sustained period on subjects with mild dementia found that the video-monitored participants’ compliance remained stable at a rate of 81% while unmonitored patients’ compliance fell by 12% (Smith *et al.,* 2007).

**2.2.3 Portable reminder devices**

Portable reminder devices have an advantage over in-home reminder device due to their portability which makes them popular amongst busy individuals. These devices are often small in size so the users can carry the device with them everywhere they go, therefore the reminder service is not restricted to only the in-home environment. Simple reminders provided by a portable medication reminder device have been reported to improve medication adherence (Kamimura *et al*., 2012). These portable devices often work by sounding an alarm and sometimes flash lights to remind the patients when it’s time to take medications (Kamimura *et al*., 2014). The electronic pillbox is a widely used and simple portable medication reminder device and is suitable for patients who are not ‘tech savvy’. Med-eMonitor is a smart pill container that is capable of cueing the taking of medication, warning the patients when they are taking the wrong medication, recording side effects complaints, and alerting carers of failures to take medication (Velligan *et al.*, 2013)(Haberer *et al.,*  2012). A study has shown that Med-eMonitor help to improve medication adherence and achieve high satisfaction ratings (De Bleser *et al.,* 2010).

The Helping Hand is an electronic monitoring tool that is suitable for blister packages.

The reminder system within the Helping Hand consists of LED lights that provide feedback to the user regarding their medication behaviour within the previous week. It also yields a beeping signal to remind patients to take their medication at the correct time. It is easy to use and widely accepted by patients and clinicians (Christensen *et al*., 2009). The Alarm Watch is a wristwatch that allows a patient, especially those away from home, to keep track of when their medications are due. The system allows the patient to make multiple daily alarms and an optional alarm instructional text message can also be displayed across the face of the watch. The watch has a vibrate mode so that only the wearer can know that it is time to take medication. There is also an emergency medical alert that can speak for the patients if they are unable to speak for themselves (Naditz 2013). MedSignals is a device that is smaller than a desktop phone, and can signal pill usage in four different ways: beeps, flashing, text or voice. It can also verbally announce how many pills the user should take and how to take them, and can track patient’s medication usage and upload the information to patient’s file for use by healthcare professionals (Naditz 2013). TimeCap fits a conventional prescription medication vial, and contains a digital timepiece that displays the time of day and day of the week when the container was last opened. This helps the patient who forgets when or if they took their most recent dose as they can find out by simply checking the digital timepiece on the cap. The timepiece also contains an alarm that beeps when a dose is due (Mckenney *et al.,*  1992). Results from a systematic review study shows that simple devices that monitor and store adherence records and devices that combine digital displays with audible reminder alarms appeared to be the main characteristics of Electronic Medication Packaging devices most useful for improving medication adherence (Checchi *et al.,* 2014).

**2.3 Mobile Applications to Improve Medication Adherence**

The number and use of apps in the area of health and wellness, not only for patients, but also for healthy people, is increasing. Several studies showed beneficial effects of mobile application used in terms of patient compliance and quality of life in various disease states. Some studies have shown that medication reminder systems are helpful for patient’s adherence, especially when non-adherence is unintentional. Smartphone use is constantly growing in the United States and all around the world, and apps that are helpful for adherence can be downloaded for little to no cost. The accessibility of these apps has been noted as a benefit for patients with complex medication regimens, as well as, caregivers of others or family members.

**Mobile MedAlert**

Many projects have applied the short message service (SMS) technology in ensuring patient adherence, such projects include: the Mobile Med Alert, a mobile medical alert system that sends SMS to patients, prompting them to take their drugs (Okuboyejo *et al.*, 2012). It will design architecture for mobile health interventions and develop a prototype SMS-based system to improve out-patient adherence. Mobile MedAlert was developed using programming tools such as extensible hypertext markup language (xHTML), hypertext processor (PHP), MySQL and the integration of Ozeki SMS gateway. Its main features includes: it can alert patients about potential drug in-take at a scheduled time, in accordance to drug regimen; it allows for feedback mechanism whereby the Patient can respond appropriately to alert messages. In both cases, the application aims at increasing patients’ compliance to treatment and in the long run, reduces the rate of noncompliance in relation to drug regimen.

**Mobile-phone based Patient Compliance System (MPCS)**

Another research work considered a Mobile-phone based Patient Compliance System (MPCS) that can reduce the time-consuming and error-prone processes of existing self-regulation practice to facilitate self-reporting, non-compliance detection, and compliance reminder among patients in Nigeria. The uniqueness of this work is to apply social behavior theories to engineer the MPCS to positively influence patients’ compliance behaviors, including mobile-delivered contextual reminders based on association theory; mobile triggered questionnaires based on self-perception theory; mobile enabled social interactions based on social construction theory, also explained how mobile phone can help patient to comply to their medication treatment; the existence of mobile phones and its uses in health sectors in Nigeria.

**WelTel**

Also Projects such as WelTel have applied wireless technology in ensuring patient adherence: The WelTel Kenya was a multisite randomized clinical trial of HIV-infected adults initiating antiretroviral therapy (ART) in three clinics in Kenya. Patients were randomized (1:1) by simple randomization with a random number generating program to a mobile phone short message service (SMS) intervention or standard care. Patients in the intervention group received weekly SMS messages from a clinic nurse and were required to respond within 48hours. Randomization, laboratory assays, and analyses were done by investigators masked to treatment allocation; however, study participants and clinic staff were not masked to treatment. Primary outcomes were self-reported ART adherence (>95% of prescribed doses in the past 30 days at both 6 and 12 month follow-up visits) and plasma HIV-1 viral RNA load suppression (<400 copies per mL) at 12 months. The primary analysis was by intention to treat. Patients who received SMS support had significantly improved ART adherence and rates of viral suppression compared with the control individuals. Mobile phones might be effective tools to improve patient outcome in resource-limited settings.

**Wedjat**

In Norway, SMS messages are sent to educate parents with Type 1 diabetic children. These messages included definitions, facts and tips for managing diabetes. Text to Change (South Africa) project employs an SMS-based quiz to test users’ knowledge of HIV/AIDS and encourage testing and counseling. Wedjat is a mobile medication reminder and monitoring system. It is a smart phone application designed to help remind its users to take the correct medicines on time and record the in-take schedules for later review by healthcare professionals.

**Voice-based Mobile Prescription Application (VBMOPA)**

In a Voice-based Mobile Prescription Application (VBMOPA) was designed and implemented to improve health care services. The application can be accessed anyplace anytime, anywhere through a mobile phone by dialing an appropriate number, this connects users to an e-prescription application that is resident on a web server. This system could lead to costs and life savings in healthcare centers across the world especially in developing countries where treatment processes are usually cumbersome and paper based.

**TRICKs (Text Reminders for Immunization Compliance in Kids)**

TRICKs (Text Reminders for Immunization Compliance in Kids) which sends out text messages of immunization reminders prior to immunization dates; Text messaging to motivate walking in older African-Americans

**Text4baby**

Text4baby, the first free national health text messaging service in the United States that aims to provide timely information to pregnant women and new mothers to help them improve their health and the health of their babies; a mobile phone text message program to measure oral antibiotic use and provide feedback on adherence to patients discharged from the emergency department and the use of text messaging to increase the receipt of influenza vaccine among low-income urban children. Studies have also been carried out to measure the effectiveness of electronic reminders, SMS, and phone calls in improving patient adherence.

**HeartSaver**

In Heartsaver,a mobile medical device for real-time monitoring of a patient's electrocardiogram (ECG) and automatic detection of several cardiac pathologies was developed in. Another study investigated the potential of short message service (SMS) reminders at reducing non-attendance in physical therapy outpatient clinics. The primary outcome was rate of nonattendance without cancellation. Secondary outcomes were cancellation and attendance rates and exploration of other factors associated with nonattendance. The Cameroon mobile phone SMS (CAMPS) trial; a randomized trial, tested the efficacy of weekly reminder and motivational text messages, compared to the usual care in improving adherence to Highly Active Antiretroviral Treatment in patients attending a clinic in Yaoundé, Cameroon. Another study developed and tested MEMO; a mobile phone depression prevention intervention for adolescents. The study developed and tested the novel mobile phone delivery of a depression prevention intervention for adolescents.

**2.3.1. Existing Health-related Applications with Pros and Cons**

Regarding existing health care applications, there are similar applications out in the market, yet most of them require a fee for use so that patients may keep their own medical records within one application based on category. Furthermore, there are several applications available on reminding patients when to take pills and these applications have been shown to be popular in the market. The majority of them are available for under $10 USD. Specifically, MyMedical by Hyrax Inc. and MedHelper are the top two applications. Both applications have a similar concept: providing a tool to organize medical information in one place for app users. These applications are designed to help patients and/or caregivers keep track and schedule prescriptions, medications, refills, doctors, and pharmacies along with personal medication-related information [Hyrax, MedHelper].

Application users can place different kinds of medical information into an application such as a personal profile (e.g. weight, height, blood pressure level, cholesterol level), medical charts (e.g. X-rays, MRIs), and/or medication information (e.g. a picture of a pill). Each application has different categories, which enables users to accordingly place relevant information into each category. The main point of having an application is to facilitate users in viewing and/or managing their medical records in one place. These features in applications may help increase patient health care outcomes as well as medication safety.

Although users find it helpful to use these applications, a critical requirement is that users have to place all their medical records into the application themselves. This may be very time consuming and inconvenient if application users do not have necessary skills to enter the information. Furthermore, the process may become more difficult as patients take more medications/prescriptions and accumulate more chart data. The more health information the application users have, the higher the chance of them making errors in entering the medications’ names, chart values, etc.

Another remarkable application reviewed was called ‘M-prescription’ developed by SK Telecom HC Biz Office. This free of charge application included unique functions to store and manage prescriptions in smart phones. It also allowed patients to access necessary information regarding their prescription medications, such as indications, directions, and common adverse drug reactions. The most significant function was the automated system. Unlike My Medical by Hyrax Inc. and MedHelper, in which patients need to manually place all the medical information into the application, M-prescription does not have this requirement. Information is automatically populated based on patient's medical records that are submitted by physician. Based on several articles discussing the pros and cons of medical-related mobile applications results are summarized in Table I. The medication applications were identified based on features claimed by manufacturers and ranked based on the relative desirability or usefulness of the features. The apps with basic medication reminder features coupled with enhanced levels of functionality tended to be rated the highest among all applications.

In searching for appropriate applications, users will have a difficult time finding the right application for them. For example, Apple lists the popular applications first and so on. Applications targeted for small audiences will not likely be visible and it will be hard for users to find and use them. Additionally, many of the applications listed consist of beneficial features, yet significant controversy still remains regarding privacy in the use of applications. Users question whether their personal health information (PHI) will be protected during use.

**Table IV. Pros and Cons of existing applications**

|  |  |
| --- | --- |
| **Pros** | **Cons** |
| Having a companion website that allows medication regimen entry from a computer | Not available in various languages |
| Being able to schedule medication instructions | Not having a HIPAA compliance statement |
| Being able to back up and retrieve data from a storage system | Being unable to generate medication reminders for multiple individuals on different medications |
| Allowing the user to enter, search, and select medications | Being unable to generate medication reminders without use of cellular or wireless connectivity |
| Being able to remind patients to take their medication and to record taken and missed doses | Lack of provision of drug interactions information |
| Being able to transmit, print, or export medication regimens and/or medication-taking behaviors | Difficult to choose an appropriate medical mobile application from a proliferative number of applications available in markets |
| Allowing providers to input and maintain the patient’s medication regimen | Not available on every platforms, limited to a single platform (e.g. iOS) |

**2.3.2. Privacy Concerns**

While the mHealth system provides benefits to healthcare with improved adherence and quality of life, it also precipitates other issues, such as privacy and security. Many studies have been identified related to privacy and security being a primary concern within healthcare. For example, in utilizing mHealth patients realized that numerous mHealth related applications contain various functions that require security and privacy. Patient health information and personal health records are stored frequently. However, the majority of currently available mobile applications, including medical applications, impart little or no security. Furthermore, some of the popular applications, which retain personal health records, do not even provide a password for security. As the adoption of the mHealth application by patients and health care providers has increased, several studies have investigated state/regulation and concerns/challenges related to privacy and security.

Providing complete privacy and security to patients, providers, organizations, and vendors is a challenging task. Currently, the Health Insurance Portability and Accountability Act (HIPAA) of 1996 mandates that a national baseline of privacy protection for health information be provided as a part of governmental regulation. Another legal policy called the Health Information Technology for Economic and Clinical Health Act (HITECH) addresses, as part of the American Recovery and Reinvestment Act of 2009 (ARRA), concerns regarding privacy and security. In addition, several other governmental legislations, such as the Sarbanes-Oxiety Act, the Food and Drug Administration (FDA) regulations, the Office of Civil Rights (OCR) enforcements, and the Federal Communication Commission (FCC) imparts guidance regarding healthcare privacy and security. Unfortunately, gaps and weaknesses found within the policies and regulations allow for leaking of privacy and security information.

For example, organizations such as the FDA provide regulations to address privacy concerns, but the regulations are specific for medical device mobile applications. Another issue is that there is no unique age or skill requirement, knowledge set, credential, or legal documentation requirement to develop healthcare applications. As a result, studies suggest that health IT staff may not have the appropriate knowledge or experiences in mobile privacy and security regarding application development and management. They also mention that many users are not aware of the lack of security regarding the release of their personal information.

As use of mHealth has increased, more concerns/challenges about medical privacy have increased. The primary concern is patients’ misunderstanding the “outside of HIPAA protection” regarding individual medical data or sources that can be easily accessed to share patient’s personal information.

For instance, patients assume that medical data collected by any healthcare provider will be under HIPAA regulation, while use of the mHealth application may not fall under HIPAA regulation. However, once the patient’s data is collected by the healthcare provider, most of the collected data will be disclosed to the software vendor and/or third party sites for appropriate as well as inappropriate purposes (e.g. advertising without the patients’ authority). In this situation, a spy, or also known as a data broker may be involved. Data brokers do not adhere to HIPAA regulations.

Moreover, downloading and saving collected health data is another concern under HIPAA protection. The developers of mHealth have noted concerns and challenges related to privacy in terms of its quality and quantity of collected data. The mobile application collects an extensive amount of data over a period of time not only on health-related information, but also on the lifestyle of the patient. Once the data are collected, those data are shared with third parties, again, meaning patient personal information can be leaked. Current studies suggest the development of more specific and suitable policies and regulation as well as further investigation seeking ways to improve.

**2.3.3. Discussion**

The objectives of this study were to review articles associated with existing applications to improve medication adherence and quality of life, to discuss currently marketed health-related mobile application with their pros and cons, and to explore security and privacy concerns with regard to mobile applications. This study provides beneficial information for patients and primary caregivers, as well as pharmacists and other health care providers. Specifically for patients and primary caregivers, current applications contribute to improve patient’s adherence with medication by many different features including administration alarms, drug information search, and medical records access. Various mobile applications allow pharmacists and other healthcare providers to back up and retrieve the patient’s health information, such as patient’s vitals, lab values, and medical charts, and to easily transmit and export medication regimens within the healthcare system. The majority of reviewed studies showed a positive impact on the use of existing mobile applications for medication adherence and quality of life which eventually provided for an improvement in effectiveness and safety of medication therapy.

Even though the retrieved studies reflected positive perspectives, a few studies revealed negative aspects, especially related to privacy concerns. For example, in order to access medical information, someone must place all medical records into an application, which is very time-consuming and inconvenient. As a patient takes more medication or receives more lab results, use of the app may become confusing and harder to manage after a certain point. This may also result in a greater chance of medication error.

In preparing for future development and use of mobile health related applications special features should be researched, with a few of them being patient medical record linking, pop-ups for automated medication administration alarms as well as contraindications. Use of signs and symptoms severity scales for pain, depression, blood pressure and glucose also can also be included to facilitate the conduct of clinical trials to improve patients’ adherence and quality of life. In order to resolve the main concern regarding privacy, further research is warranted for the development of applications to include an enhanced Patient Health Information security feature with a unique code and passcode. In addition, an overall description of medications and other features should be included using a simplified format, such as icons or lay-terms, to improve patient’s understanding.

**2.3.4. Limitations**

Although this review provided a comprehensive overview of the landscape surrounding health care related mobile apps, several limitations exist. It should be noted that a large proportion of articles regarding health-related applications published between January 2004 and December 2014 were excluded because they were either non-health related studies, non-US based, commentaries or abstracts without full text access. Additionally, the articles that solely focused on patient adherence, quality of life, and privacy concerns were lacking. Instead, most articles focused on certain disease states and the effect of mobile applications on those disease states. The authors also caution readers as information on the commercial applications reviewed in this study was obtained solely from the existing literature and associated websites. Developers of the mobile apps were not contacted to obtain information for this study. Lastly, outdated mobile phones were used in some studies, which did not reflect contemporary technology and current trends. Those findings were not deemed to be useful and therefore excluded from the results as most patients currently utilize smartphones.

**2.3.5. Conclusions**

Future use of health related mobile applications is expected to increase in various healthcare settings. Mobile applications are considered to be a valuable tool for patients, caregivers, and healthcare professionals. For future innovative heath related mobile applications to be developed, they must focus on compatible features such as reinforced Patient Health Information security with unique code and passcode as well as automatic linking of prescriptions.