MOBILE MANAGEMENT AND PRESCRIPTION OF MEDICATION

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1. INTRODUCTION TO MEDICATION MANAGEMENT

The major method of treating disease in the developed world is through the prescription of drugs. It is estimated that, on a global basis, 3 billion prescriptions are issued annually. The fundamental process of prescribing and issuing medication is common in most parts of the world. Typically a patient will visit a General Practitioner (GP) who will diagnose any health problems and issue a prescription accordingly. It is then the duty of a pharmacist to dispense the medication based on this prescription and advise the patient on how it should be taken. In practice this process is much more complex as GP's must not only diagnose and prescribe, but must also consider the patient's profile in terms of possible allergies to certain medications and how the new prescription will interact with other treatments that may already have been prescribed. In addition to this, the prescribe-to-intake process for medication usually incorporates more entities than just the GP, patient and pharmacist. In many cases health insurers, government agencies and even pharmaceutical wholesalers will form part of the chain. One of the major expenses in the management of medication is payroll-time spent on the administrative duties needed to service the requirements of various health plan providers. Although not all attributed to medication related administration, it is estimated that between $0.25 and $0.40 of every healthcare dollar in the US is spent on excessive administration costs (Lee et al., 2000).

As well as the inefficiencies introduced in the prescription/medication issue process, patient oriented issues are also prevalent. Medical compliance or adherence indicates the

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precision with which a patient follows a medical prescription. This is a relatively new research domain that is currently receiving much attention. Non-compliance has a negative impact on both the individual patient and the healthcare system and wider economy. The impact is clear: if a patient has been prescribed correctly following diagnosis, non-compliance becomes an important barrier in optimizing treatment. The individual costs of sub-optimal treatment can range from almost nil to critical when for example the effects on chronic hypertension lead to a stroke or when a transplanted organ is rejected (Aswad et al., 1993; Uquhart, 1993). It has been suggested that as high as 50% of patients fail to adhere to the terms of their prescriptions. In the United Kingdom it has been estimated that in the range of 6-10% of hospital admissions are due to problems associated with medications (DoH, 2000). In the United States of America, figures have been released to suggest that non-compliance in patients suffering from cardiovascular disease resulted in more than 125,000 deaths and several thousand hospitalisations a year. These represented 20 million lost working days, costing over $1.5 billion in lost earnings.

2. NON-COMPLIANCE

2.1. Introduction

The problem of non-compliance is a complex one, involving many stakeholders above and beyond the patient. Reasons for non-compliance may be identified as falling into one from a possible four categories: Drug-related issues, Patient related issues, Medical-practice-related issues and Follow-up-related issues. These are shown in more detail in Figure 1.

Non-compliance may be simple to explain for illnesses exhibiting weak symptoms, but non-compliance also occurs for severe diseases. It has been shown that patients with mild forms of diseases tend to comply less than patients with moderate to moderately severe diseases. In addition, patients with extremely severe or even terminal illnesses usually comply less than the moderate group.

It is not possible to identify a typical ‘non-compliant’ patient nor is it possible to suggest different population groups as being better or worse than others. Nevertheless, for the elderly population, it is possible to identify a number of features that may clearly aid to their non-compliance;

1. Elderly patients receive more prescriptions per head that any other group of the population.
2. Elderly patients are at more risk from complications arising from poor medication management. This is due to the physiological changes associated with ageing which affect the body’s ability to handle drugs and to the potential adverse affects of multiple medication such as cognitive, physical and sensory impairment.
3. Demographic ageing may result in the overall level of non-compliance rising.

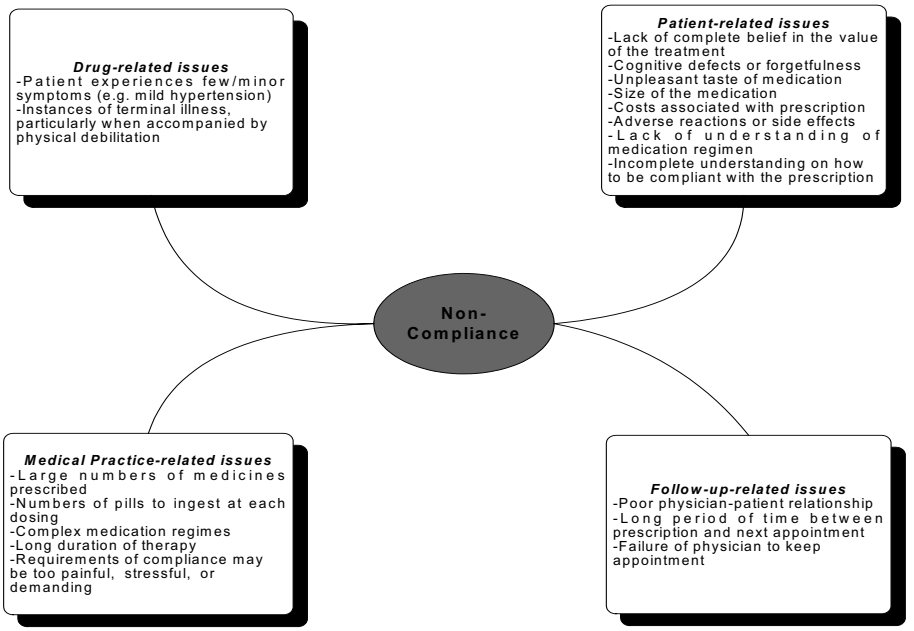

Figure 1. Issues relating to poor patient compliance.

The literature suggests that two related sets of factors can help explain non-compliance and that most often both are present:

- The motivation, beliefs and capacities of the patient in relation to medicine taking.
- The recognition of the importance of motivation by the doctor (or others) and their resulting actions.

Factors contributing to non-compliance may be patient-specific, some are systemic, some are the results of intentional actions and some are the unintentional consequences of other factors. Figure 2 shows a model of compliance which is based on an approach which emphasises perceptions and practicalities.

To assist with the issue of non-compliance a plethora of approaches have been devised, tested and employed. In general these may be segregated into two main approaches: direct and indirect.

- Direct methods involve: Observation of patient taking medication; Measurement of the levels of a medicine in biological fluids (e.g. blood, urine);

Measurement of clinical attendance and count the number of missed and cancelled appointments; Screening of urine or blood samples for medicines prohibited by prescription (e.g. caffeine and nicotine).

- Indirect methods involve: Questioning of a patient verbally or via a questionnaire during the treatment; Assessing patient compliance based on their clinical response; Undertaking pill counts; Use of electronic counters or medication monitors; Evaluation of patient diaries for completeness and compliance with instructions; Compliance assessment through family or nurse.

One of the commercially successful indirect methods has been the use of medication monitors. The following section elaborates upon this area.

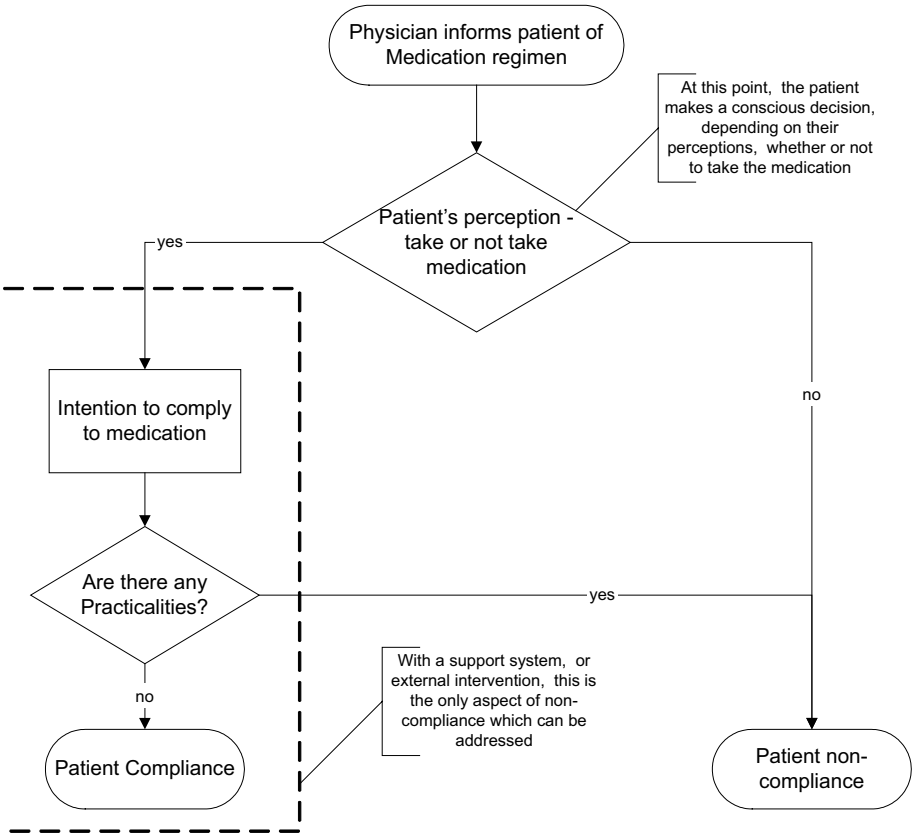

Figure 2. Model of compliance based on patient perceptions and practicalities.

2.2. Classical Compliance Aids

A medication compliance device can be defined as "a container or device which is normally designed to hold solid oral dosage forms for a defined period" (Walker, 1992). Although most common medication storage systems, including blister packs and conventional screw top medication bottles, meet these criteria, modern compliance aids tend to be something more elaborate. Commercially available solutions vary greatly in functionality; these devices can range from a partitioned container to a complex electromechanical device with telecommunication capabilities. Irrespective of the level of functionality the primary requirement of any compliance aid is to assist in self-medication management. Variations in the levels of functionality are purely as a result of manufacture's interpretation of constraints such as cost, technology and user requirements.

2.2.1. Types of Compliance Device

Typically compliance aids have been classified into three categories. This classification is based on functionality, and the categorization is as follows:

1. Pill holders
2. Alarm based aids
3. Monitoring devices

2.2.1a. Pill Holders.

This category includes devices that are primarily pill containers. Typically they consist of a container with several compartments each of which represents a dosage interval. This container can be carried with the patient and medication can be extracted as desired. The main variation in these devices between manufactures tends to be in terms of size, shape, number of pills they hold, and the number of medication intervals they support. A typical example of this type of device is illustrated in Figure 3a. It can be seen that this device has seven compartments; each compartment has a flip lid and is marked with a letter indicating a day of the week. Here the manufacturer has also included Braille markings to aid those who are visually impaired. In this particular implementation, each of the compartments is quite large and capable of holding large quantities of medication. This renders the device less portable and several manufactures have adopted a much smaller design with trade offs in the medication capacity. This type of system is capable of providing coarse guidance, as it does not cater for individual dosage intervals during the day.

Another popular approach has been the use of a plastic box with between 28-56 compartments (Corlett et al., 1996). This allows the medication for each day to be subdivided to represent different times during the day.

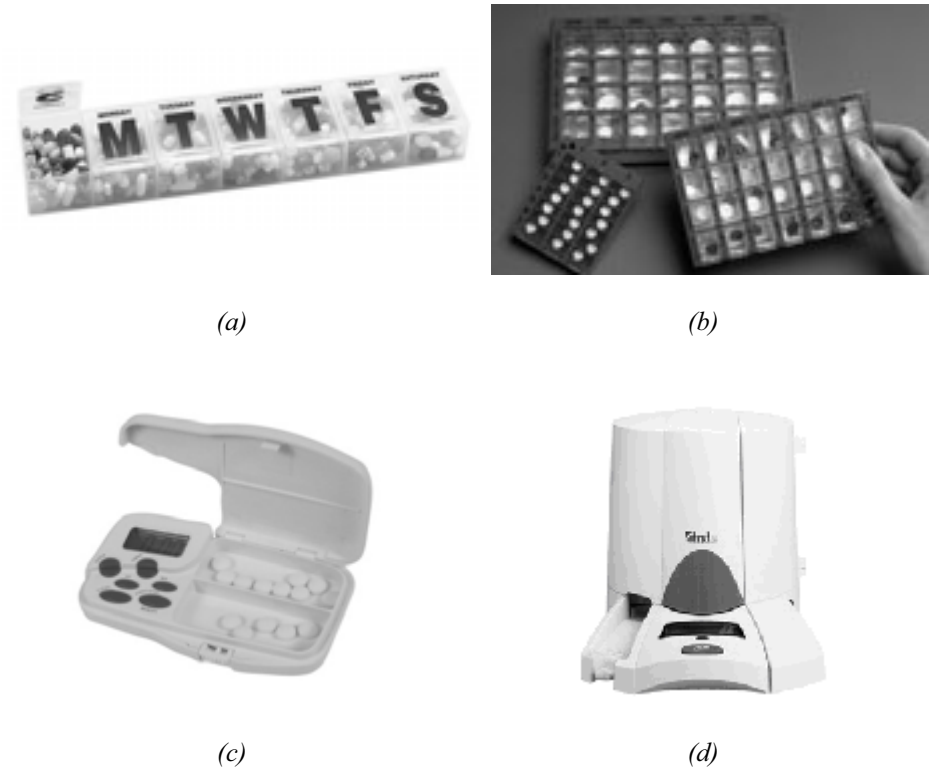

Figure 3. (a) 7 day pill holder (b) Dosset compliance aid (c) Alarmed pill holder (d) MD2 Compliance aid.

This is a realistic patient requirement. The Dosett system (www.dosett.com) shown in Figure 3b provides this functionality. This device is available in three sizes enabling the patient to choose which configuration suits best. Dosett is one of the most frequently studied compliance aids and has been shown to be beneficial to the elderly and to community based psychiatric patients (Rivers, 1992).

2.2.1b. Alarm Based Aids.

These devices are based around a timer and alarm mechanism and are usually accompanied by some sort of medication container similar to that mentioned above. Some (Szeto et al., 1997) have attempted to provide electronic reminders based on pill bottles. Generally these devices can memorize the medication schedule and provide different alarm types depending on the medication time. In some cases the device includes a reservoir of cartridges for a weekly supply of medication that can be inserted into the electronic reminder module.

These devices are sometimes referred to as active compliance aids, again the functionality and configuration vary among manufacturers. Figure 3c illustrates a typical system. Here the medication is stored in a two-compartment container; attached to the left of this is an electronic clock and alarm. The medication regimen is programmed into this timer using the buttons. When medication is to be taken an alarm sounds and the patient must open the compartment and remove the correct medication. This is a simple yet effective approach. Other solutions provide more compartments for medication, and several manufactures have designed systems were a weeks supply of medication can be stored in seven different containers, and the electronic module can be attached to each container on the appropriate day of the week.

2.2.1c. Monitoring Devices.

In most cases compliance monitoring devices offer the functionality of the aforementioned systems with additional recording and telecommunication capabilities. In some instances the dispensing process is also automated. The MD2 system, as shown in Figure 3d exhibits the characteristics of a compliance monitoring device. It is a home based unit and provides a comprehensive range of features. At pre-programmed intervals, MD2 will "announce" that it is time to take a medication dose. This announcement consists of multiple features: a voice message, a flashing light, and a textual message on an inbuilt display. To dispense the medication dose, the individual simply presses an exterior button, and the medication is dispensed in a small plastic cup. Instructions such as "Take with water" can be announced when the button is pressed. The remaining time until the next dose is displayed on the LCD screen. The device holds up to sixty of the plastic cups, which have to be manually preloaded with the correct dose of medication. The MD2 system also provides a means of telecommunication with a care model. In instances of non-compliance the MD2 system will automatically contact the call centre which subsequently places a call to either the user or a named relative to alert the instance of non-compliance.

2.3. Assessment of Current Compliance Aids

Acceptance of the aforementioned compliance aids is widespread. It is evident that the variance in functionality and complexity of the classical compliance solutions results in varied performance. The portability and low cost nature of the simple organisers and alarm based systems make them an attractive solution, however, the comprehensive functionality and in particular the telecommunications features of the larger home based monitoring systems render them as better solutions. Regardless of the functionality, most of the current compliance control systems are only effective if the patient is willing to take the medication but is impeded by practical issues, as illustrated in Figure 2.

There is a general feeling that in many cases critical care patients are apprehensive about leaving the home. However, it is believed that mobile solutions can alleviate these worries. Additionally, any attempt at further optimisation of any compliance control

solution must address the broader issues not necessarily related to the patient. Enhancement of the interaction between stakeholders (Wertheimer and Santella, 2003) and in particular, real-time monitoring of compliance statistics, and optimisation of the prescribing process shall address some of the issues associated with non compliance. When these factors are taken into consideration it is evident that an optimal compliance solution must allow mobility and interaction between stakeholders. This is realizable through the use of mobile telecommunications technology.

3. ICT AND HEALTHCARE

3.1. Introduction

The application of Information and Communication Technologies (ICT) to healthcare can be described as e-health or telehealth. E-health, the most commonly used of these two terms, describes the practice of protecting and promoting health. E-health covers all aspects of ICT in healthcare and can incorporate all stakeholders in the healthcare arena.

3.2. Technology in Point of Care Applications

The acceptance and growth of Personal Computer (PC) based technology in point-of-care applications has been widespread. In 1999 64% of European GP's used a PC, see Figure 4 (InterCam, 1999). This is almost twice the number for 1996. In addition a staggering 90% to 100% of the 105,000 European pharmacies are currently equipped with a PC.

It is interesting to note, however, that the main use of PC's in GP's surgeries is secretarial or reception oriented, followed by management of the surgery. It is believed that the crucial indicator of acceptance of information technology in primary healthcare is the use of Electronic Patient Records (EPR).

EPR systems allow management of administrative, clinical and financial patient information. In recognition of the benefits of such an approach, many government and private healthcare administrations have encouraged its introduction. EPRs have almost been fully implemented in the UK, with 90% of doctors storing information on patients electronically. Closely following are the Netherlands and Denmark, with 80% and 75% respectively. The use of digital records in Germany and France is between 60% and 70% and in the USA 46% of GPs are using EPR.

Another critical factor in the uptake of ICT in healthcare is the application of internet technology. Internet based applications can be used to increase the quality of healthcare in remote areas, educate healthcare professionals and allow for sharing and clustering of healthcare resources and information. Statistics show that in the UK alone over 80% of GPs have access to the internet. However, similar to the case of the number of GP's using PC's, it is difficult to establish the nature of utilisation of this service.

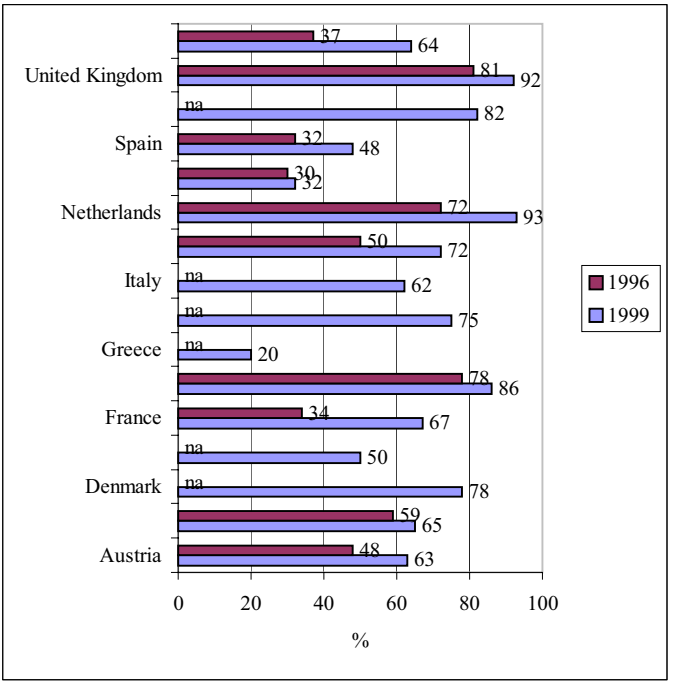

Figure 4. Proportions of GP's using PC's in European countries (Deloitte & Touche, 2000).

3.3. Electronic Prescribing

Much effort has been directed at streamlining the process of medication management from a medical professional's perspective. The area where most interest has been generated is that of electronic prescribing (e-prescriptions) or Electronic Transmission of Prescriptions (ETP). This is when computers and telecommunications technology are used to capture, store, print and in many cases transmit prescription information. Early E-prescription systems where little more than custom written software that enabled a GP to generate and print off a prescription which could be signed and physically passed on for further processing. Even such primitive systems had numerous advantages over conventional paper based techniques:

- Elimination of eligible prescriptions. This eliminates the need for a pharmacy to contact a GP to confirm what has been written and reduces the possibility of dispensing incorrect medication. Cases have been documented where

physicians have been tried and found guilty of negligence for writing eligible prescriptions.

- Reduction in forged or stolen prescriptions. A common problem mainly attributed to substance abuse where individuals seek unauthorised quantities of medication by modifying or generating hand written prescriptions.
- Easy issue of repeat prescriptions. When a patient requires a repeat prescription, the issuer can easily regenerate the new prescription from a cached copy.

Modern e-prescription systems allow the prescription data to be transmitted securely, via the internet, to the next point of concern. As well as this, many of the previously manual and time consuming tasks are now automated, these include (Sternberg, 2003).

- Administrative tasks, such as billing.
- Drug interaction checking. This involves warning the GP of any adverse effects caused by introducing new medications to a patient's current regimen.
- Real time formulary checking. Particularly important in regions where managed care plans dictate what medication a patient is entitled to.
- Drug allergy screening. Based on a patient's profile the system can flag medications that are not suitable for the patient.

Although obstacles such as initial cost and lack of interoperability are a hindrance (Chin, 2003), healthcare agencies in most countries recognise the potential advantages of such techniques and many have already established or are conducting trials on e-prescription systems.

4. MOBILE TECHNOLOGY

4.1. Mobile Telephony

The de facto standard for mobile telephony in Europe is the Global System for Mobile communications (GSM). GSM first appeared in the early 90's and since then its acceptance has been wide spread. The goal initially was to provide a mechanism for good quality voice communications using a digital cellular architecture. This architecture also provided some data functionality including low bandwidth data transmission and most popular of all SMS (Short Message Service) (Beolchi, 2003). Although potentially nearing the end of its lifecycle, the growth in the application of GSM technology shows no sign of slowing. Since the late 90's there has been much anticipation over the introduction of GPRS (General Packet Radio Service) and third generation technologies, particularly UMTS (Universal Mobile Telecommunications Service). The intention is that these technologies will eventually replace GSM ultimately with UMTS, using GPRS during the transition. GPRS uses GSM infrastructure with additional hardware and software. The packet switched nature of the service enables an always on connection and it yields superior bandwidth to GSM. It was forecast that GPRS would be introduced in late 2000 and rapid acceptance and widespread penetration would soon follow. The

reality is slightly different, as only now, at the time of writing, do most mobile operators offer GPRS services accessible through a moderate range of handsets. Transmission speeds are also lower than first expected and the cost of using the service remains quite high. The delay in the role out of GPRS has had an effect on the timescales associated with 3G technology. Boasting ultimate speeds of up to 2Mbps, the first commercial 3G services are only starting to emerge.

As intended, the main utilisation of GSM technology has been in voice communications and SMS. Other data services have also used GSM as a bearer technology for data communications. The most prevalent being the Wireless Application Protocol (WAP). WAP was first established in 1997 by a consortium of telecommunication solution providers who realised the need for a framework to enable portable devices to connect to the WWW. The protocol was developed paying particular attention to the constraints of handheld devices such as limited connectivity bandwidth, small screen size, and low power. WAP specifies an end to end framework that allows a mirco browser, installed on a mobile device to retrieve specially developed content from the WWW via a gateway or proxy server. Unlike standard web content which is composed using HTML this content is assembled using WML (Wireless Mark-Up Language). Most mobile phones are now supplied with a WAP micro-browser installed and most if not all mobile operators have WAP gateways.

4.2. Personal Digital Assistants

Although the promise of the wireless broadband internet has been slow to materialise, the rapid growth in the integration of handheld computers in the practice of medicine continues. The prominent genre of handheld computer used today is the Personal Digital Assistant (PDA). The PDA began life almost 20 years ago when Psion introduced the Psion 1. This device incorporated all the functionality of its ancestor, the pocket calculator, along with simple organiser functions and the ability to store a limited amount of text. Evolution of these early devices was restricted as manufactures were constrained by integrated circuit and display technology at that time. It was not until almost a decade later, when Apple entered the portable computing arena, that significant advancements were made. Their device, the MessagePad, represented a major milestone in the evolution of the PDA. Key features of the device included a touch sensitive screen and hand writing recognition.

Modern PDA's are not so much characterised by their manufacturer, but more by the operating system which they support. The two main rivals in the PDA operating system arena are Palm and Microsoft. The Palm software, PalmOS was first developed for their hardware, the Palm Pilot series, but it has since been incorporated by several manufacturers. Palm have claimed dominance for several years now, however significant ground has been gained by Microsoft powered devices, particularly since the introduction of their latest generation software 'PocketPC'. Evaluation of both technologies comparatively is difficult. From a user's perspective opinions are divided. Some favour the windows based PocketPC environment because of its ergonomic similarity to

Microsoft's desktop oriented products, others feel that the simplicity, flexibility and wide spread market acceptance of PalmOS make it a more appropriate choice. From an organisational or development perspective opinions are as equally divided. Integration of PalmOS based devices with existing infrastructure is relatively straight forward due to the open nature of the platform and the level of developer support attributed to the extent of Palm's existence in the marketplace. The arguments supporting the ease of integration of devices using PocketPC is equally as just, a particular advantage claimed is that due to the similarities between the PocketPC environment and full blown Windows, porting of desktop applications to mobile platforms requires only incremental costs. As opposed to the Palm platform, where software will require substantial or complete redesign during migration.

4.3. Smart Phones

Since mid 2000 a new genre of devices has arrived. Many observers assumed this inevitable. These devices commonly referred to as 'Smart Phones' incorporate both PDA and mobile telephone technology inside one unit. This gives the user access to organizer type functionality as well as voice and data features. Although many connectivity peripherals have been developed for the classical PDA (including modem cards, bluetooth units and GSM modules), this is the first series of devices that have incorporated both technologies at manufacture. The major challenge in developing these devices is realising a unit that is small and portable enough to compete in the modern mobile phone market, yet large enough (particularly with respect to the display size) to function as a full blown PDA.

5. STATE OF THE ART IN MEDICATION MANAGEMENT

Over the past decade an unprecedented number of information and communication technologies have promised to affect healthcare delivery (Jadad and Delemothe, 2003). From a physician's perspective, the e-health era has brought about significant changes in the ways in which medicine is practiced. Assistance to and automation of tasks such as patient management and administrative duties have greatly reduced the manual overheads that medical professionals encounter. This new approach to healthcare has led to increased efficiency and better quality of care for patients. Although significant, it is reckoned that this is only one of a number of milestones evident in the evolution of modern patient care. An ongoing development which is considered significant is the increased adoption of mobile computing technologies by medical professionals. Classically a clinician's interface to an e-heath system would have been desktop based; however this is restrictive as most medical professionals require mobility. Modern handheld devices have not only supplemented the classical fixed systems but in many cases, particularly with the evolution of wireless data transfer, these mobile platforms have become the successor. Indeed, for many doctors, the organiser functions of these devices alone justify the expenditure (Al-Ubaydli, 2004).

Several technologies have been introduced and discussed in previous sections of this article. It is evident that the favoured platform in mobile e-health delivery is the PDA. Although limited in terms of system resources these devices compare favourably over their closest contender and bigger brother the notebook computer. Superiorities include:

- Size and Weight. A typical PDA (a standard Palm Pilot or Pocket PC) can easily be carried in the user's pocket and weighs little more than a mobile phone.
- Battery Life. Mainly due to the absence of a moving media (hard disk drive) and small screen size, most PDA's can operate for considerable periods (10 hours plus) without the need for recharging.
- Instant on. PDA operating systems do not perform a boot sequence; this gives medical professionals instant access to records/services.
- Cost. Latest release PDA's are typically less than half the cost of low end notebook computers.

The issue of connectivity is also interesting as more and more applications are providing direct connectivity via a wireless network to central databases and servers, where previously connectivity was usually gained via synchronisation with a PC. It is worth noting that the adoption of WAP using mobile phone technology in healthcare has been slow, particularly from a medical professional's perspective. It is believed that this can mainly be attributed to the fact that applications can not be sufficiently represented on devices with small screens and limited input characteristics. Most PDA's are also capable of supporting WAP based applications however in instances where connectivity has been fundamental the trend has been more towards custom written communications applications using the internet as the underlying infrastructure. Other approaches are also common, including the use of cut down web browsers, and in some cases proprietary technology like the web clipping system developed by Palm.

A plethora of medical applications are currently available for all platforms and both Microsoft and Palm boast their superiority in the marketplace. Irrespective of platform, most of the high end commercial applications offer a full suite of functionality, including patient record access, e-prescribing and medical reference. The e-prescribing aspect of these systems allow physicians to utilises all the benefits of modern fixed e-prescribing systems while on the move, either on a hospital ward or in a patient's home. A typical example of such a system is Rx+. This e-prescribing tool is part of a suite of clinical automation tools called 'Touchworks' by 'Allscripts Healthcare Solutions' (http://www.allscripts.com). Allscripts Rx+ is designed to run on the PocketPC and is an ambulatory medication management and prescription communications tool featuring drug and allergy interaction checking and plan-specific formularies.

6. COMPLIANCE CONTROL IN THE FUTURE

Several types of compliance aids have been discussed in earlier sections of this article. Although many of these devices can be described as portable or mobile compliance aids, most of them that support connectivity are home based. Indeed many of the home based systems that do have communications functionality use proprietary protocols and do not utilise existing data communications infrastructures such as the Internet or wireless technology. All of the existing solutions are custom built and serve no other purpose other than managing medication. A slightly different approach to compliance controls and monitoring is the use of existing technology and devices. A typical example of such a system is the use of a pager or SMS to send an alert to a patient when it is time to take medication. This approach is particularly cost effective if the patient has a mobile telephone. Another system that has been adopted is the use of PDA's with customised software that alerts the patient at medication time. Some systems also allow the patient to flag that they have taken their medication. This is nothing more than an elaborate electronic diary system, however this is favoured over paper based records as when a patient flags that they have consumed the medication the event is time and date stamped. In paper based systems a patient can forge the results by amending the medication record at any time. This feature is particularly important when using compliance assistive techniques in clinical drug trials.

It is believed that the most efficient approach in modern compliance control is to utilise existing technologies and concepts in tailored devices. One example of this approach is the MEDICATE system. This system is being developed by a consortium of European entities and is the result of a research program investigating the issues surrounding the compliance problem. The MEDICATE solution consists of a home based compliance device that is capable of dispensing medication and recording patient compliance. A novel feature of this system is that it incorporates a detachable module that allows the patient to take their medication management out of the home. This detachable component can hold a day's supply of medication and incorporates the necessary electronics to remind the patient and record compliance. The detachable module can also be synchronised with the home based system when in close proximity (within the home) via a wireless link. The wireless link uses bluetooth technology, a standard designed to facilitate short range radio communications. As well as consisting of a patient oriented compliance device the MEDICATE system supports medication management from a medical professionals perspective through the implementation of a care model. This care model allows GP's, Pharmacists, care workers and any other entities in the supply to intake chain for medication to be interconnected. The home based compliance aid is also connected to this care model using an inbuilt modem and a conventional telephone line. The system uses internet technology and doctors can prescribe either from a PDA or a desktop platform. When a doctor enters a prescription it can be sent to the next operator concerned, usually a pharmacist. The pharmacist can then administer the medication appropriately. The prescription data is also sent directly to the unit in the patient's home, and when the actual medication is loaded into the device the patient can rely on the device for timely reminders of when medication should be

taken, based on the up loaded data. When a patient fails to take their medication, the event will be recorded and if critical a carer can be contacted. A central server and database act as a hub for the system and through time a profile of patient's medication compliance patterns can be established. This profile can be used in further consultations and prescription issues as it will highlight instances of non-compliance which the GP can take action against.

It is clear that compliance is a significant issue from a patient and healthcare perspective. With advances in technology it is likely that complex care models supporting mobile medication management and prescribing will prevail.

7. ACKNOWLEDGEMENTS

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8. REFERENCES

Al-Ubaydli, M., 2004, Clinical review: handheld computers, *British Medical Journal*. **328**:1181-1184.

Aswad, S., Devera-Sales, A., Zapanta, R., and Mendez, R., 1993, Costs for successful versus failed kidney transplantation: a two-year follow-up, *Transplantation Proceedings.* **25**: 3069-70.

Beolchi, L., 2003, *Telemedicine Glossary: Glossary of Concepts, Technologies, Standards and Users, 5TH Edition,* European Commission, Brussels.

Chin, T., 2003, 5 obstacles to e-prescribing, *American Medical News.* **46**(18):17-18.

Corlett, A. J., 1996, Aids to compliance with medication, *British Medical Journal*. **313**:926-929.

Department of Health, Prescriptions Dispensed in the Community Statistics for 1990 to 2000, England (August, 2000); http://www.doh.gov.uk/pdfs/sb0119.pdf

Deloitte & Touche, The Emerging European Health Telematics Industry, Market Analysis, February 2000.

Jadad, A. R., and Delamothe, T., 2003, From electronic gadgets to better health: where is the knowledge?, *British Medical Journal.* **327**(7410):300.

Lee, R. D., Conley, D. A., and Preikschat, A., eHealth 2000: Healthcare and the Internet in the New Millennium, WIT Capital industry report (2000); http://www.witcapital.com.

Rivers, P. H., 1992, Compliance aids – do they work?, *Drugs and Aging*. **2**:103-11.

Sternberg, D. J., 2003, Make life a little easier, *Marketing Health Services.* **23**(2):44.

Szeto, A. Y. J., and Giles, J. A., 1997, Improving oral medication compliance with an electronic aid, *Medicine & Biology Magazine*. **16**:48-58.

Uquhart, J., 1993, When outpatient drug treatment fails: identifying non-compliers as a cost-containment tool, *Medical Interface.* **6**:65-73.

Walker, R., 1992, Stability of medical products in compliance devices, *The Pharmaceutical Journal*. **248**:124-6.

Wertheimer, A. I., and Santella, T. M., 2003, Medication compliance research: still so far to go, *Journal of Applied Research in Clinical and Experimental Therapeutics.* **3**(3).