AN ASSESSMENT OF THE MATURITY OF TELERADIOLOGY SERVICES WITHIN THE WESTERN CAPE PUBLIC HEALTHCARE SYSTEM

A.H. Hartmann¹ & L. van Dyk²
Department of Industrial Engineering
University of Stellenbosch, South Africa
14807289@sun.ac.za¹; lvd@sun.ac.za²

ABSTRACT

Telemedicine can be defined as the exchange of health care information and the delivery of clinical health care at a distance, by means of information and communication technology (ICT). Driven by technological advancements, telemedicine adoption rates increased significantly over the past few years. In an effort to benefit from these advancements, the South African National Department of Health (NDoH) is encouraging the delivery of healthcare in the public health sector through telemedicine.

Many studies suggest a range of reasons for the generally low success rate of telemedicine services. A Telemedicine Service Maturity Model (TMSMM) was developed by the Health Systems Engineering Group of Stellenbosch University to encapsulate these reasons in a systematic way and to enable the description, evaluation and optimization of an existing telemedicine services.

According to the Government of the Western Cape their Department of Health is the most advanced and reputable in the country, with emphasis on constantly improving quality of health care provided to its citizens. Telemedicine services which are successful at this level could be considered as a template/guideline on how to implement successful telemedicine services in the remaining 6 provinces.

The purpose of this paper is to describe the process of evaluating existing telemedicine services (teleradiology in particular) implemented in the Public Health sector of the Western Cape by means of the Telemedicine Maturity Model.
1 INTRODUCTION

One of the major challenges South Africa is facing in the 21st century is providing quality primary health care (PHC) to all citizens of South Africa. The current health care system is under increasing pressure, due to the rapidly growing population, the fact that a large portions of the population live in rural areas and the increasing lack of resources. Eighty percent of the population depends on the government for healthcare. The government is not equipped to support these numbers [1].

1.1 Western Cape Health Care System

According to the Western Cape Government, the Province of the Western Cape health care system has the best reputation in the country. The way forward for the Western Cape Department of Health is to place emphasis on the improvement of information management systems and the optimisation of the primary health care sector with the help of advanced information and communication technology (ICT)[2].

Health Care in South Africa operates on a referral system and the procedure is as follows: Patients visit a Community Health Centre (tier 1) and if the medical condition requires it, they are referred to a higher tier hospital in this case a Primary Health Clinic (tier 2) and from there if needed to a Specialist Hospital (tier 3). A common issues encountered is that medical staff at the rural, lower tier facilities have a limited capacity and medical knowledge to diagnose certain medical cases and thus require expert advice, thus the patient needs to travel long distances to be seen by qualified Medical Officers (MO). In the majority of referred cases patients could have been treated at the local clinic instead of being transferred.

Telemedicine is a potential solution to improve the current health care system in South Africa, which the National Department of Health (NDoH) recognised in its formulation of the 1998 Telemedicine Strategy.[3]

“The mission of the telemedicine strategy is to facilitate the provision of high-quality and cost-effective health care to all the citizens of South Africa.”[3]

Telemedicine is considered the exchange of health care information and the delivery of clinical health care at a distance, by means information and communication technology (ICT)[4].

“Telemedicine is not new ... It is unlikely that there is any medical practitioner in South Africa who has not practised telemedicine, albeit unwittingly.”[5]

Per definition a telephone call between a doctor and a patient or the exchange of SMS-messages between clinician and specialist, constitutes a telemedicine service.

1.2 MRC Telemedicine Workstation

The issue of unnecessary referral, deteriorating quality of health care and the declining resources sparked the development of the so-called Telemedicine Workstation. The Telemedicine Workstation is the brainchild of the Medical Research Council and the Stellenbosch University.

The Telemedicine Workstation includes a touch screen panel, a camera and a 3G internet connection. The aim of the workstation is to enable medical staff at District Hospitals to consult with specialists and transfer medical information to and from their respective higher tier hospitals. Thus eliminating unnecessary referrals to higher tier hospitals, and improving the quality of health care. Besides connecting clinicians and specialist the workstation is to raise awareness, train clinicians in the use of telemedicine as a medical tool and identify the type of scenarios in which a store and forward services would be useful.[6]
The Telemedicine Workstation was rolled out to 90 District Hospital in South Africa, of which 7 were implemented in the Western Cape Public Health sector[6]. Since the publication of the Telemedicine Strategy in 1998 and the newly released National eHealth Strategy (2012) the department of Health has supported the development of a number of telemedicine services, with the aim to improve the Patient’s experience, quality of care and the strive for operational efficiency[3][7].

Although the intention of these projects was to strengthen the South African primary health care system, the opposite was accomplished due to unsustainability and unsuccessful implementation of the systems[8]. Due to the failure of many of such telemedicine projects the level of confidence in telemedicine has decreased, although it is recognised that the service is an effective means to overcome the challenges in the rural health setting of South Africa.

1.3 Teleradiology

Of all the telemedicine services available, teleradiology is the most common and successful implementation of telemedicine in South Africa. Teleradiology is the transfer of radiological information via electronic pathways from one geographical location to another for the purpose of interpretation and consultation [9].

The majority of South African private health groups and a few networks in the public sector have fully functional teleradiology systems based on the picture archiving and communication systems (PACSs). A digital radiology image is uploaded to an internal server along with relevant medical patient data, this data can then be accessed by clinicians, radiologists and specialist irrespective of their location.

There are more simplistic, less complex, non-official teleradiology services, which involve the use of mobile phones, and e-mail to transmit radiological data between clinicians and specialists.

Ever since the introduction of telemedicine there have been calls for a more generalised and systematic approach to telemedicine. The National Health strategy recognises the potential telemedicine has towards the re-engineering of the PHC system and the importance of monitoring and evaluating the performance of these services, to ensure sustainability and continuous improvement[7]. A Telemedicine Services Maturity Model (TMSMM) was developed by the Health Systems Engineering Group of Stellenbosch University to enable the description and evaluation of an existing telemedicine service, together with a systematic service maturation path [10].

1.4 Purpose and Scope

The purpose of this paper is to describe the process of evaluating existing telemedicine services (teleradiology in particular) implemented in the Public Health sector of the Western Cape by means of the Telemedicine Maturity Model. The parameters of the paper were set to include teleradiology services within the Western Cape Public Health sector, firstly due to the established nature of teleradiology services and secondly the highly rated Western Cape health care system.

2 METHODOLOGY

The methodology involved four phases as shown in Figure 1. The respective research methods that were used during each of these phases are shown in brackets.
2.1 Site Visits

The sites selected were not at random but are hospitals which received the MRC Telemedicine Workstation the previous years. The reason these hospitals were chosen is simply because at least one telemedicine service was known to have been implemented at the sites, thus ensuring that a minimum of one telemedicine service could be evaluated at the selected hospital.

The study was approved by the Health Research Ethics Committee at Stellenbosch University assuring that the study will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki, South African Guidelines for Good Clinical Practice and the Medical Research Council (MRC) Ethical Guidelines for Research. Further clearance had to be received from the Western Cape Department of Health to conduct this research within the public health care facilities of the Western Cape. Healthcare facilities in Caledon, Ceres, Hermanus, Robertson, Swellendam and Worcester were visited for purposes of this study.

At the beginning of each interview the interview participant was informed regarding the purpose of the study and asked to sign an informed consent form acknowledging that the information was obtained in an ethically correct manner.

During the interview the participant was asked to answer a series of questions regarding their exposure to telemedicine services (see below).

- What is your experience with respect to telemedicine?
- Which Telemedicine services are you involved with, either as a participant or as a developer?
- What is your role within the service?
- Are any standard frameworks or guidelines being used to help with the implementation, operationalization and optimization of the telemedicine service?

This series of questions enables the identification and general description of existing telemedicine services being performed at the hospital.

2.2 Description of Telemedicine Services

With the information gathered during the interview a data flow diagram was generated, with the participant, for each identified telemedicine service. The purpose of the data flow diagram (DFD) is to visualise the data flow of the telemedicine service and identify the individual processes involved. For example Figure 2 depicts a data flow diagram for teleradiology service using a mobile phone to capture and transmit the medical data. With all the processes comprising the telemedicine process identified and noted on the DFD, the mapping and maturity evaluation of the service can commence.
Figure 2: Mobile Phone Teleradiology DFD
2.3 Maturity Assessment

The assessment of the Western Cape Public Health Care teleradiology services was conducted with the help of the telemedicine services maturity model developed by the University Stellenbosch Health Systems Engineering Group.

The TMSMM Figure 3 is designed along three dimensions. These dimensions are defined as, the domain-, telemedicine service- and maturity scale dimensions. The intercept of each pair of these dimensions form a matrix, each with a specific significance and function.

![Figure 3: 3D representation of the TMSMM](image)

2.4 TMSMM Mapping

The previously identified telemedicine service is then captured using the TMSMM visualization tool. The above mentioned mobile phone teleradiology service was used as an example for the mapping process.

The idea behind the TMSMM tool is to capture telemedicine services as simply as possible and rate each aspect of the service. The DFD (Figure 1) of the service clearly indicates that the first process is a capture process. After selecting the Capture option in the Micro-level Type tab, the service process is entered according to the five domains explained in Section 2.2. The Medical Officer [Man] uses his personal mobile phone (digital image) [Machine] to create x-ray (digital image) [Material] according to his/her own discretion [Method] at the cost of Department of Health (employing institution) [Money], see Figure 4.
This process is replicated for each of the remaining processes until all the identified processes are mapped on the TMSMM. Each of the (orange) blocks is then rated according to domain specific capability statements, ranging from Ad Hoc (light green) to Optimising (dark green) see Figure 5.

Similarly as for the micro-level the meso-level and macro-level of the telemedicine service are mapped and rated.

The final result of the mapping process is the entire telemedicine service in one picture, including the micro-, meso- and macro-level services rated across the five domains (Man, Machine, Material, Method and Money), also referred to as the Maturity Dashboard (see Figure 6). The domain fields in Figure 4 are coloured orange, indicate an instance of the telemedicine service which has been assigned the lowest possible maturity rating (not available). A telemedicine service is only considered fully functional if all the processes of the service, firstly exist and secondly achieve a minimum Ad Hoc maturity rating.
### Telemedicine Maturity Model: Swellendam (LVD) ... radiolo

#### Number of Processes: 5

<table>
<thead>
<tr>
<th>Description</th>
<th>Man</th>
<th>Machine</th>
<th>Material</th>
<th>Method</th>
<th>Money</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Make a digital image copy of the paper based x-ray</td>
<td>User</td>
<td>Devices and Applications</td>
<td>Electronic Health Record</td>
<td>Work Protocol</td>
<td>Operational Cost</td>
</tr>
<tr>
<td>2 Send patient data (Varial Communication) via service provider</td>
<td>Medical Officer (level 1)</td>
<td>use(s) personal mobile phone (digital camera)</td>
<td>to create x-ray (digital image)</td>
<td>according to own discretion</td>
<td>at the cost of DoH (employing institution)</td>
</tr>
<tr>
<td>3 Send digital photos via service provider</td>
<td>Medical Officer (level 1)</td>
<td>use(s) personal mobile phone (synchronous voice)</td>
<td>to send/pull patient medical data (accorded in patient file)</td>
<td>according to mobile phone service protocol</td>
<td>at the cost of Medical Officer (Level 1)</td>
</tr>
<tr>
<td>4 Make recommendation based on patient data transferred</td>
<td>Specialist (level 2)</td>
<td>use(s) personal mobile phone</td>
<td>to send/pull radiological case</td>
<td>according to traditional medical protocol</td>
<td>at the cost of DoH (employing Institution)</td>
</tr>
<tr>
<td>5 Send recommendation via service provider</td>
<td>Specialist (level 2)</td>
<td>use(s) personal mobile phone (synchronous voice)</td>
<td>to send/pull treatment recommendation/diagnosis</td>
<td>according to mobile phone service protocol</td>
<td>at the cost of Specialist (level 2)</td>
</tr>
</tbody>
</table>

### User Community
- Infrastructure
- Electronic Health Records Management
- Change Management
- Financial Sustainability

### End-user community
- Physical infrastructure
- EHR agent across the service ecosystem
- Policies with in service context
- Business model

### Analyst community
- National, regional ICT infrastructure
- National EHR mgmt
- National policies and strategies
- National Business Case

### Society for which the service is developed
- National, regional ICT infrastructure
- National EHR mgmt
- National policies and strategies
- National Business Case

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**Figure 6: Mobile Phone Teleradiology Maturity Dashboard**

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2.5 Data Aggregation and Analysis

The information obtained during the data gathering processes described in the previous sections was collected and stored in a data warehouse, with all the information linked to the respective telemedicine services. The data was then nominalised to generate one coherent data set. The data was then organised and aggregated using pivot tables and visualisations for the purpose of analysis.

The remainder of the article is devoted to a discussion of these analyses.

3 WESTERN CAPE TELERADIOLOGY EVALUATION RESULTS

All the telemedicine services identified and evaluated via the evaluation process as explained in Section 2, were assessed with the same framework, namely the TMSMM. This allowed for quantitative aggregation of results. The discussion follows the structure of the TMSMM.

3.1 Telemedicine Devices

The machine domain represents all the devices and applications which aroused to perform telemedicine services. Figure 7 represents a pie chart of all the devices used to perform telemedicine (teleradiology specifically).

The majority (5/8) of teleradiological services utilises a normal Desktop Workstation, operating on Windows to perform a telemedicine service such as teleradiology. Due to the general store-and-forward nature of teleradiology, for example the use of email to send radiological information between two clinicians.

An unexpected result on the other hand was the low percentage of Telemedicine Workstation utilised (1/8), especially taking into account that the Telemedicine Workstation was specifically designed to perform telemedicine specific tasks. The reasons for this low usage are explained at a later stage in the paper.

The number of mobile phones (3/8) used to perform telemedicine services is impressively high considering that no official mobile phone teleradiology services have been implemented in the Public Health Care district of the Western Cape. A reason for the high percentage of mobile phone use can be attributed to the practical and mobile nature of the device.

![Figure 7: Teleradiology Devices used (fractions)](image)

Although the mobile phone is often used as a telemedicine device it receives a considerably low maturity rating in comparison to the Telemedicine Workstation, see Figure 8. The
average maturity of the mobile phone (2.19), within the context of telemedicine, is below that of the combined device maturity (2.83).

There are a number of explanations as to why the maturity of mobile phones is that much lower. The mobile phone is not designed solely as a telemedicine device; it is rather a convenience application which was born out of the need to have a portable means of communication between clinicians and specialists. The Telemedicine Workstation, departmental workstation and x-ray/ultrasound devices are all official telemedicine devices or partial telemedicine. All these services are governed by a general framework/protocol and are fully incorporated in the operational costs of the institution.

For the purpose of comparison the maturity of the mobile phone was weighted as an official telemedicine device in order to relate to the other official services on the same scale. The result is an increase in maturity by 25 percent (see Figure 8), considering the jump in maturity the use of mobile phones to perform telemedicine services could well be considered as an official telemedicine service.

In contrast with the mobile phone, the Telemedicine Workstation scores a high maturity, which does not mean that it is the better more mature telemedicine service implemented. Many more factors influence the effectiveness of a telemedicine service and the fact that the Telemedicine Workstation is only used to perform such services in 1 out of 8 cases is a clear indication of that. The Telemedicine Workstation is installed in a fixed location and thus not as readily accessible as a mobile phone and on the other hand has the same properties as a normal workstation, making it redundant.

3.2 Telemedicine Material (Electronic Health Record)

This section will analyse the material aspect involving the use of mobile phones for teleradiology purposes. As discussed in Section 3.1 the mobile phone has proven to be a very resourceful telemedicine tool, although this is the case as far as the device is considered the same is not true for the material capturing and transmission processes (see Figure 9).
Utilising a mobile phone for teleradiology purposes involves the process of capturing a digital image of the radiological examination (x-ray film), the quality and consistency of a digital image is not guaranteed or defined by any clinical effectiveness standards therefore it scores a low maturity (1.67). The transmission of the data reaches a maturity of 3.13, due to the fact that mobile data transmission protocols are well managed and measured.
The relative high maturity for work protocol (see Figure 10) is possibly an indication of the fact that technology is adapting to existing protocols and not the other way around, namely that new methods are developed due to the enabling technology available.

4 CONCLUSION

The purpose of this paper was to describe the process of evaluating existing telemedicine services (teleradiology in particular) implemented in the Public Health sector of the Western Cape by means of the Telemedicine Maturity Model. The TMSMM served as means to describe these processes and assess the maturity in a consistent way that allow for cross-service comparison.

In the course of the study 5 District Health Care facilities in the Western Cape were visited. During these visits a total of 8 teleradiology services were mapped with the help of the TMSMM, resulting in the data acquisition of 51 micro-service-level. It was shown in this paper that interesting conclusions can be drawn from an aggregated view of this data.

Future work will involve the expansion of this study by including other telemedicine services, such as teledermatology, telepathology and services from other health care facilities. This will allow for more representative conclusions as well as determining the correlation between the different aspects that constitutes telemedicine service maturity.

5 REFERENCES