UNIVERSITY OF SOUTHERN QUEENSLAND

An exploratory investigation of usage of digital stethoscope by clinicians in telehealth setting through Information Systems success model

A Dissertation submitted by

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ABSTRACT

Telehealth systems have been identified as a means of improving access and quality of healthcare services, particularly those in rural and remote areas. Since physicians are the primary users of telehealth infrastructure in providing quality care, their level of technology usage has an impact on a system's success. This study builds on current research by developing a framework to evaluate the use of DS by clinicians in a telehealth environment.

Three popular digital stethoscopes available in the market were chosen for this study and their technical features identified. A preliminary framework to assess the usage of a new medical technology, digital stethoscope in a telehealth setting was developed, based mainly on specific attributes of IS success model and Technology Acceptance Model (TAM). The study explores the relationship between information quality, system quality, service quality and their impact on clinicians' satisfaction and usage of the system.

The study was conducted in five stages: literature review, small pilot test, documentation review, focus group, and observation. The qualitative case study approach was identified as the most suitable for this study. Documentation review, observations and focus group interviews were adopted as the main qualitative data collection methods within this exploratory study. In total, 19 focus groups in India and three in Australia were conducted in hospitals located in either metropolitan areas or regional networks. The collected data was imported into Nvivo 8 for further analysis and examined for themes relevant to the literature and the development of the subsequent conceptual framework.

The key premise informing this research has been that understanding users' perceptions towards a particular medical technology is required prior to the successful implementation of a telehealth system where Digital Stethoscopes (DS) are deployed. The main finding of the study was clinicians' perceptions toward medical technologies appear to be consistent within both case studies, except for aspects such as cost and design. The information quality, service quality and system quality of a telehealth system where a DS is deployed appears to have an impact on

the level of user satisfaction and, consequently, may influence clinicians' intention to accept and use the DS in their daily practice. The preliminary conceptual model developed for this study based on the literature review to guide the data collection remained relatively unchanged, although additional factors have been included as a result of clinicians' views, thus enhancing Information Systems success model.

This dissertation contributes to the number of existing theories and provides practical outcomes for three different groups: health managers, manufacturers and clinicians.

CERTIFICATION OF DISSERTATION

I certify that the ideas, experimental work, results, analyses, software and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

19 August 2011

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION

Over the past few decades, telehealth has become increasingly important and is one of the most revolutionary information systems to be incorporated into healthcare services (Normandin 2008). Moreover, the introduction of information systems has transformed many aspects of healthcare delivery processes (Huynh & Agnihothri from Armoni 2000). Telehealth systems have been identified as a means of improving access to, and the quality of, healthcare services—particularly for rural and remote areas (Armstrong 1998). Many developed countries, including Australia, became aware of the benefits of utilising telehealth systems in order to provide quality healthcare services for patients (Dearne 2011). Since physicians are the primary users of telehealth infrastructure, their level of technology usage often has a significant impact on a system's success.

Therefore, telehealth as a type of information system needs to be evaluated so any potential problems with the system can be recognized. However, limited research has been carried out which has evaluated the success of the Digital Stethoscope (DS) in a telehealth setting. Medical professionals, such as anaesthetic consultants, could use a stethoscope for auscultation of patients' lung and heart in order to perform routine checks during pre-admission consultation and pre-surgery assessment. This essential procedure could be conducted from a remote location via a telehealth platform, which makes a digital stethoscope an important tool in providing real-time audio of the patient's heart and lung sounds (Spooner & Gotlieb 2004; Whiting et al 2007; Lewin et al. 2006).

The purpose of this study is to investigate the usage of DS by clinicians within a telehealth environment. For this reason, this study has concentrated on the development of a conceptual framework to evaluate the usage of DS by clinicians from different perspectives. Therefore, the study aims to identify the issues that are likely to influence clinicians' perceptions of the system. For the purpose of this study, clinicians are health professionals such as medical doctors, nurses and technicians whose job is involved with medical services and clinical practice. This study has adopted qualitative research methods to explore the issues that are likely to influence the usage of DS in a telehealth setting. Furthermore, this study adopts focus group sessions within field study as a qualitative research method to explore clinicians' perception of using digital stethoscopes in a telehealth setting. Focus group sessions employed group discussions and observation as data collection techniques to gather data for this study.

Specifically, this research concentrates on the Information Systems (IS) success model by Delone and Mclean (1992), Technology Acceptance Model (TAM) by Davis, (1989), and studies which have evaluated telehealth systems. In addition, the technical features of digital stethoscopes have been reviewed in order to design a preliminary framework to enable the usage of digital stethoscopes by clinicians to be assessed in a telehealth setting. This dissertation explored the DS usage by clinicians from Australian and Indian healthcare institutes and contributes to the scholarly literature in this domain. The findings of this study contribute to the gap in the health information systems literature on usage of digital stethoscopes via telehealth setting. The outcome of this research is a conceptual framework aimed to enhance current understanding of the issues associated with the usage and successful implementation of DS in a telehealth environment.

1.1 Significance of the topic

Previous studies emphasise the importance of conducting an evaluation of telehealth systems during and after implementation (Gustke et al 2000; Melcer et al 2002; Bynum et al 2006; Gaggioli 2005; Olver & Selva-Nayagam 2000; Tang et al 2006), but limited studies were found which focused on the digital stethoscope in their assessment. One study by Hafeez-Baig et al (2007) shows that within Queensland Health digital stethoscopes are currently being used by a number of physicians including cardiologists, cardiac surgeons and respiratory specialists. However, the use is restricted to patients who present in person. At the time of this study, there are no physicians in Queensland using the digital stethoscope technology for remote assessment of patients because current instruments have been found inadequate in meeting physicians' 'requirements to use this instrument on a telehealth infrastructure' (Hafeez-Baig et al 2007). Leading DS available in the market have been trialled in Australian telehealth, but clinicians have found it difficult to obtain an accurate recording of the sound from available products (Hafeez-Baig et al 2007).

The capture, clarification and reporting of users' perceptions of using telehealth systems where DS is deployed may result in an increased awareness of the situation in Australia, particularly the potential benefits or barriers associated with implementation of sustainable telehealth systems. It is believed there may be a gap in evaluating digital stethoscopes used in the telehealth context which is based on the literature review provided in the next chapter of this dissertation. A potential new evaluation framework approach may close the gap between evaluating the digital stethoscope as a device and evaluating telehealth systems in general.

1.2 Research question

The main research question for this study is:

What are clinicians' perceptions of using digital stethoscopes in a telehealth context?

In order to address this broad research topic, three sub-questions have been developed:

1. **What issues influence clinicians' satisfaction and intention to use a DS?**

User satisfaction is a popular criterion that previous telehealth evaluation studies tended to assess (Guilfoyle et al 2003; Klecun-Dabrowska & Cornford 200; Bindels et al 2003; Linassi & Shan 2005; Devine 2007; Powell et al 2009; Kosterink et al 2010; Gustke et al 2000). There are user satisfaction evaluation instruments available; for example, the UIS (User Information Satisfaction) instrument (Bailey & Pearson 1983) has been widely accepted—although criticised for neglecting the essential issues related to the success of IS. 'It measures success only indirectly, by assessing the quality of the IS product and related services' (Saarinen 1996).

According to Delone and Mclean (2002), the level of user satisfaction with the IS Success Model could depend on system, information and service quality of the information system. Based on their model, they suggest that increased user satisfaction will lead to increased intention to use and usage. Maryati et al (2006) suggest that user satisfaction is often used to measure system success and is defined as the assessment of the user's experience in using the system and the system's potential impact. User satisfaction could refer to the overall evaluation of the user's experience in using the system and the system's potential impact.

This research sub-question looks for extensive explanation for user satisfaction and intention to use the system. Moreover, this question seeks to explore whether clinicians' satisfaction and intention to use are influenced by other factors such as the system itself, information and service quality.

2. **What issues contribute to information quality and system quality of deployed digital stethoscope in a telehealth setting?**

The focus of system quality is on ease-of-use, functionality, reliability, flexibility, data quality, portability, integration and importance (Delone & McLean 2003); and information quality is concerned with accuracy, timeliness, completeness, relevance and consistency. A set of candidate factors for information and system quality has been identified based on previous studies, mainly by Delone and Mclean (1992). These factors have been assessed in this study to identify their relevance to clinicians' perception of using DS with the aim of identifying any other factors which may not have been reported on previously.

3. **How could a potential relationship between the level of clinicians' satisfaction and their intention to use digital stethoscope in a telehealth context be described?**

For this research, the user group is defined as clinicians rather than patients. Although it is extremely valuable to understand patients' perceptions of the usage of a telehealth system, this research has focused on clinicians' satisfaction in using the system. The term 'use' in this context means the degree to which a digital stethoscope is utilised or the way it is utilised by clinicians. Delone and Mclean (2002) employed the term 'use' to mean intention to use.

1.3 Outline of the dissertation

In order to explore the research questions addressed in this study, the following processes have been used and are discussed further in the following chapters of this dissertation (see Figure 1.1):

- A review of studies in which telehealth and telemedicine systems have been evaluated: discussed in chapter 2;
- A review of theoretical frameworks for technology adoption and use: discussed in chapter 3;

- A review of studies that employed Information System Success Model: discussed in chapter 3;
- Development of a conceptual framework based on the literature review to guide the data collection: discussed in chapter 4;
- Conducting a small pilot test: discussed in chapter 4;
- Conducting focus group sessions and observations: discussed in chapters 5 and 6;
- Data analysis: discussed in chapter 7;
- Identifying key findings and revision of conceptual model based on the findings from the study: discussed in chapter 8; and
- Conclusion and recommendations: discussed in chapter 9.

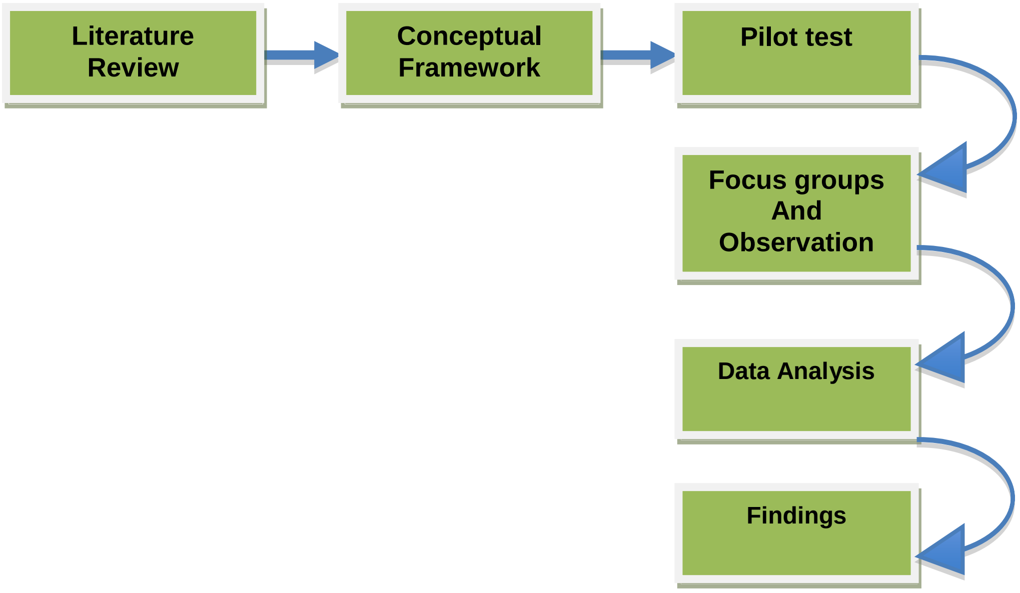

Figure 1.1: Outline of the dissertation

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

A review of the current literature is an essential component of any research study as it provides the researcher with a better understanding of the research topic, as well as enabling the researcher to identify gaps in the area of the research topic. In order to explore the perception of clinicians in using a digital stethoscope in a telehealth setting, a literature review has been conducted and is presented in this chapter. This chapter is a critical review of the literature focusing on the use of digital stethoscopes in telehealth systems. In the first section of the chapter, the notion of information systems and its importance in industries such as health organisations has been reviewed. This is then followed by a synthesis of information systems into health information systems and health informatics. The review then concentrates on telehealth/telemedicine as an area of health informatics. Popular tools and technologies used in telehealth are then identified and discussed. The final part of this chapter focuses on studies evaluating telehealth systems and concludes with the key findings from the literature review.

Information system (IS) is the major concept relevant to this study. Information systems are used in almost every imaginable profession (Stair & Reynolds 2008). For example, sales representatives use information systems to advertise products, communicate with customers and analyse sales trends. From a small music store to huge multinational companies, businesses of all sizes could not survive without information systems to perform accounting and finance operations. An information system is a set of interrelated components that collect (input), manipulate (process), store, and disseminate (output) data and information and provide a feedback mechanism to meet an objective (see figure 2.1). The feedback mechanism is the component that helps organisations achieve their goals, such as increasing profits or improving customer service. Input and output are usually classified as data. This concept is shown in Figure 2.1.

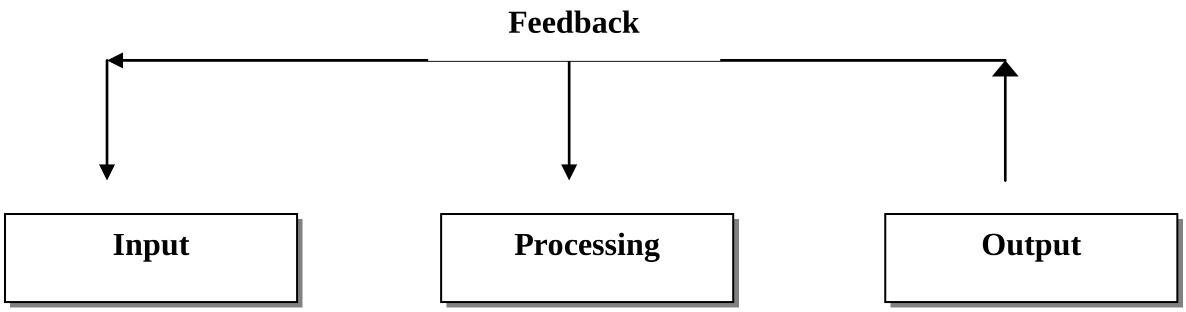

Figure 2.1: The components of an information system

Data consist of raw facts and when facts are arranged in a meaningful manner they become information. Information is a collection of facts organised so that they have additional value beyond the value of the facts themselves. Data represents real world things. Hospitals and healthcare organisations, for example, maintain patient medical data including patient identification and medical record numbers, which represent actual patients with specific health situations. In many cases, hospitals and healthcare organisation are converting data into electronic forms. Data and information work the same way. Rules and relationships can be set up to organize data into useful, valuable information.

Information systems are combinations of hardware, software and telecommunications networks that people build and use to collect, create and distribute useful data, typically in organisational settings. Hardware refers to physical computer equipment such as the computer monitor, central processing unit, or keyboard. Software refers to a program or set of instructions that tell the computer to perform certain tasks. A ***network*** refers to a group of two or more computer systems linked together with communication equipment (see figure 2.2).

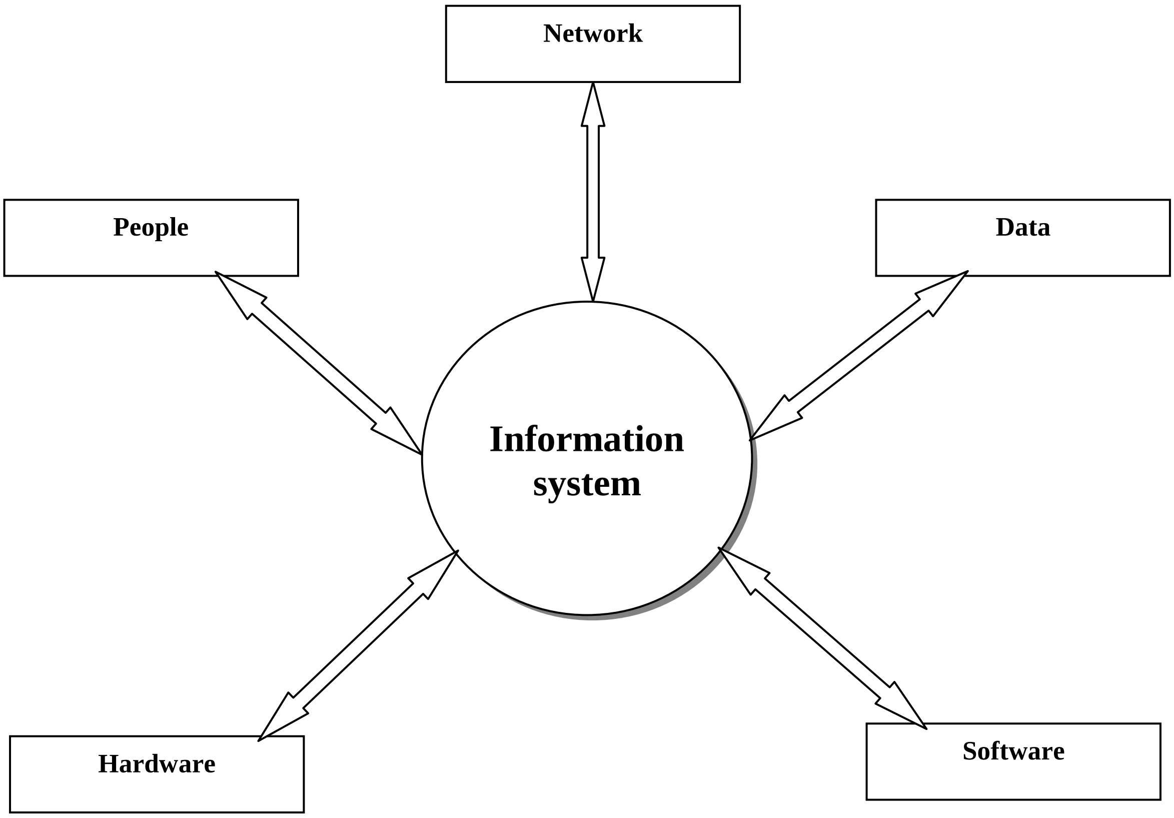

Figure 2.2: An information system is a combination of five key elements: people, hardware, software, data and telecommunication networks

(Source: Jessup & Valacich 2008)

Information systems normally involve computers and, together, they are constantly changing the way organisations conduct business. Information systems are used in almost every industry or field of business (organisations) including healthcare. An organisation is a system, which means that it has inputs, processing mechanisms, outputs, and feedback. Because information systems are so important, businesses need to be sure that improvements or completely new systems help lower costs, increase profits, improve service, or achieve a competitive advantage (Stair & Reynolds 2008). Therefore, healthcare organisations use information systems to diagnose illnesses, plan medical treatment, track patient records, and bill patients. Furthermore, Haux (2006) suggests that the aim of health information systems is to contribute to high quality and efficient patient care. This aim is explained as a patient-centred approach towards medical and nursing care, in which administrative and management tasks are needed to support such care (Haux 2006).

Information technology, computer science, information systems, healthcare services and telecommunication technology can lead to health information systems, health informatics, telemedicine and telehealth. It is important to review the definition of each of the abovementioned terms in order to be able to distinguish them. As explained earlier, one type of information system is called a Health Information System (HIS). A **Health information System (HIS)** is a data system, usually computerized, that routinely collects and reports information about the delivery of services, costs, demographic and health information, and results status. **Health informatics** is the intersection of information science, computer science and health care. It deals with the resources, devices and methods required, optimizing the acquisition, storage, retrieval and use of information in health and biomedicine. Health informatics tools include not only computers, but also clinical guidelines, formal medical terminologies, and information and communication systems. The Health Informatics Society of Australia (2008) defines Health Informatics (HI) as an evolving socio technical and scientific discipline that deals with the collection, storage, retrieval, communication and optimal use of health-related data, information and knowledge. 'The regulation utilizes the methods and technologies of the information sciences for the purposes of problem solving and decision-making thus assuring quality healthcare in all basic and applied areas of biomedical sciences for the community it serves' (http://www.hisa.org.au/ 20 Feb 2008).The main criteria for HI are health operations, research, academia and teaching; delivered by the operational health community, managers and researchers.

Early names for medical informatics included medical computing, medical computer science, computer medicine, medical electronic data processing, medical automatic data processing, medical information processing, medical information science, medical software engineering, and medical computer technology (Wyatt & Liu 2002). Since the 1970s the coordinating body has been the International Medical Informatics Association (IMIA). Health Informatics plays an important role in the Australian healthcare system, and in 2002 the Australian College of Health Informatics (ACHI) was formed as a professional association and peak health informatics professional body (Australian College of Health Informatics 2007). There are a number of clinical and non-clinical professionals working at health informatics who try to ensure quality, standards and ethical practice.

As telemedicine is known as an essential part of the field of health informatics, the following section will focus on telehealth and telemedicine and distinguish their similarities and differences.

Telemedicine and **telehealth** are known as essential parts of the field of health informatics that are a progression in an inexorable transformation in healthcare that promises to bring untold change to the healthcare industry and radically improve the delivery of care to patients (Darkins & Cary 2000). They also have the potential to provide access to high quality medical care for isolated populations, empower patients to play an active role in their disease management and, in some cases, have the potential to decrease the cost of care. Telecommunication technologies are being used to change the healthcare industry in unprecedented and irreversible ways, for example, using robotics in surgery (Maheu, Whitten & Allen 2001).

Telemedicine is a general term that refers to a wide range of technologies and applications. The word ‘telemedicine’ is derived from adding the prefix ‘tele’ to the word medicine. ‘Tele’ comes from an ancient Greek word of the same spelling, meaning ‘distance’. While telemedicine is medicine practised at a distance, telehealth is literally the delivery of healthcare services at a distance (Darkins & Cary 2000). The term ‘telehealth’ appears to be closely associated with telemedicine. Telemedicine generally means the use of communications and information technologies in order to deliver clinical care. Emery (1998, p.3-19) suggests that telemedicine can include low technology applications such as telephone calls or e-mails, or peripheral devices such as electronic stethoscope or otoscopes which are attached to audio visual media in order to transmit medical information between locations. Huston and Huston (2000) explain that telemedicine involves the electronic transmission of medical information for the purposes of diagnosis and treatment of patients. Telemedicine can use PC, telecommunications links, specialised video, audio and imaging equipment. Craig and Patterson (2005, p.8) suggest, ‘Telemedicine can be expected to improve equity of access to health care, the quality of that care and the efficiency by which it is delivered, by enhancing communication up and down the health-care pyramid’.

While some authors define telehealth and telemedicine to be the same because of their similarities, others see telehealth as being a more encompassing term than telemedicine. Telemedicine is a subset of a wider concept, which is known as telehealth, so the term telehealth could basically be used as an umbrella to describe all possible variations of healthcare services which use telecommunication technology. Telemedicine often refers only to the provision of clinical services, while the term telehealth can refer to clinical and non-clinical services that include medical education, administration and research (see Figure 2.3). Figure 2.3 shows that in telemedicine, patients could benefit from consulting the clinicians who are usually physicians. On the other hand, in a telehealth system patients not only receive consultations from clinicians, they also receive other health services in the absence of clinicians. Figure 2.3 indicates that telemedicine could be a part of a wider concept, namely telehealth.

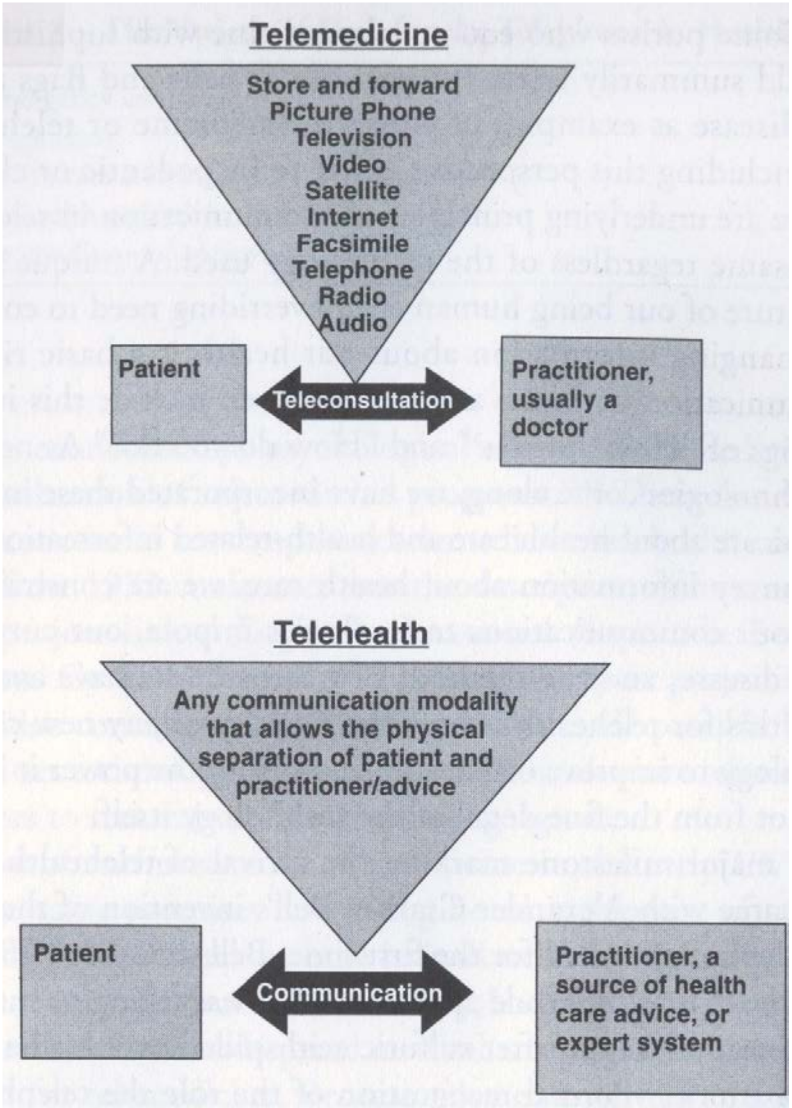

Figure 2.3: Telemedicine and telehealth

(Source: Darkins & Cary 2000)

Telemedicine implies that the remote delivery of healthcare is exclusively associated with physicians, as can be seen from figure 2.3.

Australia has a long history of effective and intelligent use of telemedicine within the healthcare system. From the development of the pedal wireless used by the Royal Flying Doctor Service in 1927, to the exciting telemedicine initiatives of the 1980s and 1990s, Australia has remained at the forefront of health communications innovation (Yellowlees, 2000). Telemedicine systems have been rapidly increasing in number and usage in Australia over the last decade, improving access to health care for patients. Within Australia, the Queensland Telemedicine Network, a state-wide health videoconferencing system, gives patients clinical and educational services. Other telemedicine systems in Australia are mainly in South Australia and New South Wales (Yellowlees 2000).

On the other hand, telehealth systems have been identified as a means of improving access to, and the quality of, health-care services, particularly for rural or under-serviced populations (Hogenbirk et al., 2006 p.64). Telehealth is the delivery of health-related services and information via telecommunications technologies (Jennett 2002). Examples of telehealth systems identified by Serghis (1999, p16) include: videoconferencing for clinical care, distance education and training, and peer support; electronic transmission of diagnostic images for analysis; online health information services; telephone call centres for giving health information and advice; and electronic medical records.

Darkins and Cary (2000, p.3) indicate, ‘Although physicians are key professionals in health care and must often be directly involved in delivering services face to face, the physician’s role is changing. Physicians are now frequently working as members of wider teams of health care practitioners and less often as autonomous individuals. To use a term that singles out one of the disciplines, whether medicine, nursing, or another, as being of singular importance in the remote delivery of health care, fails to acknowledge the importance of an overall team approach to delivering care.’

E-health is much broader than telemedicine or telehealth. It covers the use of digital data transmitted electronically—both locally and at a distance (Mea 2001) (see figure 2.4).

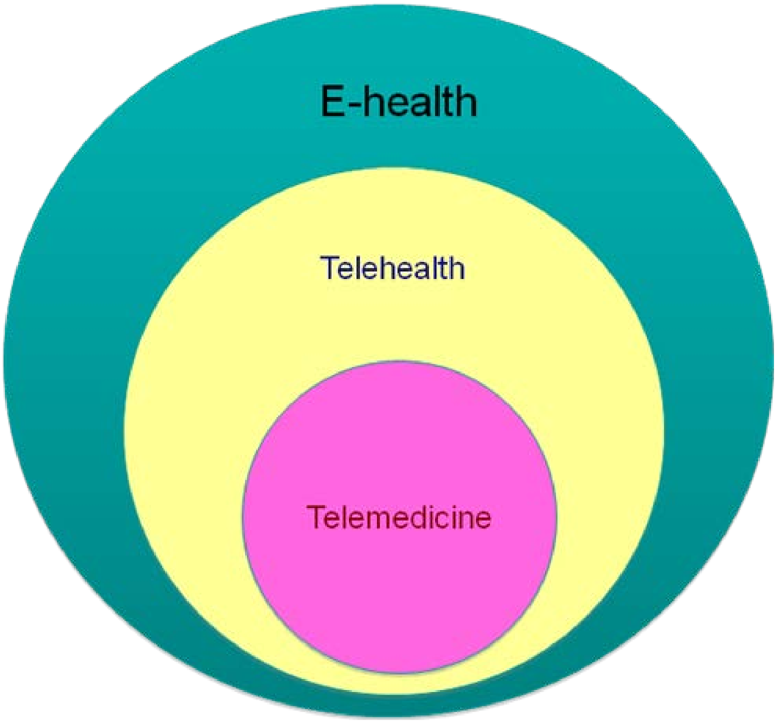

Figure 2.4: Telemedicine, telehealth and e-health

If the focus of a study would be with the practical consequences of delivering health care in situations where patient and practitioner are remote from one another and where information technology provides the bridge for clinical communication, either the term telehealth or telemedicine could be used. This study focuses on clinicians' perceptions of using a particular tool—a digital stethoscope—for remote access areas, thus, it seems the platform should be named telemedicine. But considering clinicians might be physicians, nurses, cardiologists or any clinical staff and the purpose of use could end up with providing healthcare service for remote access areas, the term 'telehealth' will be used in this study instead of 'telemedicine' because of its broader usage.

The following section focuses on the importance of telehealth.

2.2 Importance of telehealth

Residents in rural and geographically isolated areas have significant problems in accessing healthcare services. In addition to rural residents, Armstrong (1998) identified the physically disabled, the poor, prison inmates and homeless urban children as examples of groups who frequently lack access to adequate healthcare services. Telehealth infrastructure could provide some healthcare services to some remote and rural areas where there is a lack of regular healthcare services. Access problems could be due to geographical location or physical limitations (Armstrong 1998). Benefits of telehealth identified by Dansky, Jeffrey and Duncan (2005) include time saving and maximisation of existing resources, the ability to monitor high-risk patients more frequently, and provision of support to the aging population. Telehealth has been found to be useful as a communication tool between a GP and a specialist available at a remote location (Emery1998, p.3).

Elford (2007) stated the benefits of establishing telehealth for the patient are improved access to medical specialists, decreased patient stress, reduced travel time and provision of more accurate treatment—all of which lead to improved healthcare services. Telehealth is a benefit in countries where the traditional delivery of health services is impacted on by distance and lack of local specialist clinicians to deliver services (Queensland Government 2006).

Another benefit of establishing a telehealth system could be the capability of making profits for the organisations. Many telehealth programs seem unsure that they are in business; and if they are sure they are in business, they may be unclear about exactly what business they are in. This is a big mistake in healthcare systems where healthcare markets are the mechanism deciding whether or not to incorporate telehealth. This reality means that all telehealth projects should ultimately be in the business of telehealth if they are going to survive in the long term.

One important issue identified in the literature is called the business of telehealth which is concerned with how telehealth programs should focus on taking advantage of telehealth markets to make these large enough to sustain them (Armstrong 1998; Darkins & Cary 2000). The development of these markets can be seen as having three major evolutionary phases. The first phase is the sale of equipment. The second is the development of a telehealth business network. The third is the sale of health care products, using the equipment and networks when the previous two are in place. To take advantage of these opportunities, telehealth companies need to be very clear about what products and services they are in the business to deliver and how they will then market and deliver these (Darkins & Cary 2000).

This dissertation mainly focuses on the usage aspect of digital stethoscopes and is not concerned on the financial aspect of establishing and using telehealth systems, which is the reason why the business aspect of telehealth is only briefly addressed.

The following section will deliberate the usage of telehealth from different aspects.

2.3 Usage of telehealth

Telehealth can be practised on the basis of two concepts: 1. real time (synchronous); and 2 store-and-forward (asynchronous). While an asynchronous system does not rely on the presence of all parties involved in the communication, synchronous is a direct communication in which all parties are present at the same time. Real time telehealth could be as simple as a telephone call or as complex as robotic surgery. It requires the presence of both parties at the same time and a communications link between them that allows a real-time interaction to take place. Video-conferencing equipment is one of the most common forms of technologies used in real time telemedicine. Common telehealth applications of store-and-forward include email, the transmission of teleradiological, telepathological and teledermatological images; and distance-learning material used in professional continuing education, research, and administration (Maheu, Whitten & Allen 2001).

The information transmission between two entities involved in telehealth can take many forms such as data and text, audio, still images and video pictures (Craig & Patterson 2005). Combining the type of interaction and the type of information to be transmitted can allow the telemedicine to be classified, as shown in table 2.1.

Table 2.1: Classification system for telemedicine
(Source: Craig & Patterson 2005)

	Information Transmitted		
Interaction		**Still images**	**Moving images**
	Real-time	Telepathology	Telepsychiatry
	Store-and-forward	Teleradiology	Home telehealth

The clinical uses of telehealth technologies suggested by literature are: transmission of medical images for diagnosis, for example, teleradiology, which is electronic transmission of radiological patient images; real-time telehealth that could refer to groups or individuals exchanging health services or education live via videoconference; and transmission of medical data for diagnosis or disease management (Craig & Patterson 2005; Elford 2007; Maheu, Whitten & Allen 2001). This is sometimes referred to as remote monitoring. Tele-triage is the provision of health advice by telephone.

As indicated earlier, telehealth involves the transfer of electronic data that may include video file, images, sound and laboratory data (American Telemedicine Association 2007; Craig & Patterson 2005). Various clinical uses of telehealth are discussed below:

Tele-triage

The process of prioritizing injured or sick people for treatment based on the seriousness of their condition is called tele-triage (Draper 2006). The process involves a telephone discussion between a caller, who describes their symptoms, and an experienced registered person who takes the call and uses a Clinical Decision Support System (CDSS). Additionally, the person who takes the call will recognise urgent medical matters to triage emergency patients if required (Wheeler, 2006). Tele-triage is described as a systematic process that screens a caller's symptoms for urgency and advises the patient based on the severity of the problem (Bolton, Gannon & Aro 2002). Usually a series of clinical questions are asked during this service and the process will end with a clinical decision that includes what level of health service is required and when it needs to be provided.

Teleradiology

Teleradiology appears to be a significant valuable medical service for rural populations, especially in rural areas with limited access to technical and medical resources or a lack of on-site radiologists (Yawn et al 1997). Teleradiology is defined as transfer of different types of radiology images from on-site to another site by the use of data transmission networks in order to seek professional interpretation of those images or to gain a second opinion (Stryker 2003). Conducting teleradiology patient care in locations distanced from metropolitan areas could be improved by receiving services from key sub specialists such as MRI radiologist, neuroradiologist or pediatric radiologist. Char et al (2010) established the teleradiology service for inaccessible areas of northern India and their experience demonstrates that remote implementation of teleradiology is possible for rural India with valuable benefits for patients in that region.

Remote home monitoring

Remote home monitoring is a type of telehealth in which patients can be monitored from their home and their health data can be measured and transferred over geographical distances. Ruggiero et al (1999) identify home healthcare as one of the fastest growing areas of healthcare provision that uses technology in many ways to help in the care of people at home. Within these systems the data is received and interpreted, and advice for care is provided by health professionals. Additionally, technologies that can be applied within remote home monitoring can include web cam, ECG, vital signs recorder and stethoscope. Home telehealth and remote monitoring technologies can provide education, monitoring, patient self-directed care and the ability for individuals to have more effective access to health care. ‘These applications extend the vision of the clinician to facilitate quicker assessment and proactive intervention for many populations living with chronic and acute healthcare problems to improve quality of life’ (American Telemedicine Association 2011).

Tele-Cardiology

Tele-cardiology is a telehealth system that uses medical technology such as ECG and stethoscope via telecommunication networks to provide cardiology consults for patients seeking care and treatment. Sable (2004) mentions that cardiologists using tele-cardiology are in favour of real-time telehealth because of the ability to guide the clinician at the other end of the system who has limited experience in congenital heart disease.

Real-time telehealth

In real-time telehealth, a telecommunications link allows immediate interaction. Video conferencing is one of the most common forms of synchronous telemedicine. Peripheral devices can also be attached to computers or the video conferencing equipment that can aid in an interactive examination. The availability of better and cheaper communication channels, direct two-way audio and video streaming between centers through computers is leading to lower costs.

Literature identified stethoscopes as one of the technologies to be used in telehealth systems. The next section will review the stethoscope as a medical technology and its usage in telehealth systems will be explained.

2.4 Digital stethoscope and telehealth

Basically, one aspect of telehealth is capturing sound. Sound is a travelling wave which is ‘an oscillation of pressure transmitted through a solid, liquid or gas, composed of frequencies within the range of hearing and of a level sufficiently strong to be heard’ (Company 2006). Quality of sound is an important feature to be evaluated in many devices such as medical tools (Olson 1967). Quality of sound refers to the quality of audio output from different kinds of electronic devices. Additionally, according to Dictionary.com (2009) sound quality is the degree of accuracy with which a device records or produces the original sound waves that entails experiencing either pleasure or fatigue by the listener.

Traditionally, sound can be transmitted by the use of a stethoscope in the field of cardiology and other areas of healthcare. A stethoscope is an instrument used to hear and amplify sounds such as heartbeat, lungs, intestinal, venous, or fetal sounds to the ear of the listener. ‘A stethoscope may consist of two earpieces connected by means of flexible tubing to a diaphragm, which is placed against the skin of the patient at a location appropriate to pick up the sound’ (MedicineNet 2001). As can be seen from Figure 2.5, the chest piece consists of two sides that can be placed against the patient for sensing sound.

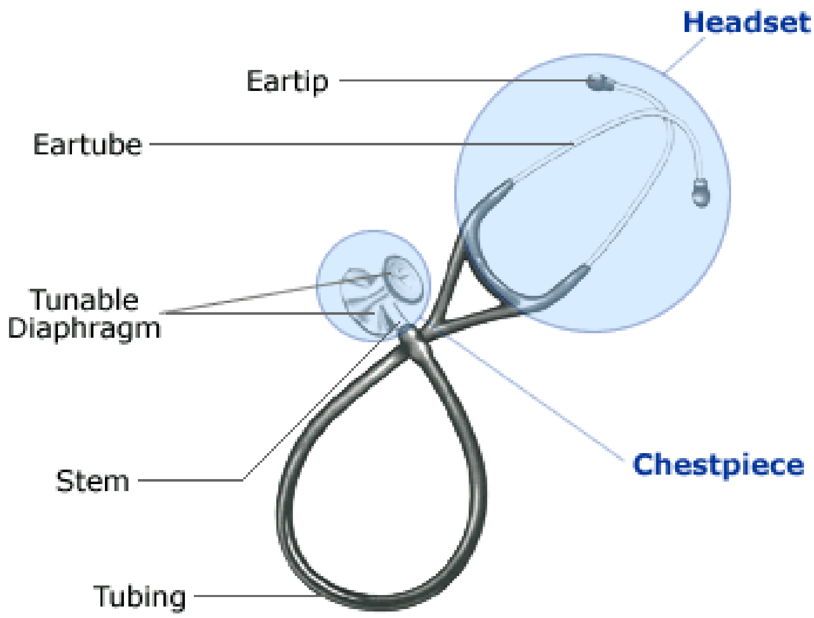

Figure 2.5: Acoustic stethoscope
(Source: http://www.mystethoscope.com/images/scope_anatomy.gif)

Stethoscopes are used to capture different body sounds such as the heart and the captured sound can be transmitted to the scope's bell or diaphragm of the chest piece via direct contact with the patient. The sounds are then transmitted down the tubing of the scope and towards the earpieces and into the ear (Callahan et al 2007).

Even with development of modern medical technologies such as cardiac Doppler or electrocardiogram[1], stethoscopes appeared to remain a reliable and cost effective diagnostic device for evaluating cardiac patients' clinical condition (Chinzer 1996; March et al 2005). Proper identification and timing of heart sounds and murmurs is identified as the key to successful cardiac auscultation. Special skill is required to listen properly to heart sounds in order to identify abnormalities, however, many medical practitioners do not feel confident enough about picking up an abnormal heart sound while using cardio devices such as stethoscopes (Koekemoer and Dcheffer 2008). Generated sounds during closed heart valves are called normal heart sounds, whereas abnormal heart sounds are any other sounds like murmurs, generated as the blood flows through an abnormally small valve, or blood flowing through a valve not closing well. 'Depending on the position of an abnormal heart

[1] Doppler echocardiography is 'a technique in which Doppler ultrasonography is used to evaluate the direction and pattern of blood flow within the heart' (Mosby's Medical Dictionary 2009).

sound on the chest of a patient, the pitch, the changes in amplitude, and the duration of heart sounds, one can determine which valves have been affected' (Koekemoer & Scheffer 2008, p4867).

Abbruscato (1998) suggests the need to maintain a doctor-patient interaction as one of the basic requirements of a stethoscope examination procedure. Normally, the patient needs to be physically present to facilitate the doctor's examination. Consequently, patients who need frequent stethoscope examinations are faced with the difficult prospect of frequently visiting their doctor at a health centre. These difficulties are particularly hard for patients who live in remote areas and who need to see a doctor on a regular basis. Therefore, Abbruscato (1998) states that there is an urgent need for a system by which a doctor can perform medical examinations on a remotely-located patient. Preferably, such a system would provide the advantage of a real-time evaluation and interaction with the patient.

Although acoustic stethoscopes are the most commonly used in the health industry, they are not suitable for telehealth systems, especially for remote diagnosis. Rather, an electronic/digital stethoscope is suitable for that purpose because sound data can be transmitted remotely. Answers Corporation (2008) discusses how an electronic stethoscope overcomes the low sound levels by electronically amplifying body sounds. Currently, a number of companies offer electronic stethoscopes, and it can be expected that within a few years the electronic stethoscope will have eclipsed acoustic devices. Some of advantages of using digital stethoscopes could be elimination of ambient noise, facility of recording sounds and featuring with direct audio output that can be used with an external recording device such as PC or MP3 recorder.

Figure 2.6 shows one aspect of an established telemedicine system by Apollo Telemedicine Enterprises Ltd in India that is using a digital stethoscope to capture and transmit body sounds.

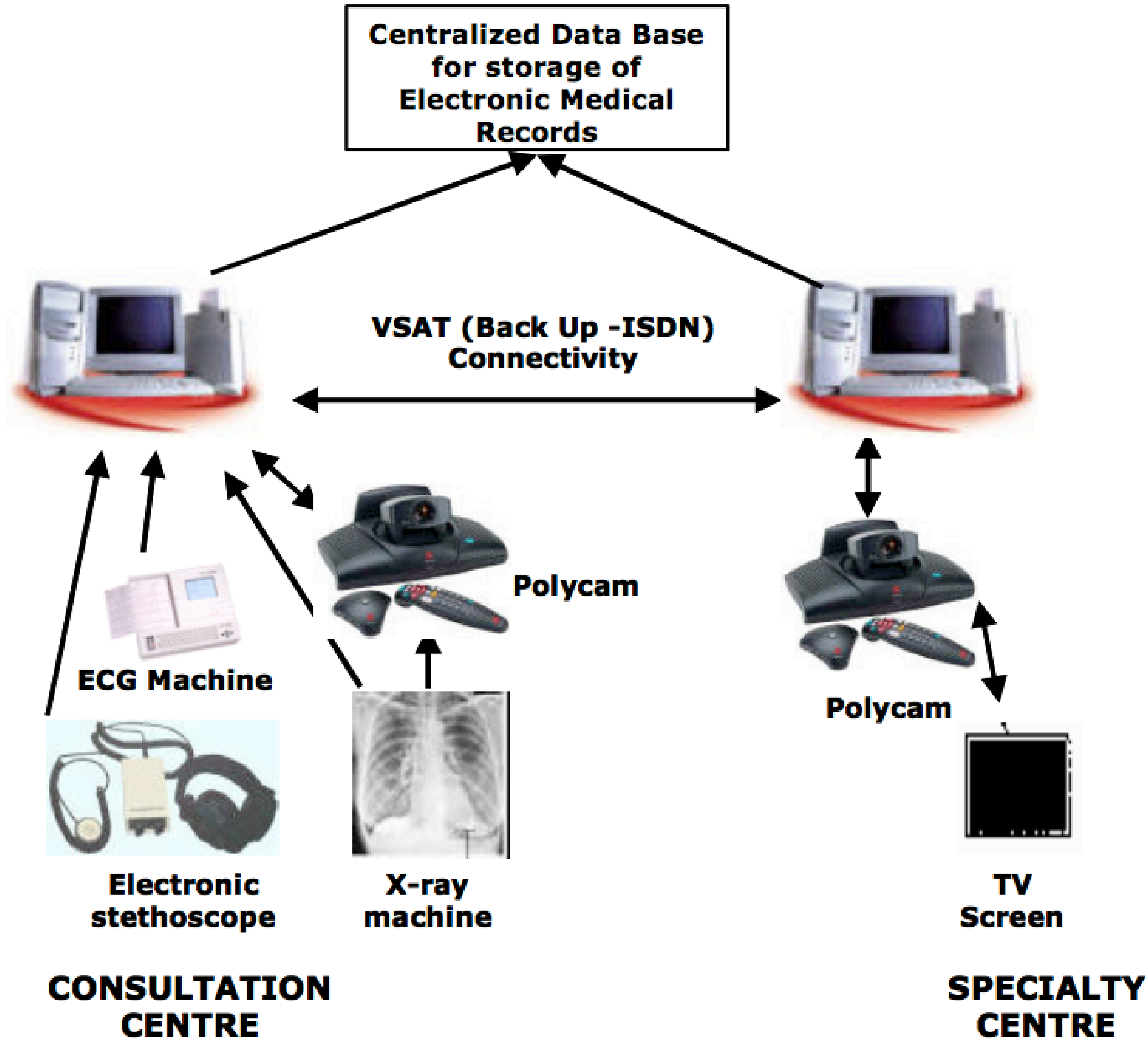

Figure 2.6: Apollo hospital telemedicine

Bowonder et al (2005) explain that a digital stethoscope is placed on the patient and connected to the telephone line and the doctor at the specialty center can hear the heart beat either through a computer system or through a telephone line directly. In the case of video conferencing the voice is transferred using a voice-enabling instrument attached to the high-resolution video camera (polycam). It has features such as echo-canceller and noise reduction units for better transmission of heartbeats (Bowonder et al 2005).

Other studies have identified problems in using stethoscopes in a telehealth system. A study by Daly et al (2005) described the development, pilot testing and challenges of a specific telecommunication system in a rural long-term setting in Iowa in the

US. During their pilot study they experienced difficulties such as software problems, connection failure because of malfunction of server and, finally, the medical director's attempts to listen to heart tones were not totally successful and could only be heard for a few seconds at a time. The pilot study identified the potential problems in the usage of a nursing home telemedicine system. Observing the usage of stethoscopes by clinicians could reflect positive/negative perceptions of clinicians from time to time throughout the study.

Spooner and Gotlieb (2004) state that the health industry, particularly cardiology, has already embraced telehealth. Electronic stethoscopes can facilitate the transmission of heart sounds with excellent fidelity. Additionally, good auscultation[2] and interpretation of heart sounds will limit unnecessary specialist doctor visits and many special investigations and treatments (Koekemoer and Dcheffer 2008).

Dahl et al (2002) addressed the need for a safe, time-saving and convenient method for assessment of patients with heart murmurs; moreover, their study confirmed that skilled auscultation alone is adequate to detect patients with innocent murmurs.

Leading DS available in the market have been trialled in Australian telehealth, but clinicians have found it difficult to gain an accurate recording of the sound from available products (Hafeez-Baig et al 2007).

A stethoscope is defined as an instrument which is used to hear and amplify the sounds produced by the heart, lungs or other internal organs. Basically, digital stethoscopes are explained as 'computer-aided products that can read sound, vibration, or acoustic signals' (Sofsian 2008). Moreover, they can store sound and this sound can be played again (Sofsian 2008). Electronic stethoscopes require conversion of acoustic sound waves to electrical signals, which can then be amplified and processed for optimal listening. Gururajan (2007) states that by using an accurate and effective stethoscope, high quality data could be collected from patients and this can directly lead to better patient management decisions. Additionally, Wallen (2006) clarifies key advantages of an electronic stethoscope over an acoustic one as 'Possibility of volume control for amplification; elimination of sound loss and resonance effects experienced with acoustic stethoscopes by selectively amplifying signals at different frequency ranges; mode control to allow

[2] Auscultation is 'the act of listening for sounds made by internal organs, such as the heart and lungs, to aid in the diagnosis of certain disorders' (American Heritage Dictionary 2007)

switching between bell and diaphragm without interrupting auscultation and electronic noise filtering' (Wallen 2006, p 370).

One of the problems related to the analysis of recorded heart sounds is that they often are contaminated with background noise and noise caused by friction between the stethoscope and the skin (Schmidt et al 2010).

Figure 2.7: Digital stethoscope

(Source: http://www.thinklabsmedical.com/electronic-stethoscope/products/ds32a-digital-electronic-stethoscope-157.html)

Figure 2.7 shows Thinklab ds32a which can be connected to an iPod, mp3 or notebook for recording and listening to heart sounds.

Global Industry Analysts (2008) announced that the worldwide stethoscope market is projected to reach US$270 million in sales by 2010. In the US, the electronic stethoscope is gaining an upper hand over normal stethoscopes, which is mainly attributed to the enhanced sound detection capability and clear digital transmission capabilities of electronic stethoscopes in applications such as telemedicine and teaching.

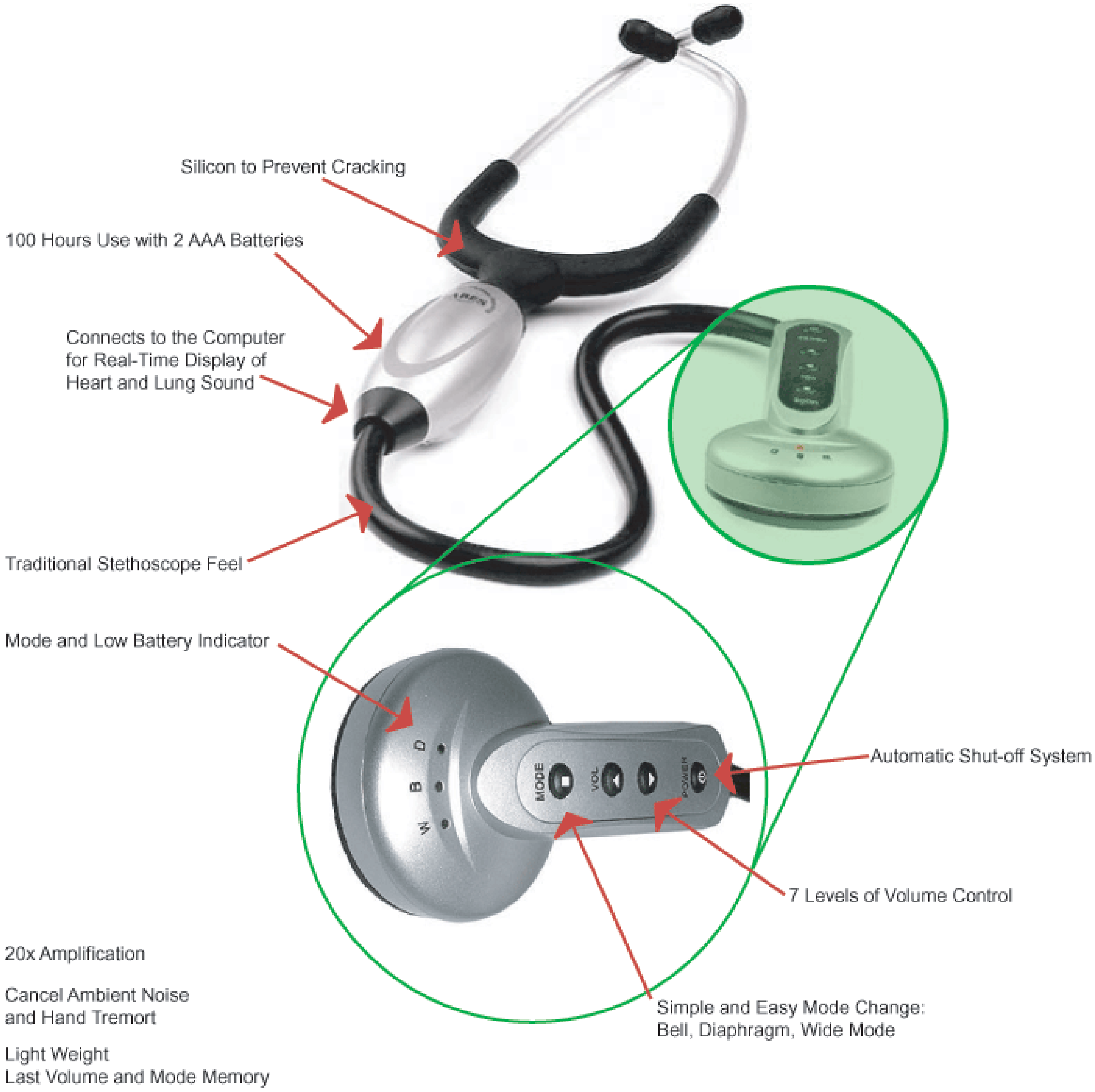

Figure 2.8: JABES Electronic Stethoscope

(Source: http://www.egeneralmedical.com/jabes-overview.html)

EC21 Inc (2009) claims that 'Now with JABES, physicians with limited medical practicing experience can easily shed light on their patients' illnesses at the first examination. JABES also allows the medical practitioners to record the body sound of their patients directly onto their PC for phonocardiogram view. With this capability, healthcare givers will have better understandings of the sound they hear for better quality medical services'.

An extensive search of the Internet was carried out in order to identify the most advanced digital stethoscopes in the global market. According to eGeneral Medical

(2008), the leading stethoscope manufacturers include 3M Littman, DRG stethoscope, Jabes, Welch Allyn, American Diagnostic Corporation (ADC), UltraScope and Philips Medical. The most popular manufacturer for digital stethoscopes, according to the number of online hits, included 3M Littman, AMD telemedicine and Think lab.

3M is fundamentally a science based company and produces the range of Littmann brand stethoscopes. Some popular models include 4100WS with Ambient Noise Reduction, 3000 with Ambient Noise Reduction, Master Cardiology Stethoscope, Cardiology S.T.C. Stethoscope and Cardiology III Stethoscope.

AMD Telemedicine is a worldwide leading supplier of medical peripherals used in telemedicine. AMD's telemedicine products include dentistry, dermatology, radiology, cardiology amongst many others. AMD claims that it can deliver cutting edge cardiology applications including electronic stethoscopes (IP live and store and forward), PC based ECGs, and cardiac ultrasound for telemedicine and mobile programs. Some popular models by AMD telemedicine include AMD-3700 Telephonic Stethoscope, AMD-3550 SmartSteth Digital Electronic Stethoscope and AMD-3200 Simulscope.

Thinklab Company was founded in 1991 and it was formed to conduct research and development in electronics and signal processing for medical and communications applications. It is claimed in the company's website that Thinklab is a specialist company, fully dedicated to the development of fine electronic stethoscopes, and to facilitating the clinician-patient connection at every level (Thinklab Medical LLC 2008). Thinklab's ds32a is the most popular product of Thinklab Company.

Three available digital stethoscopes in the market, namely, 3M Littman 4100, AMD SmartSteth and Thinklab 32a were selected for this study. Some models such as the Littmann, Cardionics and Welch Allyn provide a link to computers and some provide recording capability. 'Several electronic stethoscopes on the market can very easily allow users to record sounds and e-mail them to colleagues for teaching or even consultation' (Encyclopaedia of Surgery 2008).

Since digital stethoscopes can be differentiated based on their technical features, functions and price range, apart from price, available digital stethoscopes in the market have been compared based on their functionality and technical features.

Technical features that could describe a digital stethoscope were identified for this study and include dimension, diaphragm diameter, power, weight, frequency response, protocols, volume control, main application area, chest piece design and technology, headset material, amplify mode, ambient noise filter, battery life, audio input/output, recording facilities, PC connectivity, data communication options and additional editing software. The above technical features for the three selected stethoscopes used in this study were identified and mapped in a comparison table (see table 2.2) (* means that there is no available information for that feature).

Feature	Thinklab ds32a	3M Littman 4100	AMD SmartSteth
Dimension	73.7cm	68.6cm	20.1 cm
Diaphragm Diameter	3.9mm	2.9 cm	*
Power	2 x 1.5V - 2 x AAA Alkaline Batteries	*	120 Volts AC, 0.18 amp
Weight	181.4 g	220 g	453.6 g
Frequency response	15hZ - 20000 Hz	Bell (20-200 Hz), Diaphragm (100-500 Hz), Extended Range (20-1000 Hz)	20-1000Hz
Protocols	*	Not available	IP, email store & forward
Volume control	Continuously-adjustable Volume Control	AVAILABLE	*
Main application area	All medical specialities	Cardiology/High Performance- Adult and Paediatric	*
Chest piece design and technology	Chrome plated aluminium	Matte Finished Plated Alloy	*
Headset material	Soft hypo-allergenic (Latex-free) silicone	No answer	*
Amplify mode	Amplifies up to 50X	Up to 18 times greater than the best non-electronic stethoscopes	*
Ambient noise filter	Ambient Noise Reduction (ANR), Digital Electronic Filtering	Ambient Noise Reduction (ANR)	Background noise immunity
Battery life	2xAAA batteries provide many months of use	20 hours of continuous use from two AAA alkaline batteries	*
Audio input/output	iPod, mp3 or notebook	AVAILABLE	*
Recording facilities	iPod nano 2G	AVAILABLE	*
PC connectivity	PC and iTunes	AVAILABLE	Any MS-Windows PC

Feature	Thinklab ds32a	3M Littman 4100	AMD SmartSteth
Data communication options	*	*	*
Additional editing software	Thinklabs Phonocardiography Software	*	*

Table 2.2: Features of three popular digital stethoscopes

Table 2.2 provides the three selected digital stethoscopes comparison table. Each technical feature is briefly described in appendix A.

Table 2.2 shows the comparison of three popular digital stethoscopes available in the market. There are similarities, differences, weaknesses and strengths for each device to allow for a comparison of the stethoscopes. All three digital stethoscopes provide comparable ambient noise filters. Thinklab ds32a appears to have a superior feature in battery life against the others. Moreover, the Thinklab ds32a electronically provides the sound of a conventional stethoscope without the loss of air tubing (Thinklabs Medical LLC 2008). The Littmann Electronic Stethoscope Model 4100 features amplification and proprietary Ambient Noise Reduction (ANR) technology, allowing users to reduce ambient noise by an average of 75% (-12dB) without eliminating critical body sounds (Medema Medical Supplies 2007). Furthermore, digital signal processing offers recording, storage, and playback capabilities, as well as the ability to transfer recorded sounds via an infrared transmission to another Model 4100 or Model 4000 or IBM-compatible computer or a hand-held device (Stethoscope.com 2008).

The following section reviews the studies that have employed evaluation of telehealth systems.

2.5 Review of studies in telehealth/telemedicine evaluation

In this section the importance of telehealth evaluation will be discussed. This section also reviews previous studies in which a telehealth system was evaluated. Table 2.5 summarises the findings from this review and focuses more on the type of telehealth system, the various data collection methods, evaluation criteria, theories and models adapted in each study, limitation and suggestions for future research by each study. The significance of each study is discussed later in this section.

2.5.1 Telehealth evaluation overview

Evaluation is a widely recognized requirement for the introduction of new technologies in healthcare (Stead et al 1994). There are various methods for the evaluation of any clinical information system such as telehealth systems. Telehealth is a complex system in which its assessment needs to display how current usage, process, training and equipment meet the standards of the whole system (Reed et al 2004). In comparison to the US and UK, limited studies have been carried out to evaluate telehealth systems in Australia, therefore, understanding the perceptions of people who are involved with such systems is very important in understanding the factors influencing clinicians' usage of telehealth systems and, specifically, medical technologies. The capture, clarification and reporting of users' perceptions of using telehealth systems may result in an increased awareness of the situation in Australia, particularly the potential benefits and problems associated with these systems. Evaluating telehealth systems shows that there are a variety of program descriptions: very short-term empirical studies focused on one or two components of a larger system and conceptual models for evaluation (Reed et al 2004).

Additionally, Reed et al (2004) indicate that none of the frameworks reviewed by them allow a global or holistic assessment of telehealth as a complex system in which human factors, organizational structures and technical configurations interact. Additionally, there are a variety of demonstration and pilot projects that have been valuable in demonstrating basic feasibility and safety, but most have not been guided by a systematic framework for evaluating the effects of clinical telehealth on the criteria of quality, accessibility, cost or acceptability of healthcare (Dick 2000).

Previous studies emphasise the importance of conducting an evaluation of telehealth systems during and after implementation (Gustke et al 2000; Melcer et al 2002; Bynum et al 2006; Gaggioli 2005; Olver & Selva-Nayagam 2000; Tang et al 2006). Evaluation of telehealth system success or effectiveness is a fundamental challenge to healthcare organizations. In most cases, telehealth could greatly depend on information systems (Hu 2003); therefore, a possible approach in evaluating telehealth systems success could relate to relevant information systems studies.

Moehr (2002) suggests that the evaluation of Information and Communication Technology (ICT) requires methods that could be different from the evaluation of other technology. In this case, technology refers to static instruments such as an endoscope, a prosthetic device, a drug, or a digital stethoscope. The reasons for such a claim can be attributed to the dynamic nature of ICT, and its thorough interaction with the human, institutional and social environment (Moehr 2002). There are difficulties identified in achieving health information systems evaluation, particularly in selecting a framework and methods to be used (Maryati et al 2006). Accordingly, a number of studies in telehealth evaluation have been reviewed to gain a better understating of telehealth evaluation domains and factors that lead to successful implementation and use of telehealth systems.

Reviewing literature revealed that ‘The Canada Health Infostructure Partnerships Program (CHIPP)’ has conducted an extensive search for usable models to evaluate telehealth systems. Their research showed few models for that purpose existed, and that the number of applicable models is limited. The CHIPP evaluation framework is based on a model built by the Institute of Medicine (IOM). The IOM model addresses the main factors for success and sustainability of telecommunications in healthcare and includes four main issues, namely, quality, accessibility, cost and acceptability (Hanson & Chatterton 2005).

Another aspect of telehealth evaluation focuses on three main criteria such as safety, practicality and utility (Taylor 2005). In this case, the evaluation seeks to identify if the system was established as a safe system to use, then to establish the quality of the service. Finally, it is suggested that ensuring that the most appropriate technology is used in the most effective way should be the primary aim of any telehealth evaluation (Taylor 2005).

Yawn (2000) pointed out that many of the recent telehealth publications suggest evaluation frameworks from basic overviews of quality improvement activities to studies of technology assessment, cost effectiveness studies to community, and patient and physicians acceptance studies, and these studies are mostly based on laboratory settings or small sample sizes (Yawn 2000).

1. Task domains (based on sensory perception)
   - *Visual*
     - Inspection and evaluation of patients superficial (skin or gross deformity)
       - Color, texture, depth, body language, interaction
     - Observation of care process or procedures
       - Emergency room observation
       - Distance mentoring
   - *Visual with instrumentation*
     - Technology-assisted direct visual inspection
       - Otoscope
       - Retinoscope
     - Technology-assisted real time images
       - Ultrasound
       - Endoscopy
     - Technology-assisted delayed or on demand transmission
       - Radiographic images (flat image, black and white)
       - Digital data transmission
         - EKG
         - X-ray
         - CAT scan
       - Pathology specimens (flat image color)
   - *Auditory*
     - Direct interaction with patients
       - History
       - Follow-up evaluation
       - Patient initiated interaction
       - Education
     - Clinic-to-clinic consultation
       - Provider to provider
   - *Auditory with instrumentation*
     - Doppler fetal heart beat
     - Blood pressure assessment
   - *Smell*
     - Currently unavailable
   - *Tactile*
     - Currently unavailable
2. Tools
   - *Technology assessment*
     - Equipment performance evaluation/standards
     - Technical support needed
     - Appropriate/possible uses
3. Settings
   - *Environment*
     - Sound system
     - Lighting—foot candles
     - Room design
   - *Operator characteristics and training*
   - *Mobility of equipment for multiple uses*
4. Integration
   - *Outcomes—clinical*
     - Interaction of tasks, settings, and tools
   - *Outcomes—time*
     - Time from request to service completion
     - Time from transmission of image to report
     - Time and convenience of patient
5. Costs
   - *Development*
   - *Equipment*
   - *Support staff and training*
   - *Actual services*
     - Both ends of transmission
6. Customer satisfaction
   - *Patient*
   - *Clinician*
   - *Community*

Table 2.3: Criteria for telehealth evaluation by Yawn (2000)

Table 2.3 summarizes a suggested series of the steps from the technology and environment assessment, to clinical costs and integration, to measures of patient and provider satisfaction by first considering the value and capacity of telehealth technologies to complete basic clinical tasks. This framework provides a holistic view.

The Joint Working Group on Telehealth (JWGT) has developed a framework for evaluating telehealth projects (Puskin et al 1995) (see Table 2.4.)

Domains	Questions to be addressed
Access	Will the use of telemedicine improve access to health care?
Costs and benefits	What are the costs and benefits of such a system in day-to-day operations? Is the system affordable?
Clinical outcomes	Are acceptable outcomes designed to address questions in at least six areas or domains?
Technical Acceptability	Is the system technically acceptable?
Health systems interface	How well is the system integrated into the overall health system?
Patient/Provider acceptability	Will patients and providers accept and value telemedicine-enabled care?

Table 2.4: Criteria for telehealth evaluation

(Source*:* Puskin et al 1995)

‘The framework represents a blueprint for sharing information across federally funded projects and studies and provides examples of the questions that need to be asked for six major areas or domains of concern’ (Puskin et al 1995). The Federal evaluation framework suggests that telehealth evaluation should be designed to address a set of questions in the above six areas.

2.5.2 Analysis of the findings according to the table

In this section, studies that have focused on telehealth systems either from implementation or evaluation aspect will be reviewed and the result of the review is summarised in Table 2.5. Empty boxes from this table means that particular information was not addressed in that study. For example, a study may not make recommendations for future research.

Table 2.5: Summary of studies in telehealth evaluation

	Title/Authors	Type of system	Method	Level of participants	Evaluation criteria	Key findings	Limitations of study	Recommendations
1	Linassi& Shan (2005)/ User satisfaction with a telemedicine amputee clinic in Saskatchewan	Telemedicine	Survey	15	Patient satisfaction	Patients satisfied with system Only minor technical difficulties were identified. Telemedicine appeared to provide significant advantages over traditional method of care, reliable and cost effective.	No limitations directly address in the study but the study did not look at clinicians' satisfaction.	No recommendations were made by the authors.
2	Mackert & Whitten (2007)/ Successful adoption of a school-based Telemedicine system	Telemedicine	Case study interview	N=32	Critical factors of success in the tele kid care was investigated	Results point to factors to success both in the planning and operational phases of tele kid care. Factors include: • Different sites might adopt the system in different ways • Actual users should involve in planning • Users must be trained extensively	Case study reduced the ability of researchers to generalize	Further research should focus on studies of other systems that have achieved, or failed to achieve, similar success to further illuminate other keys to success
3	Taylor et al (2009)/ Exploring the feasibility of videoconference delivery of a self-Management program to rural participants with stroke	Telehealth	Logs, surveys, focus groups and interviews	Seven participants, their caregivers, and two facilitators formed one group, located in an urban center. Five participants and their caregivers from two remote loca-tions were connected by videoconferen ce.	Feasibility was assessed by examining recruitment and attendance rates; program adaptations; and participant, facilitator, and staff perceptions To examine preliminary outcomes, goal attainment, balance, mood, participation, and walking endurance were measured.	The findings of this study report strategies the facilitators found helpful to enhance communication. Videoconference delivery of MOST was feasible, perceived as useful by participants, and was associated with improved mood, endurance, and balance confidence.	Difficulty in seeing remote participants accurately on the monitors. The facilitators were able to adjust their local camera, but with two sites connected, the technology does not allow control of remote cameras. Participants and the volunteer found it difficult to adjust their own camera. Limiting the group to just one remote site would alleviate this limitation, but would limit timely access to MOST for many.	
4	Doran et al (2009)/ Evaluation of Teleoperated surgical	Telesurgery			Performance applicability	Each mission was successfully completed, with all stated mission objectives met.		Further work is required in facilities such as Aquarius and programs such as NEEMO.

	Title/Authors	Type of system	Method	Level of participants	Evaluation criteria	Key findings	Limitations of study	Recommendations
	robots in an enclosed undersea environment					This research brought together academia, industry, and government to expand understanding of robotic telesurgery in extreme environments.		
5	Heany et al (2009)/ The introduction of a new consulting technology into the national health service(NHS) for Scotland	Telehealth/remote consultation using digital stethoscope and other devices	Mixed method- Questionnaire and semi structured qualitative Interview	105 patients for quantitative- 9 patients, 3 doctors and 2 assistants were interviewed	• Quality of the clinical equipment • Patient satisfaction • Clinicians satisfaction • Instrument usage (stethoscope, otoscore and camera) • Safety • efficacy	Most consultations were found to be safe and appropriate.	Small number of cases	Further study of different aspects of this consultation technology is required as it develops for normalized, widespread use. Inverness, IV2 3JH Scotland
6	Bendi et al (2006)/ Quality assessment and cataloguing of telemedicine applications	Telemedicine	Survey called GQ, (General Questionnaire	Four telemedicine systems	• Technological aspect • exportability			Deeper quality assessment process would also require the evaluation of medical, economic, organisational and quality of life.
7	Olver and Selva-Nayagam (2000)/ Evaluation of a Telemedicine Link between Darwin and Adelaide to Facilitate Cancer Management	Telemedicine	Survey, (questionnaire)	20 health professionals and 8 patients	• Patient Satisfaction • clinicians Satisfaction	7 out of eight patients were satisfied. Better care and saving time reported		
8	Puskin et al (1995)/ Joint Federal Initiative for Creating a Telemedicine Evaluation Framework				• Access • Costs and benefits • Clinical outcomes • Technical acceptability • Health system interface • Provider/Acceptability			
9	Lewin Group Inc. (2000)/ Assessment of Approaches to Evaluating Telemedicine	Telemedicine	interviews	15 telephone interviews	• Access • Technical properties *Data transmission speed or bandwidth* *Data quality* *System functions and features* *Ease of use* *Reliability* *Service or maintenance requirements* • Safety • Efficacy and effectiveness • Cost and other economic impacts	1. A fundamental consideration in evaluating a telemedicine application is specifying the purpose, target audience, and the scope or focus of evaluation. Although these often are not straightforward decisions, each evaluation should specify a minimum set of elements. 2. Patient satisfaction with telemedicine has consistently been demonstrated to be high. As such, resources for future evaluations may be better allocated to areas of higher priority. 3. Lack of reimbursement for telemedicine services has been a significant confounder in past evaluations	The lack of clearly defined control groups	Further work is required to develop or adapt evaluation designs that take staged approaches commensurate with technological maturity

	Title/Authors	Type of system	Method	Level of participants	Evaluation criteria	Key findings	Limitations of study	Recommendations
					• Appropriateness of the technology • Clinician acceptance • Integration into the mainstream of care	of telemedicine. Future evaluation efforts (e.g., demonstration projects) should seek to establish comparable reimbursement environments for telemedicine and the usual care comparators whenever differences in reimbursement might affect study results. 4. The findings and utility of a telemedicine evaluation are likely to be influenced by the selection of economic perspective(s) of evaluation. To be of practical use, evaluations should account for one or more of multiple relevant economic perspectives, e.g., of clinicians, patients, hospitals, payers, or society-at-large. 5. Telemedicine comprises an evolving portfolio of technologies and applications. As such, any prospective evaluation must allow for and be prepared to assess the impact (on efficacy or effectiveness, cost, cost-effectiveness, etc.) of applications that may not have been foreseen during the evaluation design. 6. Plans for evaluation of telemedicine programs should make explicit their assumptions regarding the relationship between the timing of evaluation and the maturity of the telemedicine program, and the evaluations should be designed accordingly. 7. Given the need to minimize the influence of known as well as unknown sources of bias in comparative studies involving telemedicine, it is desirable to use randomized designs whenever possible. Depending upon the investigation, it may be appropriate to randomize one or more of patients, physicians, or delivery sites. However, randomization is often impractical or impossible for evaluating telemedicine applications. 8. A recurrent weakness in telemedicine evaluations has been the lack of clearly defined control groups. In general, a comparator should be the standard or level of care that would be provided in the absence of the		

	Title/Authors	Type of system	Method	Level of participants	Evaluation criteria	Key findings	Limitations of study	Recommendations
						telemedicine intervention. 9. The time horizon for a telemedicine evaluation should be sufficiently long to capture the stream of relevant health and economic effects and to detect any differences in these effects between the intervention and control groups. 10. In order to be successful, telemedicine must be integrated as smoothly as possible into existing, routine clinical and administrative functions, including facilities, scheduling and appointments, patient records, coding, and billing. 11. Independent financial viability of a telemedicine program will increase its prospects for integration into the health care mainstream and for long-term success.		
10	Taylor (2005)/ Evaluating telemedicine systems and services	Telemedicine	Systematic review		• Safety *Information capture* *Information transmission* *Information display* *Ergonomics* • Practicality • Effectiveness *User satisfaction* *Medical outcomes* *Financial*	Poor quality of Telemedicine publications	Reliable evidence that it is practical and cost effective alternative was hard to find at the time of writing the paper	
11	Grigsby et al (2005)/ The Evaluation of Telemedicine and Health Services Research	Telemedicine/ Home telehealth	The paper demonstrated the systematic application of HSR methods for assessing the impact of telemedicine on access, quality, and cost of care.		• Structure measure *Speed and technical quality of electronic transmission* *Adequacy of equipment* *Skill of care providers in using technology* *Cost of technology* *Geographic accessibility of services* • Process measure *Sensitivity of diagnosis* *Specificity of diagnosis* *Treatment plan is*	The parameters of quality assessment include structure, process, and outcome, and appropriate measures for each of these must be developed for telemedicine.	it is not yet feasible to make valid generalizations about the effectiveness of telemedicine across disparate health services, technological configurations, and settings.	the analysis and verification of the effectiveness, efficacy, or cost of telemedicine must be based on specific types of health services and specific configurations of technology.

	Title/Authors	Type of system	Method	Level of participants	Evaluation criteria	Key findings	Limitations of study	Recommendations
					consistent with evidence-based guidelines for care • Outcome measures Short-term Intermediate *Acceptability of services* *Provider satisfaction with care* Long-term *Quality of life* *Health or functional status*			
12	Maryati 2006/Towards a Framework for Health Information Systems Evaluation	Health Information Systems	Literature review		• System Quality *Ease of use* *Ease of learning* *Response time* *Availability* *Reliability* *Flexibility* *Security* • Information quality *Availability* *Reliability* *Accuracy* *Timeliness* • Service quality *Quick responsiveness* *Assurance* • System use *Level of use (frequency, duration)* *Attitude* *Expectations/ belief* *Knowledge/expertise* *Acceptance* *Resistance/reluctance* *Training* • User satisfaction *Perceived usefulness* *User satisfaction* • Net benefit *Efficiency* *Effectiveness* *Clinical outcomes* *Cost*	This study brings together disparate evaluation studies in both Health Informatics and IS literature to provide a comprehensive picture of the-state-of–the-art as well as research needs of HIS evaluation.	The proposed framework only focused on a specific Setting of telehealth	To validate its usefulness, this framework needs to be tested in clinical settings Further improvement and refinement of this framework is suggested

	Title/Authors	Type of system	Method	Level of participants	Evaluation criteria	Key findings	Limitations of study	Recommendations
13	Scottish centre for telehealth (2007)	Telehealth	synthesizing existing evaluation frameworks		• Technological description *Technical aspects* *Infrastructure* *Hardware* *Software* • Efficacy/ Effectiveness of the system *Transmission time* *Safety* *Sound quality* • Accessibility *Waiting time* • Acceptability satisfaction *Degree of comfort with new technology* *Consultation timing satisfaction*	Introducing evaluation criteria		
14	Paryani (2006)/ A framework for evaluation of telemedicine	telemedicine	Systematic review		• Access *Range of available services* • Cost *Investment costs* *Line costs* *Clinicians' travel* • Efficiency and effectiveness *Improved diagnosis* *Change in health care process* • Acceptability (Satisfaction) *Clinician's comfort* *Timeliness* *Technical quality of service* *Quality of communication* *Privacy* • Technical properties and infrastructure *Data transmission speed* *Data quality* *Quality of sound* *Ease of use* *Reliability*	The most important measures in this framework are access, cost, effectiveness and acceptability of care. It is anticipated that the proposed framework will assist in providing reliable data on access, cost, effectiveness and acceptability of telemedicine.	It is only a preliminary framework	The proposed framework needs to be modified and refined based on the input received by the interviews conducted with experts and telemedicine providers

	Title/Authors	Type of system	Method	Level of participants	Evaluation criteria	Key findings	Limitations of study	Recommendations
					Service requirements *Maintenance requirements* *Training requirements* *Suitability of available facility (e.g. rooms)* *Range and suitability of available equipment* *Range and availability of telecommunication facilities* *Range and availability of IT resources* • Safety			
15	Field (1996) / Telemedicine: a guide to assessing telecommunications in health care	Telemedicine			• Quality *Appropriateness of services* *Quality, amount, or type of information available to clinicians* *Diagnostic accuracy* • Access *Timeliness of care* *Availability of care* *Ease of care* • Acceptability *Clinician's perception of using the system* • Cost	Managerial, technical, policy, legal, and human factors that must be taken into account in evaluating a telemedicine program are identified. Telemedicine applications will diffuse in some measure despite limited systematic assessment of their benefits and costs.		This study encourage evaluations that will guide policymakers, reassure patients and clinicians, inform health plan managers, and help those who have invested in telemedicine to identify shortcomings and improve their programs.
16	Bynum et al (2006)/ Effects of Telemedicine on Patients' Diagnosis and Treatment	Telemedicine	post-consultation survey	412	• Diagnosis change • change in treatment plan	27% change in diagnosis and 67% change in treatment plan.		
17	Tang et al (2006)/ Applying Heuristic Evaluation to Improve the Usability of a Telemedicine System'	Telemedicine/ a digital emergency medical services (EMS) system equipped on an ambulance	14 usability heuristics evaluation. ethnographic study	three experts inspected prototypes of the system	Consistency, visibility, match, minimalism, memory, feedback, flexibility, message, error, closure, undo, language, control, document. Or 14 usability heuristics used in evaluating the digital EMS system	User interface design was improved		Usability should be given high priority in the development of a telemedicine system. development of a telemedicine system should not only take advantage of technological advances but also pay close attention to users and the human issues involved as

	Title/Authors	Type of system	Method	Level of participants	Evaluation criteria	Key findings	Limitations of study	Recommendations
								well
18	Yawn (2000)/ Telemedicine: A New Framework for Evaluation	telemedicine	Literature review		• Education (training) • Technology assessment • Settings *Environment* Sound system Lighting Room design • Integration *Outcomes-time* • Costs *Development* *Equipment* • User satisfaction *Clinicians*	Study suggests an alternative framework for evaluation based on the clinical tasks that a physician or other health care provider must do to assess, treat, and follow patients		A scheme of evaluating telemedicine for a series of medical conditions or diagnoses has been recommended.
19	Gaggioli et al (2005)/ A telemedicine survey among Milan doctors	Telemedicine	Survey (questionnaire)	361 physicians	• Technology knowledge • usage level • physicians attitude about telemedicine • quality of care	The use improvement in using telemedicine depends on Physicians' attitude of acceptance.	Low response rate. Only 21% responded to their study.	Better dissemination of information about the state of the art of research and development in telemedicine is needed.
20	Gustke et al(2000)/ Satisfaction with Telemedicine	Telemedicine	Survey, (Questionnaire)	495 Patients	Patient Satisfaction	98.3% of the patients were satisfied.		Additional constructs that may affect patient satisfaction in telemedicine should be assessed, including travel time and method of transportation, amount and quality of the time the patient spends with the consultant, age-related valuation of time, patient health status, physician communication skills, medical outcomes, and the interpersonal interactions and skill of the nurse presenter.
21	Melcer et al (2002)/ A Prospective Evaluation of ENT Telemedicine in Remote Military Populations Seeking Specialty Care	Telemedicine	Documentation review AND	Data extracted from 193 consultations	Diagnosis change	45% changed diagnosis		
			Survey (Questionnaire)	495 Patients	Patient Satisfaction	98.3% of the patients were satisfied.		

Reviewing studies from table 2.5 that focused on telehealth evaluation is very important for this study because firstly it addresses the level of satisfaction which is high with both patients and clinicians. For example, part of or the entire evaluation criteria in the studies by Linassi and Shan (2005), Olver and Sleva-Nayagam (2000), Gustek et al (2000), Melcer et al (2002) and Heany et al (2009) were focused on patient or clinicians' satisfaction in using telehealth in general or particular telehealth technology. Thus, this finding encouraged the researcher to be aware of the importance of telehealth systems in society and also supported the enthusiasm of the researcher to conduct her research in telehealth. Secondly, the studies showed that usefulness of the system was what the users most expected and what had the most influence on their satisfaction of the system. For example, studies by Taylor et al (2009) and Maryati (2006) highlighted the importance of usefulness in evaluating telehealth systems.

The main research method used for the studies shown in table 2.5 was found to be survey. Patient satisfaction is the most popular criterion that the telemedicine evaluation studies tended to assess. It seems that the sample size is not an important factor to demonstrate user satisfaction, whereas one study showed high satisfaction among seven staff and another study showed 98.3% satisfaction among 495 patients. The effectiveness of the system might be understood better from the study results if the rate of change can be determined before implementation of the system, and after implementation.

Most of the recent studies focused on user satisfaction, either patients or clinicians, rather than other aspects of telehealth utility such as service quality, technical accessibility or cost. The study by Gaggioli (2005) showed that just 12% of the doctors responded to the survey. The study result was based on 361 responses. The study did not try to validate the result or justify the methodology. There is a question why 20% of doctors in Milan were not aware of telehealth systems. The 2005 study did not explain the reason why some doctors ignored the system or were reluctant to adopt the system. However, investigating telehealth system ignorance by physicians and the possible reasons behind it could be a motivation for future research in this area.

Most of the studies showed a high rate of effectiveness in telehealth, especially in user satisfaction and diagnosis change. Therefore, the importance of implementing and utilising telehealth technologies was encountered through reviewing these studies indicated in table 2.5. No limitations or weakness with any of the systems seemed to be observed. Almost all the results showed the benefits of conducting telemedicine systems. The reasons and the need for establishing telehealth in the reviewed studies were not explained. Consequently, future research could pay close attention to user issues involved with telehealth systems and clinicians' in-depth demand for specific telehealth technologies could be investigated. The results of the study by Melcer et al (2002) showed a high rate of satisfaction, but did not make clear what they meant by 'satisfaction'—which could include ease of use, accessibility, user friendliness or accuracy. However, elaborating the notion of 'Satisfaction' from clinicians' perspective could be a direction for future research.

Hanson and Chatterton (2005) highlight the importance of developing an evaluation framework for telehealth systems as facilitation of accountability, providing directions and clarifying expectations, assisting project planning and promoting evaluation as a management tool. A need for a practical framework which can be used to evaluate the usage of each aspect of telehealth is the reason for this study. The purpose of developing a conceptual framework could be to identify relevant facts and research questions from a theoretical perspective, and to identify practical solutions to real world problems regarding usage of digital stethoscopes.

Telehealth system such as Queensland Statewide Telehealth Services (QSTS) have identified the importance of using a digital stethoscope in their system because it could greatly enhance the assessment and diagnosis of patients in remote locations and generate direct savings of patients' trip costs. Since 2004 QSTS has used a superior model of 3M Littman which was specifically designed for QSTS (Hafeez-Baig et al 2007).

As one aspect of telehealth is capturing sound, evaluating the quality of transmitted sound could be important; moreover, the quality of the digital stethoscope itself could be evaluated and be a part of the telehealth evaluation.

The digital stethoscope is widely used in countries such as Canada and the United States of America under their telehealth platform (Health Canada 2009; Alberta

Health Services 2011). Leading DS available in the market (for example 3M Littman) have been trialled in the Australian telehealth setting, but clinicians have found it difficult to gain an accurate recording of the sound from available products (Hafeez-Baig et al 2007). 'Currently in Queensland Health, digital stethoscopes are in use by a number of physicians including Cardiologists, Cardiac Surgeons and Respiratory Specialists. However, the use is restricted to patients who present in person. There are no physicians in Queensland using the digital stethoscope technology for remote assessment of patients because current instruments are found to be inadequate in meeting physicians 'requirements to use this instrument on a telehealth infrastructure' (Gururajan 2007 p.2).

2.6 Chapter summary

Health informatics and eHealth, including telehealth, are new and burning topics in Information Systems (IS) research. Reviewing the studies that highlighted the importance of implementation, usage and evaluation of telehealth study are the foundation of investigating the research topic for this study.

Telehealth as an essential part of health information systems deals with resources, devices and people to provide improved medical care for patients, especially those in regional and remote areas. Therefore, evaluating current telehealth systems, that are usually a complex system, could be essential to guide the success of future implementation of new systems.

The literature review also revealed there are limited telehealth evaluation studies in which digital stethoscopes as medical devices were considered. While the use of DS is slowly increasing among clinicians, understanding the DS quality issues from clinicians' perspective would be an important part of telehealth evaluation. In this research, the focus will be both on the quality of DS and context, that is, telehealth setting.

The literature review was conducted thoroughly to be able to understand the context of this research, and to help the researcher refine the research question and sub-questions.

CHAPTER 3: CONCEPTUAL FRAMEWORK

3.1 Introduction

Reviewing the literature revealed the importance of investigating the usage of new technology in an organisation and led the researcher to review related theoretical frameworks and subsequently identify a framework for this study.

3.2 Theoretical frameworks

There are some theoretical models developed and introduced by professionals in order to test, validate, predicate or explain the acceptance, diffusion or adoption of a new technology. Reviewing the literature has shown the importance of the need to investigate the user acceptance and usage of new technology in an organisation and this has led the researcher to review related theoretical frameworks and thus identify a framework for this study. In this chapter, a number of theoretical frameworks such as the Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), and Information Systems Success model have been reviewed. This study will not test or examine any of the models/theories empirically; rather the suggested conceptual model can be used as a guide to this study. The conceptual framework will be used to focus on specific elements of systems in use and the importance of those components from clinicians' perspective.

3.2.1 Theory of Reasoned Action (TRA)

This theory was developed by Martin Fishbein and Icek Ajzen (1975; 1980). Their model was derived from previous research that was first named the Theory of Attitude, which led to the study of attitude and behaviour. This model was applied extensively in predicting and explaining behaviour across many domains. Han (2003) mentions that information systems researchers could use this model when studying the determinants of IT innovations and usage behaviour in exploring the main characteristics. Behavioural Intention (BI) can determine the specific behaviour of a person, moreover, BI is determined jointly by the person's attitude (A) and subjective norm (SN) regarding the behaviour in question (Han 2003). Attitude is determined by the person’s beliefs about the results of performing the behaviour multiplied by the evaluation of those results, and SN is determined by a multiplicative function of the person’s normative beliefs.

Sheppard et al. (1988) explains that according to Fishbein and Ajzen (1975; 1980), a behavioural intention measure will predict the performance of any voluntary act, unless intent changes prior to performance or unless the intention measure does not correspond to the behavioural criterion in terms of action, target, context and time-frame. The model by Fishbein and Ajzen was created to deal with behaviours and not outcomes or events that result from behaviours, and deals only with those behaviours that are under a person’s voluntary control.

This theory is not an appropriate one to pursue in this study, Firstly, a decision was made to conduct a qualitative study to explore the research question. Secondly, the model is quantitative and focuses entirely on the user’s behaviour which is more relevant perhaps to psychology studies rather than IT acceptance.

3.2.2 Technology Acceptance Model (TAM)

User acceptance is a critical success criterion for IT adoption and can be sufficiently explained, accurately predicted and effectively managed by means of a host of relevant factors (Hu et al. 1999). The relevant factors can be grouped into three important dimensions: characteristics of the individual, characteristics of the technology, and characteristics of the organisational context. As technology continues to be implemented extensively within innovative technology applications which target specialised individual professionals such as physicians, it is important to study the extent to which existing theories can explain or predict their technology acceptance (Chau & Hu 2001).

Lewin Group Inc (2000, p 21) contend ‘if clinicians are not comfortable with the technology, or judge that the technology decreases their control over patient care, they may avoid using it, thereby precluding other benefits of telemedicine’. Moreover it is suggested ‘clinical acceptance of a telehealth application may depend on the degree of confidence the clinicians have in his or her clinical findings from using the system as well as the clinician’s satisfaction with the encounter in the absence of face to face interaction with the patient’ (Lewin Group Inc 2000, p21).

Han (2003) indicates that the Technology Acceptance Model (TAM) was adapted from the Theory of Reasoned Actioned (TRA) and was specifically introduced to explain computer usage behaviour. The Technology Acceptance Model (TAM) uses the Theory of Reasoned Actioned (TRA) as a theoretical basis to identify the strong links between key beliefs: perceived usefulness (PU) and perceived ease of use (EOU), user's attitude (A), intentions (BI) and computer adoption behaviour.

The Technology Acceptance Model (TAM) is one of the Information Systems (IS) models which theorise that an individual behavioural intention to use a system is determined by two concepts as follows:

Perceived usefulness (PU): the extent to which a person believes that using the system will increase performance; and

Perceived ease-of-use (PEU): the degree to which a person believes that using the system can be effortless (Davis, 1989, p 320).

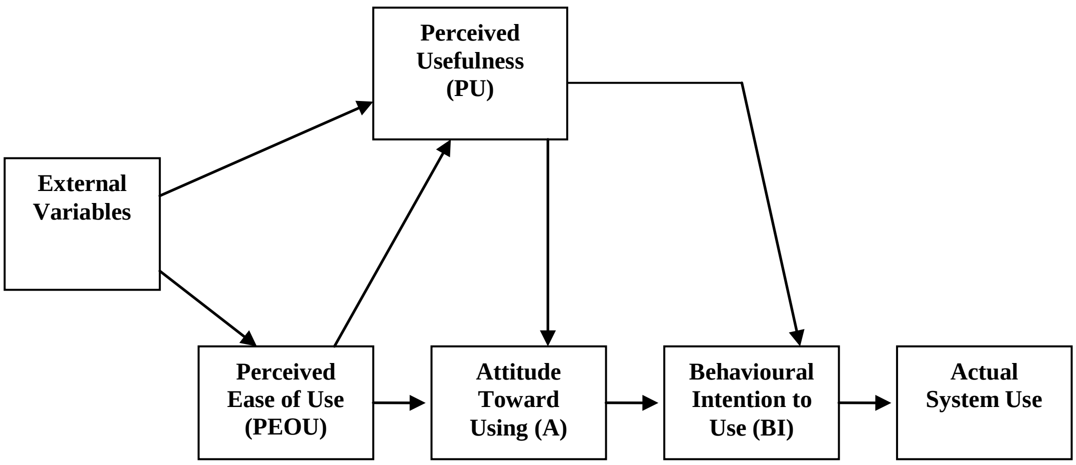

Figure 3.1: Technology Acceptance Model

(Source*:* Davis, Bagozzi & Warshaw 1989, p. 985)

Davis (1989) explains that perceived usefulness is the degree to which a person believes that using a particular system will enhance his or her job performance (see figure 3.1). This concept could apply in the telehealth context and might explain the extent to which clinicians believe that the usage of a digital stethoscope will increase their job performance in a telehealth system. Davis (1989) suggests that this term follows from the definition of the word ‘useful’, that is, capable of being used advantageously. Additionally, perceived ease of use refers to the degree to which a person believes that using a particular system will be free from effort, following from the definition of ‘ease’ which means freedom from difficulty or great effort (Davis 1989). In this study the concept ‘ease of use’ might be the degree to which clinicians believe that using a digital stethoscope is useful.

Studies have identified the relationship, importance and influence of the TAM model (Davis, 1989) variables to each other, and especially to the adoption of technology by users. Croteau and Vieru (2002) found that perceived effort and persistence have a significant impact on perceived ease of use in the case of physicians from the teaching and academic areas. Croteau and Vieru (2002) also found that Perceived Usefulness (PU) was the most significant factor affecting behavioural intention to adopt. Based on these findings, the focus of the suggested evaluation model will be more on usefulness of the digital stethoscope for clinicians rather than ease of use, because clinicians are well-educated professional users who may learn to work with new technology more easily than other users. Hu et al. (1999) identified a significant point, suggesting that ease of use has no effect on attitude and perceived usefulness because the physicians as the users can understand the new technology quickly (Hu et al. 1999; Kim et al. 2010).

The research study by Hu et al. (1999) suggests that if the telehealth systems fulfil the physicians’ needs, the system may be accepted. Physicians need to be sure that the utility of the system is what they require for their practices (Hu et al. 1999). Finally, Hu et al (1999 p.105) indicates that ‘for directing the physicians’ perceptions of the usefulness of the technology, proper user training is essential.’ The targeted technology in their study was telehealth in general, rather than specific telehealth technology.

In order to better understand the determinants of perceived ease of use, Venkatesh and Davis (1996) conducted a study to support their hypothesis which was ‘An individual’s perception of a particular system’s ease of use is anchored to her or his general computer self-efficacy at all times, and objective usability has an impact on ease of use perceptions about a specific system only after direct experience with the system’. There are different studies which have used the Technology Acceptance Model (TAM) as a theoretical framework and suggested the omission of attitude from the model. Venkatesh and Davis (1996) removed attitude from their TAM extended model because they found that attitude did not appear to mediate fully the effect of perceived usefulness and perceived ease of use on behavioural intention which is in contrast from the original model developed.

Yarbrough & Smith (2007, p656) suggest, ‘doctors are hesitant to adopt technologies that require an interruption of their traditional practice patterns’, however, it is realised that usefulness and ease of use of a new technology, derived from the TAM model, could have an impact on the acceptance of the digital stethoscope by users. In this study, TAM is used as a guide to explain the ease of use and usefulness of new technology in telehealth. Furthermore, TAM can also be used to explain clinicians’ satisfaction in using the digital stethoscope in a telehealth system context. User satisfaction has been used as a surrogate measure of system effectiveness (Ong & Lai 2004). This study also considers user satisfaction to evaluate the usage of DS in telehealth setting.

3.2.3 Information system success model

In most cases, telehealth may greatly depend on information systems (Hu 2003). Therefore, a possible approach to evaluate telehealth systems success could relate to relevant information systems studies. There are a number of available frameworks and models that could be used to evaluate information systems, particularly in the health context. Approaches to evaluate IS in the health context are developed based on a variety of domains, which include sociological, technical, economic, human and organisational (Maryati et al 2006).

Since telehealth relies on the use of information systems, a review of relevant IS research may be required to understand the important issues relevant to telehealth evaluation. Therefore, a systematic guide based on a review of studies conducted on research on information systems success is required for telehealth evaluation (Hu 2003).

Delone and McLean (1992) developed the Information Success Model as a framework for measuring the complex dependent variable in IS research. Their model itself is based on theoretical and empirical IS research conducted by a number of researchers. Since the model was developed, nearly 300 journal articles have referred to and made use of the IS success model (Delone & McLean 2003). Delone and McLean's IS success model (1992) appears to be a significant framework for evaluating system success as this model has been used extensively in IS studies.

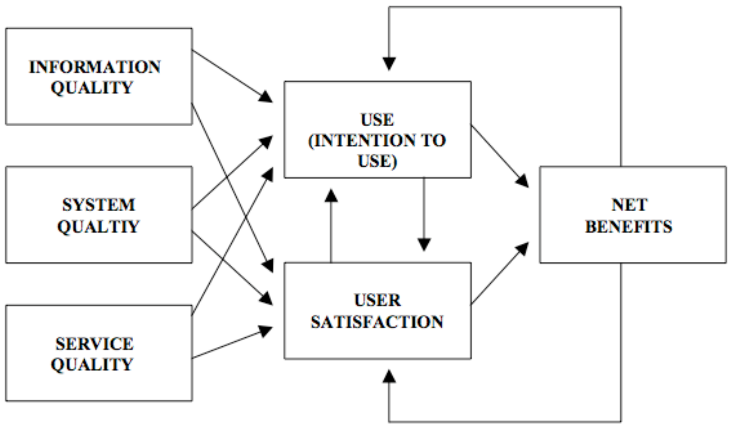

Figure 3.2: The reformulated IS success

(Source: Delone & McLean 2002)

Figure 3.2 shows the revised IS success model that was published in 2002, which consists of six interrelated dimensions of success: system quality, information quality, system use, user satisfaction, individual impacts and organisational impacts.

A number of IS studies have conducted extensive tests on the multidimensional relationships among the measures of IS success (Maryati et al 2006). A decision has been made to use the IS Success model as a guide for this study based on its appropriateness to the context. The focus of this study will be on specific attributes of the IS Success Model such as: system quality, information quality, user satisfaction and system use. The Technology Acceptance Model has been also used as a guide for this study. Part of the conceptual model was derived from the original TAM to focus on ease of use and usefulness of system and the importance of those two components on systems used by clinicians. Figure 3.3 depicts the conceptual model for this study which is adapted from TAM and the IS Success model.

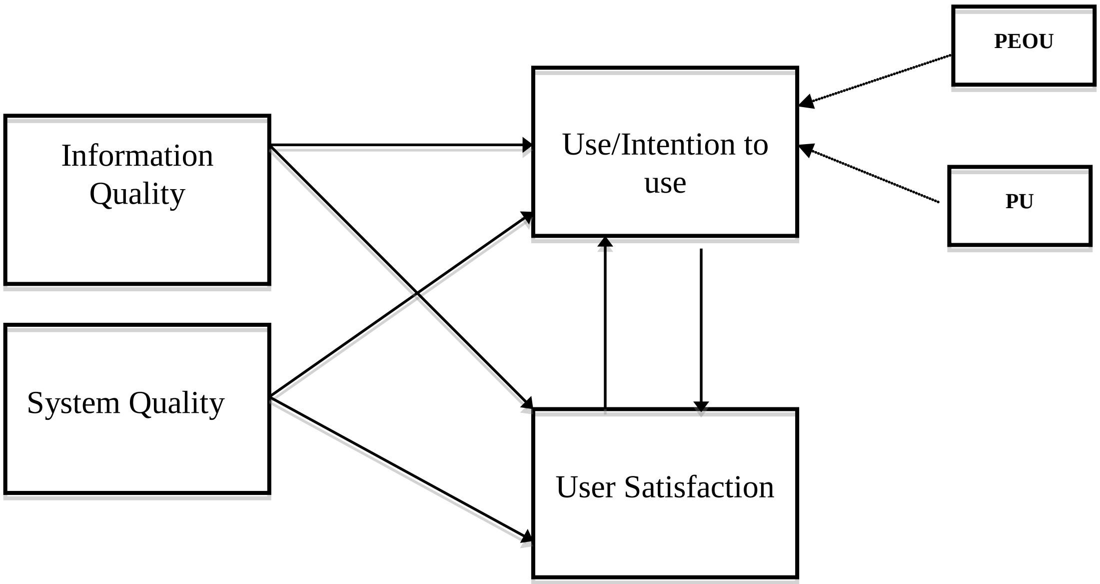

Figure 3.3: Conceptual model developed for this study

Examples of ***system quality*** measures are usefulness, availability, ease of use, ease of learning, response time, reliability, completeness, system flexibility and easy access to help (Delone & McLean 2003; Maryati et al 2006). The focus of ***information quality*** is on information produced by the system and the related criteria could be information accuracy, legibility, availability, output timeliness, reliability, completeness, relevancy and consistency (Delone & McLean 2003; Maryati et al 2006). Most information quality measures are subjective, as they are derived from the user perspective.

User satisfaction 'is often used to measure system success. It is subjective in nature as it depends on whose satisfaction is measured. Some studies relate user satisfaction to perceived usefulness and user's attitudes towards IS. User satisfaction is defined as the overall evaluation of user's experience in using the system and the system's potential impact' (Maryati et al 2006).

System use is concerned with the frequency and breadth of system usage. It refers to the person who uses it and the levels of use and training (Delone & McLean 2003; Maryati et al 2006). System use related criteria could also include perceived system usefulness, ease of use, and ease of learning and use of support (Hu 2003).

As discussed earlier in this chapter, a number of studies from the literature have identified the main area and related elements for evaluating telehealth systems:

(Yawn 2000; Maryati et al 2006; Scottish Centre for Telehealth 2007; Paryani 2006; Field 1996; Grisby et al 2005; Taylor 2005; Lewin Group Inc 2000; Puskin et al 1995). Table 3.1 shows a summary of the studies and selected constructs for evaluating both telehealth systems and information systems. From the studies reviewed, ten were chosen to be most relevant to this study. The most relevant evaluation elements were selected and are summarised in table 2.1. These studies mainly focus on the IS model in health care telehealth evaluation.

Study	**Topic**	**Selected Constructs**
Yawn (2000)	Telemedicine: A New Framework for Evaluation	• Education (training) • Technology assessment • Settings *Environment* Sound system Lighting Room design • Integration *Outcomes-time* • Costs *Development* *Equipment* • User satisfaction *Clinicians*
Maryati et al (2006)	Towards a Framework for Health Information Systems Evaluation	• System Quality *Ease of use* *Ease of learning* *Response time* *Availability* *Reliability* *Flexibility* *Security* • Information quality *Availability* *Reliability* *Accuracy* *Timeliness* • Service quality *Quick responsiveness* *Assurance* • System use *Level of use (frequency, duration)* *Attitude* *Expectations/ belief* *Knowledge/expertise* *Acceptance* *Resistance/reluctance* *Training* • User satisfaction *Perceived usefulness* *User satisfaction* • Net benefit *Efficiency*

Study	Topic	Selected Constructs
		Effectiveness *Clinical outcomes* *Cost*
DeLone & McLean (2003)	The DeLone and McLean Model of Information Systems Success: A Ten-Year Update	• Systems Quality *Adaptability* *Availability* *Reliability* *Response time* *Usability* • Information quality *Ease of understanding* *Security* • Service quality *Assurance* *Empathy* *Responsiveness* • User satisfaction • Net benefit *Cost savings* *Expanded markets* *Reduced costs* *Time savings*
Scottish centre for telehealth (2007)	Telehealth Evaluation	• Technological description *Technical aspects* *Infrastructure* *Hardware* *Software* • Efficacy/ Effectiveness of the system *Transmission time* *Safety* *Sound quality* • Accessibility *Waiting time* • Acceptability satisfaction *Degree of comfort with new technology* *Consultation timing satisfaction*
Paryani (2006)	A framework for evaluation of telemedicine	• Access *Range of available services* • Cost *Investment costs* *Line costs* *Clinicians' travel* • Efficiency and effectiveness *Improved diagnosis* *Change in health care process* • Acceptability (Satisfaction) *Clinician's comfort* *Timeliness* *Technical quality of service* *Quality of communication* *Privacy* • Technical properties and infrastructure *Data transmission speed* *Data quality* *Quality of sound*

Study	Topic	Selected Constructs
		Ease of use *Reliability* *Service requirements* *Maintenance requirements* *Training requirements* *Suitability of available facility (e.g. rooms)* *Range and suitability of available equipment* *Range and availability of telecommunication facilities* *Range and availability of IT resources* • Safety
Field (1996)	Telemedicine: a guide to assessing telecommunications in health care	• Quality *Appropriateness of services* *Quality, amount, or type of information available to clinicians* *Diagnostic accuracy* • Access *Timeliness of care* *Availability of care* *Ease of care* • Acceptability *Clinician's perception of using the system* • Cost
Grigsby et al (2005)	The Evaluation of Telemedicine and Health Services Research	• Structure measure *Speed and technical quality of electronic transmission* *Adequacy of equipment* *Skill of care providers in using technology* *Cost of technology* *Geographic accessibility of services* • Process measure *Sensitivity of diagnosis* *Specificity of diagnosis* *Treatment plan is consistent with evidence-based guidelines for care* • Outcome measures Short-term Intermediate *Acceptability of services* *Provider satisfaction with care* Long-term *Quality of life* *Health or functional status*
Taylor (2005)	Evaluating telemedicine systems and services	• Safety *Information capture* *Information transmission* *Information display* *Ergonomics* • Practicality • Effectiveness *User satisfaction* *Medical outcomes* *Financial*

Study	Topic	Selected Constructs
Lewin Group Inc. (2000)	Assessment of Approaches to Evaluating Telemedicine	• Access • Technical properties *Data transmission speed or bandwidth* *Data quality* *System functions and features* *Ease of use* *Reliability* *Service or maintenance requirements* • Safety • Efficacy and effectiveness • Cost and other economic impacts • Appropriateness of the technology • Clinician acceptance • Integration into the mainstream of care
Puskin et al (1995)	Joint Federal Initiative for Creating a Telemedicine Evaluation Framework	• Access • Costs and benefits • Clinical outcomes • Technical acceptability • Health system interface • Provider/Acceptability

Table 3.1: Selected constructs for evaluation

Digital stethoscopes can be differentiated based on their technical features, functions and price range. Apart from price, available digital stethoscopes in the market have been compared based on their functionality and technical features and are discussed in chapter 2 (see also table 2.2). Technical features that best describe a digital stethoscope were identified for this study and include dimension, weight, base material, colour, diaphragm design, volume control, chest piece design, chest piece material, earpiece design, earpiece material, ambient noise filter, battery life, recording facility, connectivity and complexity.

In order to design a preliminary framework to be used as a guide for focus group sessions for this study, IS success model, TAM, previous studies on telehealth systems evaluation models, and digital stethoscope technical features have been reviewed. Table 3.2 is an extension of figure 3.3. According to table 3.2, a number is assigned for each construct, namely:

1: LeRouge 2002, 2: DeLone 2001, 3: Maryati 2006, 4: Derived for this study, and 5: Davis 1998.

DOMAIN	INDICATOR	
SYSTEM QUALITY (TECHNOLOGY QUALITY)	DS design, features and characteristics	*Dimension (4)*
		Weight (4)
		Base material (4)
		Colour (4)
		Diaphragm design (4)
		Volume control (4)
		Chest piece design (4)
		Chest peace material (4)
		Headset design (4)
		Headset material (4)
		Ambient noise filter (4)
		Battery life (4)
		Recording facility (4)
		Connectivity (4)
		Handy shape (4)
		Complexity (4)
		Rational design (1) (balanced)
		Additional software (4)
	Reliability (1)	
	Interoperability (1) (the ability of the component parts of a system to operate successfully together)	
	Ease Of Use (2)	
	Ease of Learning (2)	
	Convenience of access (2)	
	Usefulness (2)	
	Flexibility (2) (adapt to telehealth setting)	
	Reliability (2)	
	Response Time (2)	
	Availability (3)	
	Security (3)	
INFORMATION QUALITY	Input quality	*Quiet/ Sound Proof (1)*
		Suitable Temperature (1)
	Output Quality	*Sound quality/clarity (1)*
		Sound Accuracy (3)
		Sound Sufficiency (2)
		Sound Timeliness (2) (suitable for diagnosis)
USER SATISFACTION	Overall satisfaction (2)	
USE	Level of use (2)	
	Frequency of use (2)	
	Perceived ease of use (5)	
	Perceived usefulness (5)	

Table 3.2: Preliminary conceptual framework developed by the researcher
Selected constructs adapted from IS success model and other studies from the literature

3.3 Chapter summary

User' perceptions of accepting and using new technologies, along with success use of telehealth systems, are important topics in Information Systems research. Clinicians are perhaps the most important users of telehealth technology and their level of technology usage often has an essential impact on a system's success, as literature has explained.

This research has briefly reviewed some popular theoretical frameworks such as TAM, TRA and IS Success Model. The conceptual framework was developed to understand the issues associated with usage of DS in a telehealth environment. Part of the IS Success Model by Delone and McLean (2001) and part of TAM by Davis (1998) has emerged as the main model as a guide for this study. This study does not intend to examine any of the variables of the TAM and IS Success Model, or test the models in any way: rather the aim of this study is to use those two models as a guide only to explore the clinicians' perception of using DS as a new technology in a telehealth setting. The sole focus of this study will be on specific elements of IS Success Model, that is, system quality, information quality, user satisfaction and system use.

The IS literature review helped the researcher to build a preliminary version of a framework to guide the focus group sessions in this study.

CHAPTER 4: RESEARCH METHODOLOGY AND DESIGN

This chapter details the research approach and methodology employed for this study, which attempts to explore the main research question identified in chapter 1. The research problem explores the clinicians' perceptions of using digital stethoscopes in a telehealth context through three sub questions. Consequently, the research strategy described in this chapter is considered to be the most appropriate for this study. In section 4.2 of this chapter the research paradigm, together with epistemological and ontological assumptions taken in this research study, is identified. This section will discuss positivist versus interpretivist research paradigms and suggest an appropriate philosophy as a basis for this study. Qualitative and quantitative research methods are discussed against each other in section 4.3 and the most suitable qualitative research approach to answer the research question is introduced in section 4.3.1.

Section 4.4 will review qualitative data collection methods employed for this study. In this section the type of method used to collect data and the justification for this choice is addressed.

4.1 Introduction to research

Research is a systematic investigation that employs various standard scientific methodologies to solve problems and create new valid knowledge (Grinnell 1993). Furthermore, newly generated knowledge can be applied to solve problems, improve the quality of life and provide a better understanding of conditions in any field of research (Grinnell 1993; Burns 1994). In social science, particularly the study of social behaviour, researchers are most often interested in what people do, why they do these activities, where they do them, how often they do them, and the consequences of doing them. While social science has emerged to have the same goal of 'searching for truth' as do all other types of science (Adams & Schnaveveldt 1991), the literature suggests that understanding social phenomena could be achieved through direct observation or communication with participants. Likewise, Gordon W. Allport states that 'If we want to know how people feel, what they experience and what they remember, what their emotions and motives are and the reasons for acting as they do—*why not ask them*?' (cited in Selltiz, Johoda, Deutsch, & Cook

1959, p 236). Every problem may require various strategies to be employed in order to achieve a successful research outcome. Research design can relate to a particular approach, or a research tool which involves a plan, blueprint, or guide for data collection and interpretation. In a good research design, various techniques work harmoniously together in order to perform a successful function (Adams & Schnaveveldt 1991; Maxwell 2005). No single research strategy will always provide the best results for all IS research (Benbasat et al., 1987), however, the aim of this research study is to apply a relevant research approach and proper techniques which have been introduced in scholarly literature to convey alignment between the selected approach and the investigated research questions. The research methods have been selected in order to be consistent with the research assumptions discussed in section 4.2.2 that are relevant to this study.

This chapter will further emphasize the importance of understanding various research methods and the applicability of each method to this study. The next section will review the research philosophy and discuss a specific research paradigm employed for this study.

4.2 Research paradigm

Any research project could be conducted based on the underlying assumptions about a relevant research method. Therefore, knowing these assumptions, which is called the 'paradigm', is important for the researcher to design and conduct valid research. The word paradigm has a Greek root, *paradeiknyai,* which means 'to show side by side' and represents a pattern for the individual's idea (Shtarkshall, 2004).

Thomas Samuel Kuhn (1962), who is one of the most influential modern philosophers of science, has given a contemporary meaning to paradigm (Bird 2004). Kuhn's idea of paradigm has become well known. He defined paradigm as a basic orientation to the theory and research. A scientific paradigm could be referred to as a complete system of thinking. It may include fundamental assumptions, the research technique to be used, the important questions to be answered, and examples of what good scientific research looks like (Neuman 2000). Since a paradigm is defined as a set of basic beliefs which deal with first or final principles, a researcher may follow a specific paradigm that has a meaningful view about the nature of the world and a range of possible relationships to that world and its parts which is relevant to the study in question (Guba & Lincoln, 1994 p. 107-108). By following a specific paradigm, the researcher will be able to establish basic beliefs and accept those beliefs based on that particular paradigm.

The literature reveals other meanings and concepts for a paradigm rather than simply being a theory or hypothesis. Voce (2004, p 1) considers a paradigm as a 'framework within which theories are built, that fundamentally influences how one see the world, determines your perspective, and shapes your understanding of how things are connected'. Following and believing in a particular paradigm means the holder's personal behaviour, professional activities and position about a subject of research will all be influenced by that specific paradigm. Kuhn (1962) introduced the concept of the paradigm to the modern world and mainly limited it to scientific paradigms. However, the idea of social paradigm which could be fitted into the context of social sciences was introduced by Handa (1986) who recognised and indicated the essential components of the social paradigm. In social science, the term 'paradigm' is employed to explain a set of beliefs, experiences and values that affect the way an individual perceives reality and responds to that perception. Although researchers are free to choose and follow any of the available paradigms, Kuhn (1962) suggests that two paradigms may not be compatible with each other as they do not hold the same common standard of comparison. Basically, each researcher has already made a range of assumptions about the world, the selected topic to be researched, and the way to understand the world and, therefore, the selection of a paradigm may not entirely be a matter of free choice. However, it is suggested that researchers assess themselves to identify which paradigms will best fit with their assumptions, beliefs and methodological preference (Maxwell 2005, p 37). Reviewing the relevant literature in research philosophy and approach revealed three major paradigms. Willis (2007) introduces a generally-accepted list of three different paradigms: critical theory, positivism and interpretivism. The following section will review critical theory and positivism against interpretivism paradigm.

4.2.1 Critical theory, positivism and interpretivism

Critical theory, which is the critique of culture and society, was built on the foundation of Marxism. This paradigm was introduced by scholars who believed that classic Marxism would not be a usable theory for modern society to deal with its complex social and economic structure (Willis 2007). Additionally, critical social science critiques basic social structures with the view to effect change (Littlejohn, 1992, p. 238). Orlikowski and Baroudi (1991) state ‘Critical theorists do not share common philosophical standards for the evaluation of theories. What is acceptable theory or explanation is still debatable. This ambiguity of evaluation may be difficult for proponents of the dominant research tradition to accept, given their experience with positivism’s relatively unambiguous criteria for what constitutes valid knowledge’ (Orlikowski & Baroudi 1991, p. 23). According to this paradigm, the role of a researcher is to interpret the hidden contradiction in the social order and initiate changes in the social relations and practices.

Guba (1990) suggests ‘Ideologically oriented inquiry’ as a phrase to replace the term critical theory because of its emphasis on ideology rather than methodology as a guide to research. Therefore, it may not be relevant for this research to adopt critical theory because of the risk of being confused with ideological practice instead of real research (Willis 2007).

Since this dissertation is concerned with usage of the digital stethoscope in a telehealth context, it is associated with the Information Systems research discipline. Burrell and Morgan (1979 p. 5) indicate that a positivists’ viewpoint in research is ‘to explain and predict what happens in the social world by searching for regularity, causal relationships between its constituent elements’. Contrary to this view, the interpretivist research paradigm believes that humans actions cause the creation of the empirical world and, at the paradigm level, realism of the context is important (Fitzgerald & Howcroft 1998).

Klein and Myers (1999) suggest that IS research can be classified as interpretive in that ‘our knowledge of reality is gained only through social constructions such as language, shared meanings, documents, tools and other artefacts’. Interpretive research attempts to understand phenomena through the meanings that people assign to them. Walsham (1993) states that ‘interpretive methods of research in IS are aimed at producing an understanding of the context of the information system, and the process whereby the information system influences and is influenced by the context’ (Walsham 1993, pp. 4-5).

Walsham, cited in Myers and Avison (2002), states that IS literature includes a significant number of interpretive case studies that cover a variety of topics (Markus

1983; Orlikowski & Baroudi 1991; Suchman 1987; Boland & Day 1989; Walsham 1993; Zuboff 1988). Interpretive research has become significantly more important in the field of IS than it used to be in the early 1990s (Walsham 2006).

There is a clear distinction between interpretive research and qualitative. The nature of qualitative research can be positivist or interpretivist depending on the fundamental philosophical assumptions of the researcher. According to the literature, 'The foundational assumption for interpretivist researchers is that the most of our knowledge is gained, or at least filtered, through social constructions such as language, shared meanings, documents, tools and other artifacts' (Trauth 2001, p 219). Although it is common with many research approaches to predefine dependent and independent variables, this is not the case with interpretive research. Furthermore, the interpretive approach tries to understand phenomena through the meanings that people assign to them (Trauth 2001, p 219).

Walsham (1995) recommends the most suitable way to address the differences between positivist and interpretivist approach is by considering their epistemological and ontological stances.

4.2.2 Selected paradigm for this study

This research study will be conducted using an interpretivist viewpoint. As this interpretivist perspective can help an IS researcher understand human thoughts and actions in a social and organisational environment (Klein & Myers1999 p. 67), it has the potential to produce deep insights into information system phenomena.

This study does not aim to understand the relationship between multiple dependent and independent variables; hence the notion of DS usage will be studied through research questions which are guided by the Information Systems Success Model. Therefore, positivist theory testing is not an appropriate approach to investigate this research question. Furthermore, critical theory is not chosen since this study is not examining social conditions in order to uncover hidden structures. It is the aim of this research to explore the field of telehealth where the digital stethoscope is deployed to gain a greater understanding of clinicians' perceptions. Consequently, an interpretive study seems to be the most fitting for this project, in which the researcher attempts to understand the reality as a construct of the perceptions of the users. Furthermore, an interpretive research approach is chosen for this research so the researcher is able to understand human thought and action in social and organizational contexts, in this case the health organisation. The philosophy employed for this study would be appropriate for achieving the objectives of this study as discussed through the research question in chapter one. By conducting an interpretive research, the researcher attempts to understand the phenomenon, in this case DS usage, through the meanings that clinicians assign to it. Overall usage of DS will be investigated and explored from the point of view of those directly involved in the social process, that is, clinicians. The researcher will not report facts; rather interpretation of clinicians' thoughts and behaviour regarding DS usage will be taken into account within this interpretive study.

The following section will review the philosophical assumptions of ontology, epistemology and methodology relevant to this study.

4.2.2 The philosophical assumptions of this study

A particular research paradigm may be defined by basic beliefs such as ontological, epistemological and methodological assumptions. The concern of ontology is with the nature of reality, while epistemology refers to the beliefs about how knowledge is acquired (Guba 1990; Morgan 1983).

In philosophy, epistemology is concerned with a theory of knowledge and the procedures used to obtain knowledge of the world around human beings (Lewise-beck et al 2004). Finally, the process of research is conducted under methodological assumptions. Tashakori and Teddie (1998, p.7) address the nature of reality as ontology within which positivists believe that there is a single reality, whereas interpretivists believe that reality is subjective and people experience reality in different ways. Tashakori and Teddie (1998, p.7) highlight epistemology as the relationship of the knower to the known. Interpretivism maintains that individuals and their activities need to be studied in order to understand the social world (Jarvinen 2001). In contradiction, positivists believe that the knower and the known are independent. Maxwell (2005, p 36) addresses three main philosophical assumptions as the way we can understand the phenomenon under study (epistemology), a set of very general philosophical assumptions about the nature of the world (ontology), and assumptions that tend to be shared by researchers working in a specific field or tradition (methodology). Additionally, positivist and interpretive approaches can be distinguished more accurately by reviewing and focusing on their ontological and epistemological stances (Walsham 1995).

The epistemological and ontological assumptions made in this study have been aligned with assumptions under the interpretivism paradigm. Hence, for this research, the empirical world is assumed to be subjective and the social world can only be understood from the point of view of the individuals who are directly involved in the activities which are to be studied (Jarvinen 1992, p 175).

Iivari et al (1998) suggest the concern of ontology in information systems research would be on 'information and data, information systems, human beings in their different roles of IS development and IS use, technology, and human organisations and society at large'. The philosophical assumptions that are related to this dissertation are revealed in *italics* (see figure 4.1) in adapted framework for paradigmatic analysis by Iivari et al (1998).

The ontological assumption has been made in this dissertation that usage of digital stethoscopes in a telehealth setting is seen as a socio-technical system within which human beings are viewed as voluntaristic and free willed. This study adopts a voluntaristic view of technology in which clinicians have the ability to use and control technology for their own advantage. Clinicians are considered to have human choice and they have the chance to control usage by choosing not to use the digital stethoscope in a telehealth setting.

Additionally, within this assumption the view of information/data is made on the premise that intention to use and user acceptance are not independent or objective constructs and they are a product of the human mind. User perception of using a digital stethoscope is being studied, despite the physical existence of the system and technology.

Interpretivism epistemology assumption is used for this research study; therefore, the social world is understood from the point of view of the individuals who are involved with the activities to be studied (Burrell & Morgan 1979). In respect to this research and within this assumption the information and system quality attributes that may contribute to and impact clinicians' satisfaction and intention to use digital stethoscope is understood. Moreover, this research takes a subjective approach to understand the clinicians’ perception of using digital stethoscope in a telehealth setting by investigating the sub questions introduced for this study.

The methodological assumptions are discussed in section 4.3 of this chapter.

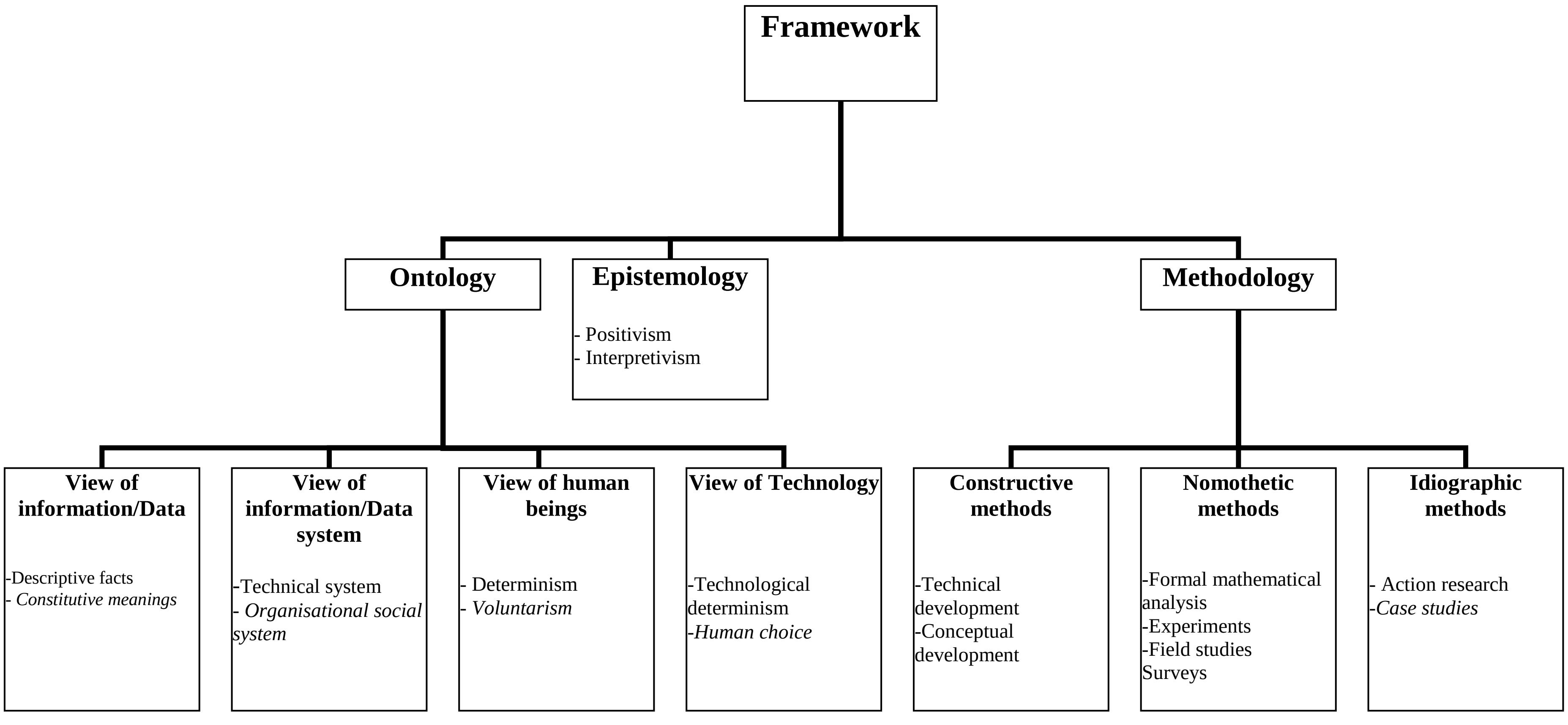

Figure 4.1: Framework for paradigmatic analysis
(Adapted from Iivari et al 1998)

4.3 Research method (qualitative versus quantitative)

Methods convey particular procedures that may include qualitative or quantitative techniques (Silverman 2006). Moreover, a methodology refers to the choices that are made about the phenomenon to be studied, methods of gathering data, and forms of data analysis in planning and executing a research. Therefore, research methodology can be defined as the application of procedures toward acquiring answers to a wide variety of research questions and the way that the researcher will go about studying a phenomenon (Adams & Schnaveveldt 1991; Silverman 2006). In social science, the researcher seeks to 'inform, solve problems, describe situations in an accurate and clear manner, and generate new ideas, test hypotheses, and pose new questions for research' (Adams & Schnaveveldt 1991). Choosing methodological techniques is not a case of true or false. The researcher has attempted to seek the most useful and appropriate method for this particular project. Consequently, the process followed by the researcher in choosing a methodology for this study was as introduced by Silverman (2005) and includes four components:

- a choice of certain methods among the many available to be used as preferred by the researcher such as listening, watching, observing, reading, questioning and conversing;
- a theory of scientific knowledge or a set of assumptions about the nature of reality, the role of the researcher, and the concept of social actor;
- a range of solutions and devices used in tackling a research problem; and
- a systematic series of steps that the researcher follows after selecting a method (Silverman 2005, p 15).

The nature of the study itself could depend on the stages of advancement of knowledge in the research area, for instance, during an exploratory stage the researcher attempts to explore new areas of organisational research; whereas, the researcher may follow a different pathway to examine the validity of a certain relationship for the hypothesis testing stage of a particular quantitative research project (Cavana et al 2001).

Four common research designs identified in the literature (Kumar 1996; Cavana et al 2001; Marshall & Rossman 2006) include:

1. Exploratory research: conducted when there is not much known about the situation. It structures and identifies new problems.
2. Explanatory research: it explains the reasons for the occurrence of a particular event. It identifies cause and effect and may be used to test the accuracy of a theory.
3. Constructive research: develops solutions to a problem
4. Empirical research: within this research the feasibility of a solution will be tested using empirical evidence.

The usage of exploratory research is essential when a researcher wants to explore areas with no or limited knowledge about it. This kind of study may be suitable for a researcher who plans to develop, refine or test a framework/tools (Kumar 1996). The purpose of exploratory research is identified as seeking new insights, asking questions and assessing phenomenon within a perspective (Adams & Schnaveveldt 1991). Additionally, the literature reveals that in cases where extensive work needs to be done to gain familiarity with the phenomenon, and there is no information on how similar problems or research issues have been solved in the past, an exploratory approach is suggested (Cavana et al 2001; Adams & Schnaveveldt 1991). Since the goal of this research is to develop a conceptual framework based on clinicians' perceptions of usage, an exploratory research approach is the most appropriate. Furthermore, this study aims to investigate the phenomenon of clinicians' usage of the digital stethoscope in a telehealth setting and clarify and understand the problem and issues involved with the usage.

Depending on the objective of the research and the properties of the subject matter, quantitative and qualitative approaches can be applied by the researcher. The next section reviews these two approaches.

4.3.1 Research design (Approach)

In the social sciences or any other discipline, quantitative or qualitative research can be applied depending on the properties of the subject matter and the objective of the research (Trauth 2001). This research involves collecting, analysing and interpreting data by observing what people do and say (Oliver-Hoyo & Allen 2006), whereas quantitative research refers to counts and measures of things; and 'qualitative research refers to the meanings, concepts, definitions, characteristics, metaphors, symbols, and descriptions of things' (Berg, 2007). Moreover, by conducting qualitative research, the individuals and the world they interact with can be understood. Qualitative research uses different methods of collecting information in comparison with methods used in quantitative research and is much more subjective. Methods in qualitative research mainly include focus groups, individual and in-depth interviews.

Scientific(positivism)	**<= Spectrum of Research Methods =>**	**Interpretivisim**
Theorem proof		Subjective/Argumentative
Laboratory experiments		Reviews
Field experiments		Grounded theory
Survey	⟷	Action Research
Case studies		Descriptive/Interpretive studies
Forecasting		Futures research
Simulation		Roles/Simulation

Figure 4.2:- Research categories and approaches
(Source: Travis 1999)

Figure 4.2 describes a number of common research approaches which are divided into separate paradigms: positivist and antipositivist. The spectrum of the research methods from figure 4.2 was explained by Travis (1999). Some research strategies stated by Yin (1989) include: experiment, survey, archival analysis, history and case study, and action research ethnography.

Hay (2000) suggests qualitative research is concerned with clarifying human environments and human experiences within a selection of conceptual frameworks. The social world is seen within from the viewpoint of the 'actor' within qualitative approach. Actors refer to people working in organizations, doing particular jobs and they form the respondents or informants, and what they say and do is an important element of qualitative research (Stuart, 1996).

Qualitative research methods are designed to help researchers understand people and the social and cultural contexts within which they live (Grbich, 2001). An expanded definition of qualitative social research is the study of people in their natural environments during their daily life. This approach tries to understand how people live, how they talk and behave, and what captivates and distresses them (Tutty, Rothery & Grinnell 1996). The use of qualitative research approach in the health area is considerable. Moreover, Gagnon et al. (2004) suggested more qualitative studies are needed to explore in more depth the dynamics of the introduction of telehealth in healthcare organisations. Consequently, this study has adopted a qualitative stance within the interpretivism paradigm to explore the issues that are likely to influence the usage of digital stethoscopes in a telehealth setting.

The research approaches within a qualitative method suggested by Jarvinen (2001) include grounded theory, case study, phenomenology, contextualism and ethnographic.

Similarly, Patton (2002) addressed four major types of qualitative research as follows:

- Phenomenology: relates to study of how individuals experience a phenomenon
- Ethnography: the discovery and description of the culture of a group of people
- Grounded theory: the development of inductive theory that is grounded directly in the empirical data, and
- Case study: refers to the collection and presentation of detailed information about a particular participant or small group

Table 4.1 describes characteristic of four qualitative research approaches suggested by Patton (2002) through focusing on various dimensions of research purpose including disciplinary origin, data collection method and data analysis.

Dimension	Qualitative Research Approach			
	Phenomenology	Ethnography	Case Study	Grounded Theory
Research purpose	To describe one or more individuals' experiences of a phenomenon (e.g., the experience of the death of a loved one).	To describe the cultural characteristics of a group of people and to describe cultural scenes.	To describe one or more cases in-depth and address the research questions and issues.	To inductively generate a grounded theory describing and explaining a phenomenon.
Disciplinary origin	Philosophy.	Anthropology.	Multidisciplinary roots, including business, law, social sciences, medicine, and education.	Sociology.
Primary data-collection method	In-depth interviews with up to 10–15 people.	Participant observation over an extended period of time (e.g., one month to a year). Interviews with informants.	Multiple methods are used (e.g., interviews, observations, documents).	Interviews with 20–30 people. Observations are also frequently used.
Data analysis approach	List significant statements, determine meaning of statements, and identify the essence of the phenomenon.	Holistic description and search for cultural themes in data.	Holistic description and search for themes shedding light on the case. May also include cross-case analysis.	Begin with open coding, then axial coding, and end with selective coding.

Table 4.1: Characteristic of four qualitative research approaches
(Source: Patton 2002, p 40)

4.3.1.1 Case study

The case study research approach within qualitative method is considered for this study. Although Travis (1999) suggests case study as a method under a positivist paradigm (see figure 4.2), case studies may be conducted within both the positivist and interpretivist paradigms (Walsham 2002; Orlikowski & Baroudi 1991; Jarvinen 2004). Qualitative case study approach has been accepted and employed within the information systems field and there are scholarly publications which focus on this approach (Benbasat et al 1987). Case study would be an appropriate approach since it is well suited to capturing the knowledge of practitioners and developing theories (Benbasat et al 1987). Besides, Eisenhardt (1989) notes that the output from case study research may be concepts or conceptual framework. Yin (1989) explains that case study is a research strategy to be likened to an experiment, a history, or a simulation and not linked to any particular type of evidence or method of data collection. Moreover, case studies can provide powerful stories to illustrate particular social contexts (Grbich 2001).

Walsham (1995) states that although Yin adopts a positivist stance in describing case study and suggests this approach as an appropriate approach to answer the ‘how’ and ‘why’ questions, his view would be also accepted by the interpretive school. Case study approach attempts to understand social phenomenon within a single or small number of naturally occurring settings (Bloor & Wood 2006).

Bloor and Wood (2006) state that case studies often use multiple methods of data collection such as interviews, observations, documentary methods and audio and video recording. The purpose of such methods is to gain a detailed understanding of the processes involved within a setting.

By adopting a case study approach, the researcher would be able to acquire an in-depth understanding of the context of a phenomenon (Cavaye 1996). Moreover, Benbasat et al (1987) suggest case study as an effective approach in unexplored or relatively new areas of research. Interpretive case studies are ‘less rigorous and more proactive in providing histories or examples of new ideas or approaches. They are like testimonies of the success of certain individuals or companies’ (Jarvinen 2004). Furthermore; reviewing information systems literature reveals significant use of interpretive case studies in a range of topics and contexts (Boland & Day 1989; Orlikowski 1991; Walsham 1993).

Bloor and Wood (2006) state that case studies often use multiple methods of data collection such as interviews, observations, documentary methods and audio and video recording. The purpose of such methods is to gain a detailed understanding of the processes involved within a setting.

Qualitative research approach has been used in the health area to examine intention, social construction and meaning in cultures, phenomena, structural processes and historical changes by using interviewing, observation and document analysis techniques (Grbich 2001). Consequently, qualitative case study approach is conducted in this study to gain a detailed understanding (cited in Yin 1994) of digital stethoscope usage within various groups of clinicians and involves multiple case explorations which will be discussed in chapter 6 of this dissertation.

The following section briefly reviews various data collection methods within the case study qualitative approach employed in this study.

4.4 Data collection method

A number of data collection methods have been introduced and explained in literature such as observation, focus groups, in-depth interview and documentation review (Silverman 2006; Jarvinen 2001; Oliver-Hoyo & Allen 2006; Marshall & Rossman 2006; Maxwell 2005; Denzin 1989). The strengths and weaknesses of each data collection technique have been extensively reviewed. The key conceptual issue that influenced the researcher in selection use of specific data collection methods was the relationship between the research question and data collection methods. Qualitative data sources include observation and participant observation, interviews and questionnaires, documents and texts, and the researcher's impressions and reactions Jarvinen (2001).

Silverman (2006) mentions four major methods used by qualitative researchers: 1) observation, 2) analysing text and documents, 3) interviews and focus groups, and 4) audio and video recording. Jarvinen (2001) suggests the most typical data gathering techniques are interview, observation, questionnaire and examination of written material. Additionally, primary data collection methods of qualitative research commonly include field notes, journals or documents review, surveys, direct observation and in-depth interview (Marshall & Rossman 2006; Oliver-Hoyo & Allen 2006). Secondary methods consist of: focus group sessions, life histories and narrative inquiry, historical analysis, films, videos and photography, interaction analysis, unobtrusive measures, questionnaire and surveys, projective techniques and psychological testing and dilemma analysis (Marshall & Rossman 2006).

Qualitative data are not restricted to the results of a specific method. Maxwell (2005) indicates that the decision about research methods depends on the specific context and issues that will be studied, as well as on other components of the researcher's design. In planning the research methods, a researcher should always include whatever informal data gathering strategies are feasible, including socialising, casual conversation and incidental observations (Maxwell 2005). Moreover, pre-structuring the methods reduces the amount of data that the researcher has to deal with, simplifying the analytic work required (Miles & Huberman 1994).

Yin (1994) states that data collection for case studies relies on various sources of evidence. He introduces six important sources of evidence: documentation, archival records, interviews, direct observations, participant observation and physical artifacts. It is common in qualitative research to combine several data collection methods over the course of the study. The researcher can assess the strengths and limitations of each method and then decide if the method will work with the questions in the setting for a given study (Marshall & Rossman 2006).

Based on reviewing the literature, a decision was made with regard to the qualitative method of data collection. This research will be conducted through the following stages:

1. Small pilot study: discussed in section 4.5.1 of this chapter
2. Documentation review: discussed in section 4.5.2 of this chapter
3. Focus group: discussed and reviewed in chapter 5
4. Observation: discussed in section 4.5.3 of this chapter

4.5 Achieving triangulation

Oliver-Hoyo and Allen (2006) indicate that triangulation is about careful review of data collected through different methods in order to gain more accurate qualitative results for a particular construct. Triangulation involves the use of multiple methods and measures of an empirical phenomenon in order to overcome problems of bias and validity (Denzin 1978). There is a distinction between: (a) data triangulation, where data are collected from different sources or at different times; (b) methodological triangulation, where several methods of data collection are used; (c) investigator triangulation, where different researchers or evaluators independently collect data on the same phenomenon and compare results; and (d) theory triangulation, where different theories are used to interpret set of data (Cox & Hassard 2005).

Additionally, Maxwell (2005) addresses two key issues in selecting and using different data collection methods: a) the relationship between the research questions and the data collection methods; and b) the triangulation of different methods. Jick (1983) explains ‘between method’ and ‘within method’ triangulation and states that 'the effectiveness of triangulation rests on the premise that the weaknesses in each single method will be compensated by the counter-balancing strength of another'. Within method means that attempts will be made within the main study to triangulate the sources of data and not rely on one method of data collection. The purpose is to strengthen the study in terms of providing opportunities to identify anomalies, etc.

This study will achieve within method triangulation to strengthen the study in terms of providing opportunities to identify anomalies, etc. Triangulation will be employed for this study as it is an effective method for capturing and fixing of social phenomena which can help to realise a more accurate analysis and explanation (Cox & Hassard 2005). For this study, triangulation of the qualitative data collection methods is achieved within the case study and through documentation review, focus groups and observations. Data are confirmed through several sources in order to ensure that observed phenomena are not unique to the social structure of a single environment.

Triangulation will be used for this study as it is an effective method for capturing and fixing of social phenomena which can help to realise a more accurate analysis and explanation (Cox & Hassard 2005). The observation methods have confirmed what was stated in focus group interviews.

4.5.1 Pilot study

A pilot study attempts to test the research protocol to prepare the researcher for conducting the focus groups. Since this research takes an exploratory approach, a pilot study has helped the researcher to determine the appropriate unit of analysis, to refine the data collection instruments and to familiarise the researcher with the phenomenon itself as suggested by Yin (1989).

After developing the research topic and reviewing the literature, conducting a pilot study has been an effective means of initiating a wider study. The processes used in conducting the pilot study were:

- Designing and reviewing focus group protocol.
- Testing the protocol with two supervisors, and a staff member from Queensland Health.

- Testing the protocol with two members of the researcher's family in order to assess if the questions are clear and easy to understand.
- Revision of the focus group protocol, based on the pilot study (protocol can be found in section 5.2).

One purpose of conducting the pilot study was to confirm the appropriateness of the selected digital stethoscopes within the Queensland telehealth platform. Digital stethoscopes have been previously tested with Queensland telehealth, especially with their video conferencing equipment. A report was provided by a Queensland telehealth technician. Another purpose was to be able to design questions for the focus group sessions. The conceptual model introduced in Chapter 4 of this dissertation was slightly modified during the conduct of the pilot study process. Both the conceptual framework and the focus group instrument were changed slightly in terms of using meaningful terms and correct English.

4.5.2 Documentation review

Documentation provides valuable sources of data for researchers. Personal documentation can include diaries, autobiographies, photographs, paintings, and other artefacts that represent the lives of the individuals or groups under study (Grbich 2001), whereas impersonal documentation comprises the public records by which cultural patterns can be examined. In the health area the impersonal documentation can include: rates of disease, hospital records, case notes and case histories, compensation outcomes and rehabilitation (Grbich 2001). Silverman (2006) states that in qualitative research, texts and documents are sometimes as important as background material for the real analysis. The advantage with this technique is that texts are usually readily accessible and not always dependent on access or ethical constraints. Documents may be quickly gathered and encourage the researcher to start early data analysis.

Documentation review is suggested as one of the data collection methods for this study prior to conducting the focus group sessions. Related documents about digital stethoscope, Queensland telehealth business strategy and model and telehealth training manual were reviewed to support the data collection.

The following documents were reviewed from the Queensland Health Government website, prior to conducting the focus group sessions:

- Queensland Telehealth Factsheet 2010
- State-wide Telehealth articles, media releases and related documentation
- Recent Queensland Telehealth achievements
- Approach to achieve state-wide coverage
- Frequently Asked Questions

Additionally, the researcher requested the Department of State-Wide Telehealth in Queensland about their current telehealth equipment and telecommunication network. The feedback received from two specialist Telehealth staff helped the researcher to understand the context thoroughly prior to conducting the focus groups in Queensland. The researcher gained an in-depth understanding of the Queensland Telehealth network from a data communication perspective, as well as being provided with relevant information regarding Telehealth's videoconference infrastructure.

Moreover, the researcher was keen to understand the applicability of three digital stethoscopes within the Queensland telehealth system and requested from the department any available information regarding applicability of those DS. Immediately prior to conducting the focus group sessions, the researcher received a short summary from one Queensland telehealth technology officer about findings for each of the digital stethoscopes that were tested with their videoconferencing equipment. The report clarified that they were able to connect two of the digital stethoscopes to Queensland video conference equipment and hear the audio. There was connection problem with the third one via its infrared option.

4.5.3 Observation

Observation is suggested by Marshall and Rossman (2006) as a highly important method in all qualitative inquiry, whereas Silverman (2006) states that observation is an unsuitable and ineffective method of data collection in quantitative research. Observation is used to realise complex interactions in natural social settings. Observation in research is more than simply seeing. It may involve hearing and touching the environment in which the researchers have an active role during the observation process (Silverman 2006). By using the observation method the researcher can look at the behaviour of others. It means that the observer can understand what participants mean when they say something. Jarvinen (2001) states that direct observation may be more reliable than what people say in many instances. Conducting observations can help the researcher discover whether people do what they say they do, or behave in the way they claim to behave.

Direct observation, which is distinct from participant observation, appears to be an appropriate qualitative method used in this study. According to the literature, 'observation' as a qualitative tool has been extensively used in order to assess and evaluate the usage of a product/technology (Marshall & Rossman 2006; Silverman 2006; Jarvinen 2001). Recommendations from the literature regarding the observation technique have been taken into account and guided the researcher in choosing and using this research approach.

In conducting the observations, the users were observed and investigation focused on answering the research questions. An objective of conducting observations was to understand the users' perceptions of using a digital stethoscope in telehealth. The aim was to observe certain groups of people rather than trying to become immersed in the entire context (Trochim 2006). Three different types of stethoscopes were given to the users for a duration of 10 minutes, in a telehealth platform. They used the digital stethoscopes to identify whether the device was properly working within the telehealth framework. The usage of digital stethoscopes in telehealth was observed to understand the behaviour and reaction of clinicians toward using a digital stethoscope in a telehealth setting.

4.5.4 Focus group interviews

Interview is one of the most common data collection methods in qualitative research. Research interviews are a popular form of qualitative research in social science, including information and library studies (Stuart 1996). One purpose for interviewing is to find out what is on a person's mind (Patton 1990). Moreover, researchers interview people to understand more about the things which cannot be observed directly. Stuart (1996) suggests that interview can help researchers to access a respondent's own perspective of a situation, explore the ways in which people work together and share common understandings with them and allow respondents time to provide their answers. Patton (1990) identified the risk of putting ideas into the heads of respondents while conducting formal or informal interviewing. ‘The purpose of open ended interviewing is not to put things in someone’s mind, but to access the perspective of the person being interviewed’ (Patton 1990, 278).

Although Byrne (2001) explains that the process of interviewing is time consuming and the quality of data often is dependent on the interviewer’s skills, the collected data can help the researcher gain an in-depth understanding of the situation and can also be a rewarding experience for the researcher. The literature reveals that interview may bring benefits for the research study, but it has some limitations identified by Griffee (2005). A problem identified with interviewing is that people may not be able to say what they think, or may not be able to state their opinion in a clear way or basically may be unwilling or uncomfortable sharing all that the interviewer hopes to explore (Marshall & Rossman 2006). It needs to be considered that the interview should take place in a quiet environment with no distractions. The interview can be structured where the researcher asks explicit questions consistently of all participants, or either unstructured in which the researcher asks open-ended questions.

Interviews can be conducted individually or within groups of participants. Focus group interviews or ‘focus groups’ are a form of qualitative research that has been used effectively in market research and in academic social research. Focus groups have been employed in this exploratory study and justified in detail in chapter 5 of this dissertation. Since focus groups are quick, time saving, allow participants’ interactions, produce rich data, low cost, have high face validity and produce user-friendly results, this research will benefit from choosing this method as the main method of data collection.

Chapter 5 has been assigned to this approach and extensively discusses and reviews the focus group method.

4.6 Conclusion

This chapter reviewed and explained the research paradigms interpretivist and positivist, and three philosophical assumptions, namely, epistemology and methodology. Qualitative and quantitative research methods were broadly reviewed and various qualitative data collection methods were addressed. The qualitative case study approach used for this study was identified as a suitable pathway to help the researcher find answers to this study’s research questions. Documentation review, observations and focus group interviews were adopted as the main qualitative data collection methods within this exploratory study.

The next chapter (chapter 5) will provide an extensive review of focus groups which is the main data collection method employed for this study; and the reasons for using such method will be justified.

CHAPTER 5: FOCUS GROUP

5.1 Definition and different aspects of a focus group

The focus group is one of the most used research tools in the social sciences and has become popular since the Second World War (Stewart, Shamdasani & Rook, 2007). To enable a better understating of focus group elements, types and uses, a number of concepts by various authors are explained below.

A review of the literature revealed various definitions for focus groups. For example, Edmunds (2001) defines focus groups as a form of qualitative research in which participants' ideas will be captured while they are focusing on a specific topic. Morgan (1997) gives a broad definition for a specific form of group interview called the focus group which is a research technique that collects data through group interaction on a specific topic established by a researcher.

The focus group sessions could be arranged to consist of 8-10 people whose qualifications have been pre-specified. Edmunds (2001) addresses options to conduct focus groups as: first, in person focus groups which could occur at a research site; and second, tele focus groups that could be conducted via telephone conferencing or Internet access. Litoselliti (2003) suggests that 'non in person' focus groups may be less appropriate for social science research. Moreover, online focus groups are not appropriate for exploring complex concepts or for projects that need a high degree of confidentiality (Litoselliti 2003, p 7). To be able to make comparisons between groups, Edmunds (2001) suggests conducting two or more focus groups.

Similarly, Bader and Rossi (1999) state that 'Focus group is the label given to a special type of group interview that is structured to gather detailed opinions and knowledge about a particular topic from selected participants'. History shows that focus groups were mainly used in social sciences, for instance, assessing the impact of the Second World War propaganda efforts; but, recently, focus groups have become a popular marketing research tool that may improve client services and evaluate changes (Bader & Rossi 1999). Focus groups as a qualitative tool have been extensively used for almost 50 years in marketing research and more recently in academic social research (Morgan 1997; Bloor et al 2001; Bloor & Wood 2006; Krueger 1994, Stewart, Shamdasani & Rook 2007; Greenbaum 2000). Despite its original use in marketing and commercial research, this method could be effective for exploratory study particularly, and in areas such as health and among clinicians.

There are other aspects of focus groups to be considered other than the above definitions. Business Dictionary (2010) defines 'focus groups' from two aspects: market research and problem solving. In order to conduct market research, a small number of participants (between 4 and 15) and a moderator could get together and concentrate their discussion on a specific product. The outcome of a market research focus group which is a type of qualitative data may or may not be representative of the general population. During problem solving sessions, a group of experts will discuss and share their ideas on a particular problem. This is also called a forecasting technique (Business Dictionary 2010).

Although group interviews can often be used as a synonym for focus group, it is essential to differentiate between focus groups and group interviewing (Morgan 1997). Group interview is a question and answer session between the participants and the facilitator. Instead of proceeding only by question and answer, the facilitator can generate a general discussion within the group on a particular topic and act as a facilitator of a group discussion rather than a questioner (Bloor & Wood 2006). Bryman (2001) (cited in Bloor & Wood 2006) states that focus groups and group interviews are different in three ways:

1. Group interviews may discuss a number of different topics, while focus groups will focus and discuss a particular topic in depth.
2. The main reason for conducting a focus group is identified as saving time and money by collecting data from a number of people at the same time.
3. Focus groups are concerned with how participants interact with each other as members of a group to discover a common language to describe similar experiences regarding the topic, whereas group interviews are only interested in participants' opinions as individuals.

Similarly, this research focuses on the perceptions of usage of digital stethoscopes in a telehealth setting. Clinicians compare three different types of DS during focus group sessions and describe their experiences and opinions toward the tested DS. ‘The groups are generally composed of 7 to 10 people who are unfamiliar with one another and share certain characteristics relevant to the study questions’ (Marshall & Rossman 2006, p 114). Krueger (1994, p 6) defines a focus group as a well-planned discussion that will gain perceptions on a specific topic in a broadminded environment. Likewise, a part of this research will explore clinicians’ perceptions of using digital stethoscopes in a telehealth platform. Therefore, the definition by Krueger (1994, p 6) has been followed for this particular research.

Groups can be organised between 4 to 10 people and each group shares certain characteristic relevant to the topic. Also, there is a need for a moderator to organise a well-planned discussion to allow the participants to interact in a group setting. Focus group sessions are aimed at gaining perceptions on a specific topic during the discussions.

Based on Krueger’s definition, the focus group seems to be an appropriate procedure to use in this research to explain people’s views regarding their experiences in using the digital stethoscopes in a telehealth context.

5.2 Why the focus group is used in different studies

Morgan (1997) describes three different uses of focus groups as follows:

- Focus groups can be used as a self-contained method. In this case, focus groups serve as the primary means of collecting data.
- They are used as a supplementary source of data in studies. For example, in primarily quantitative studies, focus groups could be used to produce survey questionnaires.
- Focus groups are used in multi method studies. The focus group method could add data that are gathered by any qualitative methods such as interview or observation (Morgan 1997, p 2).

Focus group could be a feasible method to approach and reflect participants’ feelings, attitude, beliefs and reactions toward a specific topic in comparison with other qualitative methods such as observation or one-on-one interviewing (Bloor & Wood 2006). Moreover, these feelings, attitude, beliefs and experiences are more likely to be exposed by interaction with other participants through social gathering that may occur in focus group sessions. Additionally, Morgan and Kreuger (1993) distinguish between individual interviews and focus groups. They explain that focus groups aim to obtain a variety of views, perceptions and emotions within a group context, whereas the individual interview is a technique that focuses on individual perceptions and may not be interested in participants' interactions with each other. Focus groups are more difficult to control by a researcher compared to individual interviews; moreover, focus groups can generate a large amount of data in a shorter period of time (Morgan & Kreuger 1993).

The literature shows that focus groups are recognised as an important tool in introducing new products, so using focus groups may be an option to introduce digital stethoscopes as a new product to users (Bloor et al 2001). However, the use of focus groups is not limited to the marketing and advertising industry. Some of the other areas of usage of focus groups are in media and communications research (Lunt & Livingstone 1996). Focus groups have also been used in feminist research (Madriz 2003); in a library's strategic planning process (Higa-Moore et al 2002); in health research (Kitzinger 1995); and in research on social movements such as racism (Litoselliti 2003).

Qualitative interviewing, particularly focus groups, has been found to be a useful research method in this study in order to understand individuals' opinion and values. However, one of the main reasons for conducting focus groups rather than an individual setting is to allow observations of how and why clinicians accept or reject their colleagues' ideas. Moreover, the researcher is conducting triangulation to validate findings gathered during observation for comparison with clinicians' opinions raised during focus group sessions.

The emphasis of focus group sessions is placed on the interaction among clinicians, rather than on the interaction between the moderator and group members, which will entail the researcher's understanding of the participants' perspective on the topic (Merton, Fiske & Kendall 1956).

Participants who discuss debate or clarify one another's view may give reasons about the issues that could influence their usage of digital stethoscopes in a telehealth setting. They may also discuss and assess the quality of DS and the whole system with each other. One of the underlying objectives of this research is to validate the appropriateness of the conceptual framework with practising health professionals in the telehealth context where the digital stethoscope is deployed. Therefore, in order to achieve the main goal of this study, the use of focus groups aimed to find answers to the sub-questions identified earlier in chapter 1 of this dissertation.

5.3 Reasons why focus groups have been chosen for this study

Reviewing the literature helped the researcher recognize a variety of research approaches and common data collection methods for a specific context. Recommendations from other studies (Gagnon 2004; Croteau & Vieru 2002; Hu et al. 1999; Oliver-Hoyo & Allen 2006) regarding research approach and methodology were taken into account and guided the researcher in adopting a particular research approach and method for this study. The relevant recommendations from the literature are as follows:

- The study conducted by Croteau and Vieru (2002) identified some limitations in their data collection such as voluntary responses and limited results of only two different groups of physicians at a time. Based on the above limitations, the authors have made some recommendations for future research. They recommended that more research should be done for validation of their suggested conceptual model based on TAM with more groups of participants; and longitudinal studies are needed to explore the situation over time.

- A study by Hu et al. (1999) identified some research limitations regarding sampling theory which was 'Theory of Planned Behavior' and research method which was survey. Therefore, the authors made recommendations for future research as follows:

    - A series of studies should be conducted in the future based on a variety of contexts with different user groups over a period of time.
    - Responses to their study were voluntary and therefore inevitably subject to self-selection bias.
    - Extended or integrated research approaches apart from survey may provide additional insights to the understanding of IT acceptance decisions by professionals.

- Gagnon et al. (2004) combined qualitative and quantitative approaches in their study and the data collection was based on two sources: a questionnaire and semi-directed interviews. These authors highlighted the need for conducting more in-depth qualitative studies in a telehealth context.
- Oliver-Hoyo and Allen (2006) recommend using multiple methods of data collection in order to develop a full picture of the researched situation.

Recommendations from the above studies have been considered and taken into account in this study. A qualitative case study is the principal approach used in this study and this study employs focus group as a qualitative data collection method.

5.4 Strengths of focus group

The researcher reviewed the literature and identified the key advantages in conducting focus groups. As it was explained earlier in this chapter, the most common uses of focus groups include: inspiring new ideas and creative concepts, generating impressions of products, programs and services, acquiring feedback regarding new products, investigating the opinions of the group members, and accomplishing results that are extremely user-friendly and easy to understand (Stewart, Shamdasani & Rook 2007; Kreuger, 1988). Moreover, the literature revealed that by using focus groups, the interaction between participants could highlight their view of the world, and the gap between what people say and what they do can be better understood (Gibbs 1997). Using techniques such as one-on-one interviews could take extensive time to conduct and accomplish, but focus groups would be a data collection option to gather opinions quickly and cost effectively. Non-verbal responses such as frowns, smiles and gestures can be also observed and captured by the researcher during the focus group (Stewart, Shamdasani & Rook 2007). If researchers require an insight into complex behaviour, focus group sessions could be an option to observe participants' discussion and interaction (Morgan 1997).

Focus group is a socially oriented research procedure and its format allows the moderator to explore the research topic. Since focus groups have relative efficiency in comparison to individual interviews, they have reliance on interaction in the group in order to produce rich data (Krueger 1994).

As explained earlier, the focus group interviews offer several advantages over other qualitative techniques. The following table (table 5.1) provides a summary of the advantages of conducting focus group sessions and their relevance to this study.

Strength	Relevancy
Interaction between participants during focus groups highlights their view of the world and allows the researcher to interact directly with respondents. Focus group allows respondents to react to and build on the responses of other group members. The format allows the facilitator the flexibility to explore unanticipated issues as they arise in the discussion (Gibbs 1997; Stewart, Shamdasani and Rook 2007; Marshall and Rossman 2006; Morgan 1997)	***Relevant:*** During one hour focus group sessions a number of clinicians can share their ideas, whereas in a one-to one interview each clinician requires an hour to discuss the topic. Clinicians could be influenced by the comments of their colleagues during a focus group. So participants may be encouraged to discuss matters they wouldn't do in a one-to one interview (Axin & Pearce 2006). Any unanticipated issues arising from the discussion would be interesting for this research and could lead to revision of the conceptual framework. Moreover, conducting focus groups may revise new factors related to the research topic. Mazza (2006) suggests that focus groups helped to uncover some potential problems in his research. Also, clinicians could be influenced by the comments of their colleagues during a focus group
The gap between what people say and what they do can be better understood (Gibbs 1997).	***Relevant:*** Participants, by sharing their ideas and interaction with each other, may minimise the gap.
Clients, users, participants or consumers can become a forum for change (Gibbs 1997).	***Relevant:*** This is a relatively new domain of research and focus group participants can provide valuable insight into the topic.
Focus groups provide quick results and the cost is relatively low compared with one-to one interview (Stewart, Shamdasani and Rook 2007; Marshall and Rossman 2006; Morgan 1997)	***Relevant:*** The researcher can finalise data collection and analyse it in less time and within budget. This method will allow the moderator to conduct several sessions, analyse the results and prepare a report in a shorter time in comparison with other data collection methods.
Researcher can observe nonverbal responses such as gestures and smiles (Stewart, Shamdasani and Rook 2007)	***Relevant:*** It is very important for this research to observe the body language of respondents while discussing the topic which will help data analysis.
Open response format provides large and rich amounts of data and will increase sample size of qualitative studies by permitting more people to be involved at the same time (Stewart, Shamdasani and Rook 2007; Marshall and Rossman 2006; Krueger 1994)	***Relevant:*** For this research, a large amount of data will lead to better data analysis to find the answers to the research questions. This is the best method among other qualitative methods that makes it possible to have a number of clinicians participating in this research at the same time. Since this research needs to be done within a limited time, focus group enables the researcher to increase the sample size without the considerable increase in cost and time required for the individual interview method.
Focus groups are very flexible to be used including variety of individuals and within variety of settings (Stewart, Shamdasani and Rook 2007)	***Relevant:*** The user group for this research are clinicians. Clinicians are very busy people and arranging individual interviews is not as easy as using focus group.
The result has high "face validity". (Marshall and Rossman 2006; Krueger 1994)	***Relevant:*** The findings of this research need to appear believable to those using the information.

Strength	Relevancy
It is a socially oriented research procedure (Krueger 1994)	***Relevant:*** Doctors are likely to follow their colleagues in using new medical devises. Clinicians could be influenced by the comments of their colleagues during focus group.
Focus groups place people in natural, real life situations as opposed to the controlled experimental situations typical of quantitative studies (Krueger 1994)	***Relevant:*** This research is following the interpretevist philosophy and will not direct or force respondents to limit their responses
The format allows the moderator to probe (Krueger 1994)	***Relevant:*** This will allow the moderator to check any unanticipated issues. This is not possible within the structured questionnaire approach.
Focus groups have relative efficiency in comparison to individual interviews (Morgan 1997)	***Relevant:*** For this research saving time and money is very important. So using focus group method for this research makes it superior to individual interviews
The strength of relying on the researcher's focus is the ability to produce concentrated amounts of data on precisely the topic of interest (Morgan 1997)	***Irrelevant:*** This is an exploratory study so the participants will feel free to address any related issues that the moderate may not have predicted. The protocol would consist of open-ended questions
The results are extremely user friendly and easy to understand (Stewart, Shamdasani and Rook 2007)	***Irrelevant:*** The transcripts will produce huge volume and there is an issue of coping with the volume of data and identifying themes from it.

Table 5.1: Focus group advantages

The main strengths of focus groups identified through the literature and their applicability to this research study reveal that they are: quick, time saving, allow participant interactions, produce rich data, are low cost, have high face validity and produce user-friendly results.

5.5 Weaknesses of focus group

Almost all of the data collection techniques have some weaknesses and the focus group as a qualitative data collection method is no exception (Krueger 1994). A review of the literature revealed that the researcher should be aware of the methodological limitations before the conduct of focus groups. Litoselliti (2003) suggests that focus group should be avoided if the participants do not share some common characteristics and be able to interact with each other regarding the researcher's topic of interest. The researcher has less control over the focus group data produced in comparison with other methods such as one-on-one interviewing.

Therefore, careful planning will be required to reduce the risk of bias during focus group data collection. It may be difficult for the researcher to clearly identify an individual message through the focus group discussion; and open-ended responses from the participants could make the interpretation of results a difficult task for the researcher (Gibbs 1997).

Another disadvantage of using focus groups is possible risk of residual uncertainly about the accuracy of what the participants say while the interviewer has less control over a group discussion (Krueger 1994). Moreover, time can be lost while dead-end or irrelevant issues are discussed (Marshall & Rossman 2006). The weaknesses of focus group may affect the quality of results, so increasing the knowledge about the usage of focus group and its imitations may help the researcher in making the right choice of research method.

Specific weaknesses associated with the focus group technique and its relevance to this study are grouped together in the table 5.2 with strategies adopted in this research study to minimize their effect.

Weaknesses/Disadvantages	Relevancy
The researcher has less control over the data produced (Morgan 1988) than in one-to-one interviewing (Gibbs 1997)	***Irrelevant:*** The moderator will only control the time and remind about the topic if the respondents discuss irrelevant issues
Focus group research is open ended and cannot be entirely predetermined (Gibbs 1997)	***Irrelevant:*** This study will conduct focus group in order to become familiar with the area of research and confirm the protocol. Researcher does not tend to predetermine the sessions at this stage
It may be difficult for the researcher to clearly identify an individual message. The researcher has less control over a group interview than an individual one (Gibbs 1997; Marshall and Rossman 2006; Krueger 1994)	***Relevant:*** The research will observe the interaction among clinicians and if any more clarification is needed the researcher may ask the individuals for clarifications and explanations. The researcher tends to let the respondent to talk freely about topic which may raise new issues about the topic that the researcher did not think about it an advance.
Focus groups can be difficult to assemble and the groups can vary a great deal and can be hard to assemble (Gibbs 1997; Marshall and Rossman 2006; Krueger 1994)	***Relevant:*** Clinicians are very busy people and arranging focus group sessions for this research through Queensland health was difficult. So external supervisor of the researcher helped to assemble the sessions to help against the recruitment problem (Bloor & wood 2006).
Focus groups are not fully confidential or anonymous, because the material is shared with the others in the group (Gibbs 1997)	***Irrelevant:*** This study will look at clinicians' perception of technology and doctors are likely to follow their colleagues in using new medical devises. So sharing material and interacting with each other will help this study.

Weaknesses/Disadvantages	Relevancy
The responses from members of the group are not independent of one another, which restricts the generalisation of result. (Stewart, Shamdasani and Rook 2007)	***Relevant:*** The researcher may ask for clarification from individuals during the focus groups if required.
The result may be biased by a very dominant member or the moderator may bias results by providing cues about the type of responses desired on particular topic. There is an issue of power dynamics in the focus group setting. There is very real concern that the moderator, in the name of maintain the interview's focus, will influence the group's interactions (Stewart, Shamdasani and Rook 2007; Marshall and Rossman 2006; Morgan 1997)	***Relevant:*** Bias could happen to any research despite using different research method. Using other methods of data collection along with focus group may minimise the bias. Also, moderator will try to listen and observe rather than direct the respondents to proper response. So the researcher will use this power only for controlling the time and remind about the topic to stop discussion of irrelevant issues. Bloor & Wood (2006) confirm that "it is usual for the moderator to specify at the outset time limit contributions, in order to encourage contributors by deadline setting" (Bloor & Wood 2006 p90).
The "live" and immediate nature of the interaction may lead a researcher or decision maker to place greater faith in the findings than is actually warranted (Stewart, Shamdasani and Rook 2007)	***Irrelevant:*** For this research data will go to further analysis by conducting observation. So the researcher will not place great faith in the focus group findings
Open-ended responses make interpretation of results difficult. So focus group data appeared to be difficult to analyse (Stewart, Shamdasani and Rook 2007; Krueger 1994)	***Relevant:*** The transcripts will produce huge volume and there is an issue of coping with the volume of data and identifying themes out of it. Although open ended responses may make the interpretations of result difficult, it will encourage participants to interact with each other to identify important relevant issues to the topic that will produce rich qualitative data.
Time can be lost while dead-end or irrelevant issues are discussed (Marshall and Rossman 2006)	***Relevant:*** The moderator should control the time and remind about the topic if the respondents discuss irrelevant issues
The method requires the use of special room arrangements and highly trained observer moderators. The discussion must be conducted in an environment conducive of conversation (Marshall and Rossman 2006; Krueger 1994)	***Irrelevant:*** The external supervisor for this research will arrange suitable place to conduct focus group. The moderator will be trained by her supervisors in advance.
Group members are able to influence the course of the discussion. For some types of topics, the presence of a group will affect what they say and how they say it (Krueger 1994; Morgan 1997)	***Relevant:*** Doctors are likely to follow their colleagues in using new medical devises. So it is inevitable that clinicians may be influenced by the comments of their colleagues during focus group which may encourage them to finalise their responses. But the moderator will control the session in order to keep the main topic as priority of discussion.
There is some residual uncertainly about the accuracy of what the participants say (Morgan 1997)	***Relevant:*** Observation conducted along with focus group to strength the data analysis.

Table 5.2: Focus group limitations

5.6 Selection of participants

Since the purpose and plan of the focus group have been developed, the next step is 'selecting focus group participants'. People normally tend to share their beliefs, thoughts and views with those who are similar to them in certain ways (Litoselliti 2003).

Krueger (1994) suggests that purpose drives each study and before deciding about participants and inviting them to the group interview, it is better to focus on the purpose of the research so this provides a guide for invitation. Prior to inviting participants, it is advised to review the research budget because if there is a limited budget only a small number of sessions could be conducted—which may influence the participants' selection (Krueger 1994).

The common characteristics among participants of focus groups normally consist of both 'knowledge and familiarity', and 'demographic characteristics', that is, gender, educational level, age and race (Litoselliti 2003, p 32). For this research, the clinicians appear to have similar knowledge and educational level. 'The more homogeneous the groups in terms of background and perspectives, the fewer groups will be needed' (The Pennsylvania State University 2007). While the research topic is defined as 'An exploratory investigation of usage of digital stethoscope by clinicians in a telehealth setting', clinicians were invited to participate in the focus groups for this study irrespective of their race and gender. However, their age group was limited to a minimum of 20 years of age to ensure that nursing and medical students would have enough clinical knowledge to participate in the focus groups for this study. Participants' culture, race, nationality and gender were not an important issue and not the concern of this study.

Simon (1999) suggests five specific steps to be followed in order to identify and invite participants:

1. The number of required participants needs to be decided. The researcher will invite as many potential participants as possible because clinicians, especially doctors, are extremely busy and it can be very hard to get them together for a focus group session.

2. The focus group purpose statement needs to be reviewed and key attributes of participants need to be listed.

3. Based on the list of desirable attributes, possible participants can be brainstormed and categorised.

4. Refine the list based on common characteristics and homo/heterogeneity.

The last step is to store the participants' names and contact details safely, finalise the list and send the invitations. In this study, the researcher will save the focus group details and results in a safe place at USQ. Data will be stored in a cabinet in the supervisor's USQ office. Any computer transcription is stored on USQ computer in an authenticated format. Access is password protected. There are different ways to recruit participants for focus groups: database, telephone screening, advertising, face-to-face contact and social networks (Litoselliti 2003).

Kruegerger (1994) mentions several specific strategies that could be used for identifying participants for focus groups. One of these strategies is known as 'Nomination'. Krueger (1994) suggests asking names of potential participants from the parties that are not taking sides. These kinds of parties are those who are likely to know a number of people such as clergy or local business owners. For this particular study, the external supervisor, who is a facilitator for Telehealth Services, advised the researcher of suitable clinicians to participate in the focus groups. The potential participants were contacted via emails and phone calls to ask about their availability to take part in focus group sessions. Later, they were formally invited to attend the focus group sessions.

The role of the focus group moderator will be defined in the next section and the specific functions and responsibilities of the moderator in guiding the discussions will be identified.

5.7 Moderator (Facilitator)

Immediately after selecting the participants and inviting them to a focus group session, there is a need for a moderator/facilitator who can guide the discussion and maintain the group's focus. Greenbaum (2000, p. 23) describes a facilitator as a responsible person who will manage the total research process to deliver groups that are successful. A successful moderator will ensure that the participants discuss key questions; moreover, she/he will not allow the participants to shift away from the topic under discussion or force their ideas onto others (Litoselliti 2003).

Qualities that could make participants comfortable or uncomfortable need to be considered by the moderator. An experienced moderator could have better control over the research process. Moderators are viewed as the persons responsible to complete the research plan successfully (Simon 1999; Greenbaum 2000).

The degree of the moderator's involvement and control over the focus group could depend on the level of structure with regard to asking questions and managing group dynamics (Morgan 1997). These aspects of moderator involvement are identified by Morgan (1997) as elements of research design. Social science researchers prefer a low level of moderator involvement that forces a less structured approach to asking questions and managing group dynamics. In contrast, marketing researchers tend to design their research with regard to high levels of moderator involvement (Morgan 1997). A good and successful moderation may be associated with the personal and professional characteristics of the moderator. Greenbaum (2000) suggests the personal characteristics of a successful moderator as self-motivating, hard-working, a quick learner, self-confident, friendly, a good listener, having strong powers of concentration and capable of handling a difficult work schedule. The author found several professional characteristics required for a successful moderator, including ability to work effectively with a group process; ability to change course quickly and effectively; remaining objective at all costs; understanding what to do with the information generated from a focus group; and understanding how to read nonverbal reactions of participants and use them to facilitate the group discussion. There are also specific skills required for an effective moderator. Litoselliti (2003) suggests 'the moderator should have some familiarity with moderating focus groups, particularly with probing, open ended questioning, focused discussion and group dynamics'. Some essential skills for the effective moderator highlighted by Litoselliti (2003) include being confident and in control, as well as flexible and adaptable to the way the discussion develops. A good moderator should be opinion free and non-judgmental so she/he can support positive and negative comments about the topic and avoid showing any personal opinions. Finally, superior personal and interpersonal, communication and managing skills are required for a good moderator.

The literature discussed the characteristics and skills necessary for effective moderators to facilitate group discussions. The researcher was not able to travel to the research sites in India due to financial constraints and educational commitments, so her principal supervisor moderated the focus group sessions conducted in India. Although the researcher for this study was not exposed to moderating focus groups, attention had been paid to guidelines and recommendations from pioneering authors and researchers in qualitative research, especially in conducting focus groups, and endeavoured to put these suggestions into practical use.

As this study comes under social science research, the researcher applied a low level of moderator involvement that aimed to bring about a less structured approach to asking questions and managing group dynamics.

5.8 Preparation activities and physical characteristics of focus group

Fundamentally, a researcher should aim for a well-planned focus group prior to each session. Although planning may seem a simple and straight-forward phase, it can be the most complicated part of the focus group process because it involves consideration of purpose, users and target audience, and matching all of these to the available resources in a written plan (Krueger 1994, p 42). Planning will be discussed in detail later in section 5.10 of this chapter.

Before conducting the focus groups it is important to think about choosing the location. Site selection may be an essential requirement for the success of the focus groups. The quality of the environment and level of comfort may influence the level of participation (Stewart, Shamdasani & Rook, 2007). The important point in selecting the setting, whether it is going to be in the researcher's office or any other location, is to make participants comfortable (Simon 1999). The site should please both participants and the researcher. A site that makes participants uncomfortable and interrupts the researcher recording the session will be ineffective. Morgan (1997) suggests likely alternatives for site selection as conference rooms in a public facility such as a community centre, university or library. Focus groups may be conducted at a participant's home or the researcher's office.

The physical shape of the table used for the focus group could be an important element of the session site. The shape could be a circular or rectangle conference table. U-shaped arrangement of seat will be suitable for videotaping. To be able to generate a friendly, informal atmosphere, name tags could be used by the participants. This can ensure that everyone is able to address other participants by name. An effective procedure is to ask participants to seat around an oval table so there is eye contact among participants and the moderator. While the location of the session may influence the type of responses provided by participants, the environment for the focus group should be neutral and visual distractions to the participants should be eliminated (Litoselliti 2003; Morgan 1997; Krueger 1994). In this study, the researcher conducted the focus groups before morning tea in each of the hospitals. Morning tea was offered to participants in appreciation of their help and participation.

An audio recorder was a vital tool for each focus group session. The session was recorded either via an audio or an audio-video recorder. Recording the focus group session is a primary action prior to the transcribing phase. The use of high quality equipment is recommended (Litoselliti 2003). Audio recording equipment that is normally used for one-on-one interviews may not be suitable for recording group interactions. Microphone, extra batteries and tapes/DVD should be supplied and conducting a live test before the session is vital (Morgan 1997; Bloor et al 2001). Other arrangements recommended in planning the focus group are spatial arrangements such as seating arrangements. These may influence the degree of participation and leadership behaviour (Stewart, Shamdasani & Rook, 2007). Comfortable distance for participants should be considered because those who sit very close to each other may feel uncomfortable.

Perhaps, prior and during focus group sessions, unexpected problems may arise and it would be impossible to predict the troubles that the research team may face during the session. However, the moderator should expect unpredictable problems and be prepared to direct the group back to the topic discussion (Stewart, Shamdasani & Rook, 2007).

Both an audio and video recorder was used for this particular study as this project seeks to capture group interactions.

5.9 Bias

Bias refers to any kind of effect that could misrepresent the data of a study; and is considered as a negative part of research and should be avoided. Bias arises in both quantitative and qualitative studies at any stage of research and from a number of sources (Bloor & Wood 2006). Developing biases may affect the validity of the results of focus groups (Stewart, Shamdasani & Rook 2007). These authors suggest three different forms of bias as: 1) the need for consistency; 2) personal bias; and 3) unconscious need to please the client. Litoselliti (2003) suggests using neutral questions in order to minimise bias resulting from leading participants.

The following practical advice by Stewart, Shamdasani and Rook (2007, p. 86) is considered as a guide to avoid bias:

- Avoid ‘turning on the charm’. This may mistakenly cause participants to believe that the researcher supports their ideas and is keen to hear about it.
- Do not ignore respondents who have unfavourable point of views about the topic.
- Reduce frequency of directing questions to those respondents who hold favourable views.

The researcher for this study was aware of potential biases and attempted to avoid them as much as possible. By receiving adequate training in conducting focus groups, avoiding interruption in group discussions and avoiding too much body language when asking questions, the researcher endeavoured to minimise the level of bias for this study.

5.10 Conducting the focus groups

Krueger (1994) suggests a plan for conducting focus group includes three stages: planning the study, conducting the interviews, and analysing and reporting.

Planning the study

Planning is an important stage in conducting successful focus groups (Krueger 1994). For this research, the researcher focused on the topic and purpose of the research. The researcher designed a plan to help organise the rest of the research process. Planning the focus group was one of the most complex stages of this study.

The planning stage for this research entailed consideration of purpose, users and target audience, followed by writing a plan. The following planning steps suggested by Krueger (1994) are employed in this study:

- Determining the purpose
- Determining the research procedure
- Conversations with the decision makers
- Determining who to study
- Listening to the target audience
- Selection of the focus group location
- Developing a plan and estimating resources needed.

Morgan (1997) reveals three factors that may affect the capability to plan for focus groups as ethical concerns, budget issues, and time constraints. These factors have affected this research in the following ways:

1. Ethical concerns: USQ, like many other universities, required the researcher to obtain ethic approval for the research project. This was followed by a similar request from Queensland Health where the focus group sessions were held at one of the Queensland Health centres. The ethic clearance process took about 10 months, which delayed the conduct of the focus groups in Queensland.

2. Budget issues: The researcher had access to a limited budget for her research provided by USQ. The researcher could not afford the travel costs for some of her first focus group sessions, therefore, the researcher's supervisor took the responsibility of being the focus group moderator and travelled to the focus group location to conduct the focus groups. The researcher was briefed about the sessions and was provided with access to audio/visual records of the sessions. The data collection issues have been detailed in chapter 6 of this dissertation.

3. Time constraints: As the participants of focus groups are clinicians, they have limited time to participate in meetings for research purposes. Arranging focus group sessions that could take place at a suitable time/date for clinicians was a challenging task.

Despite the abovementioned factors, the researcher designed a well-constructed plan and followed the practical steps advised by Stewart, Shamdasani and Rook (2007) and Litoselliti (2003). The researcher recruited the participants beforehand and a reminder was sent to them about the sessions two days prior the meeting. The researcher double checked arrangements regarding the booking venue and equipment beforehand and carried extra batteries and other research tools. The researcher arrived early on the day of the focus group session and checked the room ventilation, name tags, food for morning tea and materials required for the focus group.

Immediately after the session the researcher checked the audio recorder and made sure that the whole session conversations were captured and recorded. The researcher went through notes made during the focus group and made sure all comments were clear and readable. The researcher reviewed the session immediately after each focus group session and tried to link body language and non-verbal behaviour to the respondents' comments.

Steps in the design and use of focus groups explained by Stewart, Shamdasani and Rook (2007, p 48) include:

- Problem definition: a clear understanding of the problem and research question is required.

- Identification of sampling frame: A sampling frame is a list of people that the researcher believes would be representative of the larger population for that research. An excellent approximation of the population of interest is required.

- Identification of moderator and generating interview guide: The moderator, and the form and type of questions, need to be compatible with the group to be interviewed.

- Recruiting the sample: The recruitment process requires identification of a place and time so participants will be contacted and asked to participate in a group at a particular time and place. Recruitment of a few more participants than the desired numbers is advised.

- Conducting the group: The moderator leads the group during the discussion of the topic and will facilitate discussion among all the group members.

- Analysis and interpretation of data, writing the report, decision making and action: This phase of focus group would be similar to other types of qualitative research.

Overall, this study employed the suggested plan introduced by studies such as Stewart, Shamdasani and Rook (2007) and Krueger (1994).

5.11 Organising and conducting focus groups for this study

As mentioned previously, stage two of this research was held through focus group sessions as a form of qualitative data collection method in order to explore clinicians' perception of using DS in a telehealth setting. Moreover, it was aimed to validate the relevance of the conceptual model developed for this study. Generally during a focus group, participants can be asked their opinions about a concept, product, service, advertisement, idea, or packaging. Based on consultation with healthcare professionals, a number of focus group sessions were planned for this research with 5-10 participants in each and the researcher planned to facilitate the sessions as moderator. An external supervisor from Queensland Health advised the researcher that he would manage the participant recruitment. The participants were chosen from clinical staff, doctors, nurses and practitioners from the healthcare setting. The user group was defined as clinicians for this study. In order to scope this research project to a PhD program, a choice was made to restrict the study of the clinicians as the user group, and exclude patients from this research.

It is considered that members of groups should have similar characteristics to perform their tasks more effectively (Stewart, Shamdasani & Rook 2007), so there was no need for homogenous users because clinicians have been asked to look at functional aspects. All medical professionals use stethoscopes in the same way because of the uniform condition, so there was no moderation dimension.

Invitations were sent to all potential participants inviting them to participate in the focus group sessions for this study. Once the participants were selected, they were informed briefly about the research project and its objectives and aims.

The focus group sessions have been conducted in the form of brainstorming. Therefore, during focus group discussions the awareness of usage of telehealth, digital stethoscopes and associated issues were discussed and then examined within the scope of this study. The expected time for the focus group was 45-60 minutes, although it actually took more than an hour, and the discussions have been fully recorded. The recorded data was reviewed and several back-ups were generated in order to compile the transcripts from the recorded data.

5.12 Focus group protocol

Topics put to the focus group were:

System quality aspects

- How easy is it working with a digital stethoscope?
- Can you please describe how the telehealth system reacts when using the DS in conjunction?

  Probe for: *ease of use, ease of learning, response time, reliability, completeness, and system flexibility.*

Information quality aspects

- How would you describe the quality of the information that you receive when using the DS and telehealth system in unison?

  Probe for*: sound quality issues, security of information transmitted, usefulness in making a diagnosis.*

User satisfaction aspects

- Please describe any advantages you feel are associated with using a DS in the telehealth environment.
- Please describe any disadvantages you feel are associated with using a DS in the telehealth.

  Probe for: *possibility of referrals to other colleagues to use the system?*

Intention of use aspects

- Under what circumstances/conditions are you willing to use the DS integrated with the telehealth platform?

  Probe for: *expectations of the system, any potential barriers in using the DS and telehealth system together, and motivations in using the DS in telehealth.*

- What training and support aspects should be taken into consideration if using a DS and the telehealth network together?

- What physical environmental conditions should be considered while using a DS in the telehealth environment?

The following chapter (chapter 6) describes in detail the data collection method adopted for this study.

CHAPTER 6: DATA COLLECTION

Chapter 5 described focus groups as one of the qualitative data collection methods applied for this study in order to investigate the research question and sub-questions introduced in chapter 1 of this dissertation. Chapter 4 reviewed positivist versus interpretive research paradigms and suggested a philosophy for this study. Qualitative and quantitative research methods have also been discussed in chapter 4 and qualitative case study considered as an appropriate approach. Through case study approach, documentation review, observation and focus groups was suggested as the relevant data collection method for this research topic. A small pilot test was conducted prior the conduct of observation and focus group session. The pilot test resulted in revision of protocol for the focus group session.

The objective of this chapter is to discuss the implementation of data collection methods. The chapter will firstly discuss the investigated research sites for this study. Then an overview of the process of participants' recruitment will be provided. This chapter will specify the research method techniques adopted for this study to collect data, the process for recruiting participants, choice of research site and the constraints the researcher encountered during data collection.

6.1 Introduction

Previous chapters discussed strategies and procedures involved in selection of the research question, research approach and data collection method. An overview of previous chapters is summarised in figure 6.1.

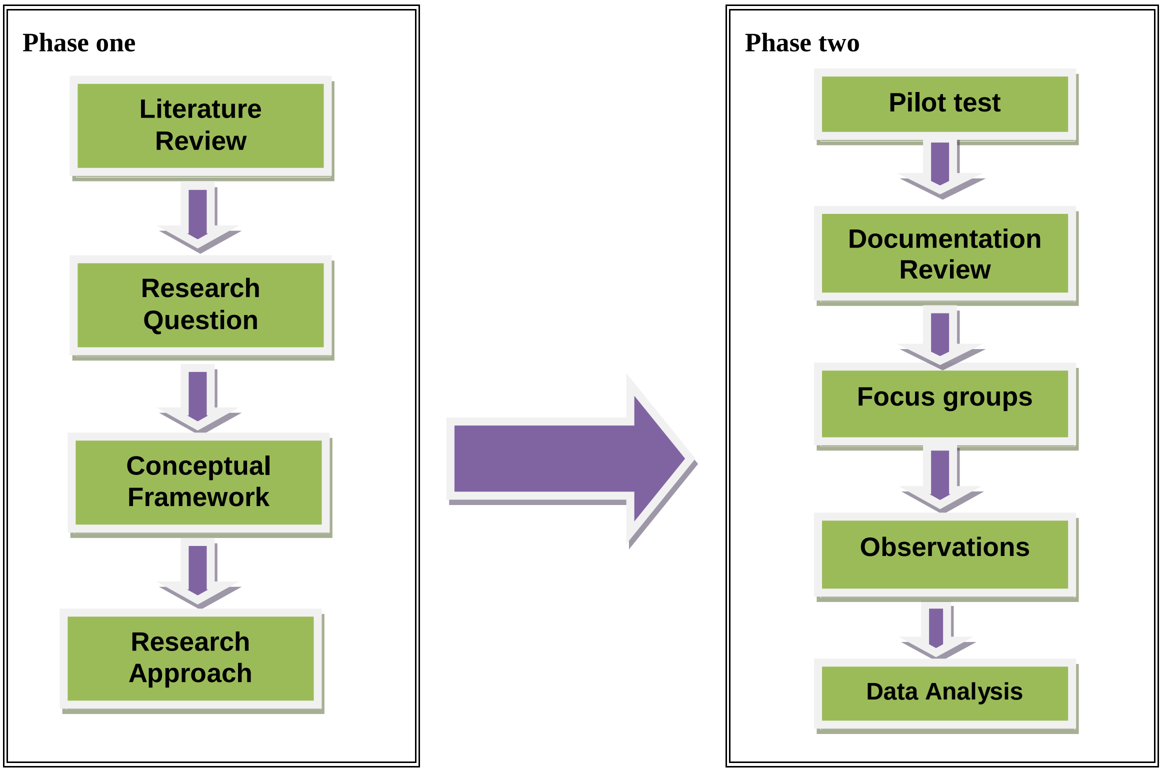

Figure 6.1: Research framework for data collection

The model shown in figure 6.1 has adopted a two-phase model that explains the process of investigating the research question for this study. According to figure 6.1, the literature review was conducted thoroughly to develop the research question. Moreover, the literature review helped the researcher to build a preliminary version of a conceptual framework that was discussed in chapter 3 of this dissertation. The figure shows that phase one is successfully linked to phase two of this research.

Phase one has been discussed comprehensively in previous chapters. Phase two of this research commenced with data collection and, in accordance with figure 6.1, a pilot study was conducted as the early stage of phase two in order to test the research protocol for accuracy and significance. The pilot study was only a small test which was conducted in researcher's office at USQ. In total, 5 people participated in the pilot test including the supervisory team members and two family members of the researcher. The pilot test helped the researcher to refine the data collection instruments and to familiarise the researcher with the phenomenon, which is discussed in section 4.5.1 of chapter 4 of this dissertation. Following the pilot test, a review of documents in telehealth system was conducted. Focus groups and observation were accordingly conducted once the protocol was tested and ready. The last part of phase two, data analysis, will be discussed further in the next chapter.

As discussed in chapter 4, observations and focus group interviews have been chosen to help the researcher explore the research questions of this study. Focus groups have been selected as a useful method for exploratory research used for this study. Observation in research is more than simply seeing; it may involve hearing and touching the environment (Silverman 2006). As discussed comprehensively in the previous chapter, researchers have an active role in the observation process. Recommendations from the literature regarding the observation technique were taken into account and guided the researcher in choosing and using the data collection method within case study approach for this study. In conducting an observation, the users were observed and investigation was conducted regarding the research questions. During this stage, users were given stethoscopes to work with in the telehealth context. One of the objectives of conducting observations was to understand the clinicians' perceptions of using a digital stethoscope in a telehealth setting.

6.2 Research site background

The research sites for this study included Australian and Indian healthcare institutes. The specific research situation in Australia and India and the number of similarities between the two environments may result in transferability of one case to other case study between these two contexts. Similarities between the two situations include:

- In India, the majority of the population (72.2%) live in rural areas, which could benefit telehealth services extensively (Government of India 2001). In Australia, 'More than two-thirds of people lived in Major Cities (68%) and the remainder (32%) is in Regional and Remote areas' (Australian Bureau of Statistics 2009). Moreover, Queensland has a relatively high proportion of its population in the Inner and Outer Regional areas (37%) compared with the other large states (Australian Bureau of Statistics 2009). Therefore, telehealth services maybe a solution to enhance the quality of healthcare for Australian who resides in rural and remote areas.

- In both contexts, telehealth is mainly used to save travel time and costs (Yellowlees 2000; Queensland Government 2006; Gurney, Hafeez-Baig, & Gururajan 2009; Merrell 2009)
- Similarity in language. English is a commonly spoken language in both countries. Although national culture might have some implications for a research study, this would not be within scope of this thesis. Within both contexts there are still clinicians perception investigated, same telehealth technology deployed and the same conceptual framework developed and used despite the cultural differences within two contexts.

Once the research problem is defined, a plan to conduct the study is established and potential participants are identified, an efficient way of contact is required to gain access to the research site and institution. Gaining access to the field under study is a crucial issue in qualitative research in comparison with quantitative studies (Flick 2002). The following problems regarding entering institutions as a research field are mentioned by Wolff (2002) as potential issues for the researcher to be aware of.

- Institutions may react defensively towards the researcher because of the belief that the research can disturb the system to be studied.
- Research is always an intervention into a social system.
- Although data protection is very important, this may interrupt the process of agreement.

The researcher for this study also encountered some issues and tried to minimise them prior entering the research sites. As discussed in chapter 5 of this dissertation, after selecting the participants, they were informed by the researcher about the research project and its objectives, aims and benefits for society—especially the health industry. The researcher assured the health organisations and the participants that the collected data and the results would be stored in a safe place at USQ.

The following section outlines the research sites for this study, including Australia and India; moreover it discusses the process of accessing those sites.

6.2.1 Indian healthcare institutes

The researcher experienced a long and unforseen delay in receiving ethical clearance from one Australian health sector. Therefore, an alternative research site (apart from Australia) was considered necessary for data collection. The researcher’s supervisor had contacts within some health research centres in India, so some healthcare institutes in India were chosen for this study. As discussed earlier in chapter 4 of this dissertation, due to financial constraints and educational commitments, the researcher was unable to travel to India, but developed the research protocol carefully for data collection purposes. Therefore, her principal supervisor conducted the focus groups as the moderator.

During data collection in India extensive data was collected for this study. The selection of Indian health institutes as the main site for focus group data collection entailed other considerations, as outlined below.

As well as the large population in India being capable of providing a suitable platform to test new technologies, India has one of the world's most diverse and modern healthcare systems. India has its own satellite communication system and devotes a remarkable amount of bandwidth to medicine, health and education (Merrell 2009).

A team of researchers in India agreed to be involved with the focus group sessions to be conducted in India because this group of researchers is already collaborating with the researcher’s supervisor. An investigation of health centres in India showed that there are a number of appropriate centres in metropolitan and regional areas. In total, 19 focus groups have been conducted in India, as detailed in section 6.4.1 of this chapter.

The speciality services available at hospitals/medical centres that were visited for this study in India include diabetic, heart, and ophthalmology and multi speciality. Table 6.1 summarises services available at each hospital in India visited for data collection.

Name	Specialist services
Hospital 1	Ophthalmology
Medical centre 1	Cardiology
Medical centre 2	Cardiology
Diabetic foundation	Diabetology
University	None
Hospital 2	Multi speciality hospitals
Hospital3	Multi speciality hospitals
Medical college	Multi speciality

Table 6.1: Indian Hospitals' summary of services

Table 6.1 summarises services available at each hospital in India where the focus group sessions were conducted. Some of the hospitals have multi speciality services, whereas others perform ophthalmology, cardiology or diabetology as their speciality services. The following section provides information about the method of contacting hospitals in Australia.

6.2.2 Australian healthcare institutes

Once the data collection in Indian healthcare institutes was conducted and Queensland Health ethical clearance was obtained, the researcher conducted her study in some of the Australian healthcare institutes. The Australian data collection included focus groups at three hospitals, plus an expert interview.

Table 6.2 summarises the hospitals' background and facility services. All three hospitals are located in Queensland. One is located in a metropolitan area; one is a regional hospital and the one is located in a remote area.

Name	Specialist services
Hospital 1	Multi speciality hospitals
Hospital 2	Visiting specialist services
Hospital 3	None

Table 6.2: Australian data collection site

(Source: http://www.health.qld.gov.au/)

Hospital 1 was located in a large city and offers numerous speciality services such as mental health, emergency medicine, endocrinology; gastroenterology; obstetrics and gynaecology; oncology, paediatrics and many more. It also offers other medical services including radiology, pathology and pharmacy. Hospital 2 was located in regional Queensland and only offered visiting specialist services for patients such as radiology and physiotherapy. Hospital 3 does not offer any speciality services as it is located in a remote area of Queensland. Apart from general medicine, it offers rural mental and oral health services.

The next section describes the method used to recruit participants for this study.

6.3 Recruitment of participants

Recruitment is defined as the process of attracting, screening and selecting qualified people for a job at an organization or firm (Oppapers 2011). A similar process may be used to gain access to potential participants for a research study. Recruitment of participants is one of the most challenging aspects of research in the health context and it involves providing information to the potential participants and generating their interest in the proposed study (Patel et al 2003).

Techniques were introduced by Patel, Doku and Tennakoon (2003, p 234) to enhance recruitment and these were taken into account for this study, and include:

- ‘Consider the participant’s perspective (costs and benefits)
- Stress the relevance of the research
- Establish adequate training and supervision, targets and investigator incentives
- Implement assertive tracking procedures using various modes of communication’.

Using a recruitment technique that would be appropriate to the location, culture and study population was a challenging issue for this research. Since the ethics clearance provided by Queensland Health took considerable time, the researcher was unable to complete her recruitment plan in a timely fashion. The following sections explain the process of recruiting participants within India and Australia.

6.3.1 Indian healthcare institutes

Recruiting participants was carried out without the presence of the main researcher and the researcher’s principal supervisor moderated all the focus groups in India. An Indian external researcher, hired by the researcher’s supervisor, was also involved with recruiting participants and conducting focus groups. In order to reduce the implications, the researcher was in touch with the research team in India frequently and reviewed the recorded sessions on a regular basis to ensure the protocol was used properly.

To organise the sessions, the research team[3] had to contact almost 32 web sites and gather close to 50 addresses. Potential telehealth participants were contacted over the phone. The results of the preliminary stage of acquiring contacts showed that 18 telephone numbers were not in use anymore, 12 hospitals said that they had closed their operations, and clinicians from only 6 health institutes attended the focus group sessions. The contacts have been carried out with the use of different communication tools such as emails, telephone, mail, face-to-face contact and indirect contact through a third party.

After conducting six focus groups and reviewing the outcomes of the sessions, the research team felt that with the amount of collected data, which was from only 6

[3] Research team included the PhD student, supervisory team and a team of researchers in India that agreed to be involved with focus group sessions conducted in India.

institutes, it may not be sufficient for this research so a decision was made to conduct more focus groups with some local hospitals. Finally, the research team was able to conduct 19 focus groups within Indian healthcare institutes.

Appendix B shows the focus group sessions conducted in India. The table provides date, hospital name, location, number of participants and participants' occupations for all 19 sessions. Participants' occupations included nurse, physician, technician, cardiologist, general physician, neurosurgeon, telemedicine staff, pulmonologist, anaesthetist, attendant doctor, theatre staff, auxiliary midwife and nursing assistant. Out of the 19 interviews conducted, 5 of the hospitals are located in metropolitan areas, 14 hospitals fall into a regional network, and none of the sites/hospitals/clinics that have been visited for conducting the focus group were located in remote access areas.

Distribution of contributed health centres in India		
Venue	**Number**	**Percentage (%)**
Hospital	12	63
Medical centre	6	32
Health foundation	1	5
Total	19	100

Table 6.3: Summary of Indian health care organisations that participated in this research

The above table shows the distribution of hospitals and medical centres in India that have participated in focus groups for this study. According to table 6.3, majority of responses came from public hospitals with the wider implications to the community, whereas only one private health sector (which was a health foundation) agreed to participate in this study. Therefore, above mentioned population is well represented for the healthcare professionals.

Selected sample regarding participants in India		
Participants	**Number**	**Percentage (%)**
Nurses and midwives	22	27.5
Physicians and other doctors	36	45
Specialists	10	12.5
Technicians (including Telemedicine technicians)	8	10
Hospital staffs	4	5
Total	80	100

Table 6.4: Selected sample regarding participants in India

Selected sample of participants in India is shown in table 6.4. The participants included nurses and midwives, physicians, specialists, technicians, and other hospital staff. The majority of participants for focus groups in India were general doctors and physicians.

6.3.2 Australian healthcare institutes

The researcher's external supervisor from Queensland Health agreed to recommend suitable participants for participation in the focus group sessions and observations, and assisted in the recruitment of the participants with initial contacts being made through telephone or email.

The researcher contacted Queensland Health via email prior to conducting the focus groups which explained the research aims and the researcher's activities, and seeking their help and participation. Three positive responses were received from hospitals in Queensland and confirmation emails were obtained. The researcher organised the data collection stage at those hospitals.

The user group is defined as clinicians for this study. The participants have been chosen from clinical staff, that is, doctors, nurses and practitioners within the healthcare setting. As discussed in chapter one of this dissertation, the scope of this project does not include patients as part of the user groups to be studied.

Selected sample regarding participants in Australia		
Participants	Number	Percentage (%)
Doctors	8	38
Nurses	11	52
Medical student	1	5
Specialist	1	5
Total	21	100

Table 6.5: Selected sample regarding participants in Australia

Table 6.5 shows the sample of participants for focus groups in Australia. Twenty-one clinicians including doctors, nurses, medical students and specialists took part in the focus groups and observations. In Australia the majority of participants were nurses.

6.4 Constraints encountered in data collection

Conducting the focus groups was not an easy and straightforward task. The researcher faced some unforeseen problems prior and during the sessions. In the next section the constraints regarding collecting data in India and Australia is discussed in detail.

6.4.1 Indian healthcare institutes

The focus group protocol was developed in advance for the research team to be used in Indian data collection. All of the focus groups were conducted based on the prepared protocol.

In some places, due to the hierarchy levels in the healthcare institutes and power dynamics among the clinicians, the subordinate staff were unable to equally participate in discussions as they had their head of department and senior doctors with them. Marshall and Rossman (2006, p 115) encountered similar issues and state that researchers choosing to use focus group method 'should be exquisitely aware of power dynamics and be able to facilitate well—these are crucial skills'.

Although the reception, level of participation and overall interaction was generally acceptable, the research team in India faced the following problems in some of the institutes during the time of collecting the data through focus groups. The majority of these issues were addressed in chapter five of this dissertation:

- Bias in terms of 'power dynamics' (cited in Marshall and Rossman 2006, p 115) from senior doctors was experienced during some of the focus groups. The chief doctor decided to represent his opinions as that of everyone else. Although there was a team of clinicians present at the focus group session, the chief doctors did not give their team a chance to talk.
- Some video recorded conversations of the focus groups were not very clear, so it was suggested to provide a 'collar microphone' in the future so that the voice could be captured in full.
- The majority of the interviewees were unfamiliar with digital stethoscopes or the telehealth/telemedicine set up. The reason may be that there is a doctor every 50 metres in urban areas of India, even in rural areas, and the presence of doctors is available most of the time. Therefore, these people had to come to cities only for critical care treatment. Moreover, the transportation facilities are reasonable, so an emergent need for a telemedicine set up was not properly felt by the doctors. Also, almost all the hospitals have many devices and tricks for attracting these rural patients to travel and present at one of those hospitals.

Problems specifically identified by the focus groups' moderator are summarised as follows:

- Required software did not work in the first health setting in India.
- India had a different power connection and this caused some unexpected delays.
- Due to unpredictable circumstances, on two occasions, participants did not turn up for the focus group discussion.
- Limited control on the agenda, either due to lack of time or dominance by senior doctors.

- In a few discussions, participants experienced the digital stethoscope for the first time and were unable to give meaningful comments, especially in a telehealth context.
- In a few focus groups, participants were not exposed to telehealth.
- In some sessions, senior physicians dominated the discussions.
- Due to varying specialist areas, physicians' opinion was not comparable.

There were other technical and non-technical problems identified by the research team in conducting the focus groups in India as follows:

1. Voltage converter – from 110 to 220
2. Distance from one place to another
3. Not honouring the appointments at some places
4. Lack of awareness about the need for the research
5. One of the tested stethoscopes was not picking up the signals properly
6. Comparing the telemedicine/telehealth to video conferencing by the participants.

6.4.2 Australian healthcare institutes

Three different types of stethoscopes which were introduced in chapter two of this dissertation were given to the users. Three digital stethoscopes were given to them for duration of 10 minutes on a telehealth platform. It was planned to have one entity in a remote area and the other in the main centre. Therefore, two separate rooms were organised for the research team at each hospital to be able to set up the telehealth platform. The research set-up consisted of two laptops, an external modem, two webcams, two sound recorders, a video recorder and special software for point-to-point connections. Participants' observation was fully documented by the main researcher. Also, a video camera recorded all the sessions and participants' behaviour regarding the use of the three digital stethoscopes being tested.

Hospital 1 is located in a city with a large number of patients seeking health services daily. Doctors are extremely busy professionals, so arranging focus groups was totally based on clinicians' convenience. Since the research team was unable to access all the doctors at the same time for the study, doctors' participation was at their own convenience. The total number of participants included nine doctors and three nurses for hospital 1.

The first participant from hospital 1, a doctor, provided some feedback about the usefulness of telehealth system for clinicians, especially within the pre-admission sector of anaesthetics. The rest of the doctors and nurses attended later in the morning and were observed regarding use of DS, and their comments about digital stethoscopes' usage were documented.

The participants from hospital 2 tested the stethoscopes for about half an hour in separate rooms and provided their feedback individually and later during a group interaction. The participants were three medical doctors and one medical student from Queensland Health. A group of five nurses and one doctor from hospital 3 participated in this project. Each participant tested three different digital stethoscopes on a patient (a member of the research team) and then moved to the next room to assess the sound received from the same digital stethoscopes through the computer-to-computer network. As participants of this study are clinicians, mainly doctors, it was very difficult to have the doctors at the same time in the same room to test the digital stethoscopes. Doctors were regularly called out for urgent visits and had to leave the researchers for up to two hours before returning.

6.5 Documenting and recording of data

Visual data are important to the qualitative data collection beyond the traditional forms of interviews, focus groups, or participant observations. 'Using visual data raises the question of how to edit these data appropriately and whether methods originally created to analyse texts can be applied to these sorts of data' (Flick 2006, 241). As many people are familiar with video recording it has become a useful device for use in qualitative research. Audio/video recorders have positively contributed to qualitative research, replacing researchers' handwritten notes by documenting the interaction in an interview (Bloor & Wood 2006).

Acoustic and audio visual possibilities for recording sessions have had an important influence on developments in qualitative research over the last 20 years (Bloor & Wood 2006). One condition for this progress was that the use of recording devices such as tapes, MP3, mini- disc, and video recorders has become common in daily life. Recording devices have enhanced some forms of analysis such as conversation analysis and objective hermeneutics (Flick 2006). The documentation of data is not only a technical step in the research process, it also has an influence on the quality of the data to be used for interpretation (Flick 2006, p 293).

Once the data is recorded and documented it needs to be managed, organised and stored in a safe place. The next section discusses the management of the collected data in this research project.

6.6 Managing collected data

Collected data was not immediately available for analysis, but required some processing and data management. The way data are stored and retrieved is the heart of data management. Without a clear working plan, data can easily be miscoded, mislabelled, mislinked and mislaid; therefore, a good storage and retrieval system is critical for keeping track of what data are available (Denzin & Lincoln 2000). The aim in this project was to keep the collected data, either in digital format or written notes, in a safe place and to make several retrievable copies should the originals be lost or deleted.

In order to control the process of data collection and organisation of the data, a well-planned register was developed to keep track of collected data. Once each section of data had been transcribed and analysed the register was updated so the researcher was able to reduce the chance of being disorganised due to the large volume of collected data.

6.6.1 Transcribing

Transcription is widely employed in applied research within different disciplines and has been identified as a fundamental process in the qualitative analysis of data (Lapadat & Lindsay 1999). Professional transcribers can be hired by researchers to enhance the quality of transcribed data. Since external transcribers are available in many cities and provide quick transcripts with reasonable costs (Stewart, Shamdasani & Rook 2007), qualitative researchers are able to have their transcripts transcribed externally and then focus on analysing the data themselves.

Transcribing appeared to be the first step in analysing the focus group data. The focus group interviews were transcribed in order to provide a written record of group discussions and interaction in order to help the researcher in further analysis. For this particular research, an external transcriber was hired to formulate the transcripts from the data collected in India. After reviewing the transcriptions the researcher realised the transcription was incomplete and inaccurate, which required the researcher to review all the text several times and check its accuracy against the audio and video files. The researcher refined the transcripts and performed spelling and grammar checks. The aim was to fill in gaps and missing words as much as possible. The literature revealed that the transcript may not reflect the entire character of discussion (Stewart, Shamdasani & Rook 2007), therefore, behavioural responses and non-verbal communications that have been observed by the researcher were also documented and accompanied the transcripts for broad and in-depth analysis.

The following chapter discusses the available software used for data analysis. Furthermore, the next chapter will review the entire process involved with analysing the collected data. It will also provide details on the results of data analysis during observation and focus group sessions.

CHAPTER 7: DATA ANALYSIS

The previous chapter reviewed and discussed the qualitative data collection methods adopted for this study in order to investigate the research question. The process of data collection and some practical problems that the researcher faced during data collection was also explained in-depth and discussed. This chapter discusses the techniques for qualitative data analysis and provides a description of how the data was analysed. Thematic analysis is the main process employed for this study to analyse the data and develop findings in the form of themes. An overview of thematic analysis will be followed (see section 7.1.3 of this chapter) by the process adopted for coding and categorising data. Subsequently, the data collected through focus groups was imported into Nvivo 8, for further analysis. The data was examined for themes relevant to the literature (see chapter 2) and the conceptual framework (described in chapter 3).

7.1 Introduction

Reading interview transcripts, observational notes, or documents that are to be analysed was suggested by Maxwell (2005) as the initial step in qualitative analysis. Qualitative data are exceedingly complex and not readily convertible into standard measurable units of objects seen and heard; they vary in level of abstraction, in frequency of occurrence, and in relevance to the central questions in the research (Marshall & Rossman 2006, pp. 156). It is important to establish the significant classes of things, persons and events, and the properties which characterize the data (Marshall & Rossman 2006).

In this section, the qualitative data analysis method and the processes for coding and categorising the data collected from the transcripts relating to this study will be discussed.

7.1.1 Qualitative data analysis methods

'Analysis is a process of examining something in order to find out what it is and how it works' (Corbin & Strauss 2008, p. 46). Consequently, the researcher needs to decide how to divide the main component of research into different smaller components to create knowledge out of each part. Since analysis is a dynamic process, the researcher may be able to brainstorm and generate ideas prior to reaching any conclusions. Corbin and Strauss (2008) highlight that analysis involves interpretation of what the researcher understands of events, objects and phenomenon. The researcher may choose specific tool(s) and strategies to proceed with analysis and interpretation of data.

Maxwell (2005, p. 95) provides an overview of the different strategies and conceptual tools for qualitative analysis and then discusses some specific issues in making decisions about analytic methods. Maxwell (2005, p. 95) states that reading the interview transcripts, observational notes, or the documents that are to be analysed is recognised as a primary step in qualitative analysis. It is also suggested that the researcher listens to interview records prior to transcription, which creates an added opportunity for analysis. The researcher may write notes and memos in data about what she/he sees or hears while reading or listening to the records. This can be helpful in developing tentative ideas about categories and themes.

Qualitative data are exceedingly complex and not readily convertible into standard measurable units of objects seen and heard; they vary in level of abstraction, in frequency of occurrence, and in relevance to the central questions in the research (Marshall & Rossman 2006, pp. 156). The authors suggest that it is important to discover the significance of classes of things, persons and events and the properties which characterize the data. Additionally, it is recommended that researchers use preliminary research questions and the literature reviewed earlier as guidelines for data analysis. The theoretical framework described in chapter 4 was used both to guide focus group session development and the data analysis for this study.

Grbich (2001) clarified many types of analytical procedures within qualitative research. However, three main modes of analytical procedures were identified on the basis of: the researcher's position in regard to data collection; type of data collected; and the variety of interpretive approaches.

The four main modes introduced by Grbich (2001) included:

- **Investigative**: The methodologies within this mode are historical analysis, discourse analysis and semiotic analysis.

- **Enumerative**: This deals mainly with documentation. In this approach the data will be collected completely before the analysis. Content analysis is enumerative.
- **Iterative**: Methodologies within this mode include grounded theory, phenomenology, ethnography, oral histories, case studies and action and evaluative research.
- **Subjective**: The characteristic of this mode is that texts are not assessed to a great extent and the researcher's and participants' voices are usually both heard. Heuristic phenomenology and memory work are examples of methodologies within this mode (Grbich 2001).

Since a case study methodology is the employed research approach for this study, an iterative mode will be chosen for data analysis. Grbich (2001) explains: 'Iteration involves going out into the field, collecting information by observing or interviewing, transcribing this information, reflecting upon it and subjecting it to an initial analysis to determine "what is going on", then using the information gained to guide the next venture into the field'. The levels of analysis that may be undertaken are: ongoing preliminary analysis; thematic analysis and coding (Grbich 2001 pp. 231). This particular study employed thematic analysis within an iterative mode of data analysis.

7.1.2 Thematic analysis

Thematic analysis is regularly used by scholars and researchers in literature, sociology, psychology, cultural anthropology and many other fields (cited in Boyatzis 1998). Boyatzis (1998, p. 161) defines a theme as 'a pattern in the information that at minimum describes and organises the possible observations and at maximum interprets aspects of the phenomenon'. The process involves the identification of themes through 'careful reading and re-reading of the data' (Rice & Ezzy, 1999, p. 258). According to Morse and Field (1995, p. 139), thematic analysis involves the search for and identification of common threads that extend throughout a set of interviews. Themes do not easily emerge from the interview data since they are usually quite abstract and therefore difficult to identify, so it suggested that the researcher steps back and considers (Bowen 2006). The researcher should search for themes that emerge as being important to the description of the phenomenon (Daly, Kellehear & Gliksman, 1997) and will contribute to answering the research questions.

Following the suggestion by Boyatzis (1998), themes for this study emerged from the data during analysis, capturing the essence of meaning or experience drawn from the varied situations and contexts.

7.1.3 Coding and categorising

The central analytic task of thematic analysis is the understanding of the meaning of texts (Marks & Yardley 2004). Coding through thematic analysis is a difficult and time consuming process. The reason is that there are generally no standardised categories, although a series of computer packages have recently become available to aid thematic analysis. The computer is a mechanical aid in this process, but cannot analyse textual data in the way that it can numerical data. It is mainly within the researcher's mind to understand, highlight, code and interpret the material. Therefore, Computer Assisted Qualitative Data Analysis Systems (CAQDAS) allows researchers to manage a larger volume of interview data than manual analysis can and facilitate thematic coding (Marks & Yardley 2004).

The main categorising strategy in qualitative research is coding (Maxwell 2005, p. 96) which is different from coding in quantitative research. Coding in qualitative research is applying a set of categories created in advance to the data. The coding will follow explicit rules, and one of the goals is frequency counts of the items in each category. In qualitative research, 'the coding is not to count things, but to fracture the data and rearrange them into categories' (Strauss, 1987, p. 29). Categorising data have been done in order to develop theoretical concepts, which is useful to make comparisons between the concepts in the same category (Maxwell 2005, p. 96). The theoretical categories usually refer to the researcher's concepts, instead of representing participants' own concepts. The identification of connections among different categories and themes is addressed by Maxwell (2005, p. 96) and refers to a 'connecting step in analysis, but it is a broader one that works with the result of a prior categorising analysis. This connecting step is necessary in building theory, a primary goal of analysis'.

By employing a thematic analysis approach the researcher creates and applies 'codes' to data. Coding refers to 'the creation of categories in relation to data; the grouping together of different instances of datum under an umbrella term that can enable them to be regarded as 'of the same type'' (Gibson 2006). The idea of coding for this study is to develop themes and related factors under each theme to determine how they relate to each other within the data in order to refine the developed conceptual model.

The most popular data analysis programs are Leximancer and Nvivo. 'Leximancer is a content analysis emulator that replicates manual coding procedures used in content analysis through a series of algorithms and statistical processes' (Smith, Grech & Horberry 2002). This program is mainly used for a quick analysis of qualitative data which may not be suitable for in-depth analysis of large amount of data. Since this study aims to develop themes out of the large number of transcripts, a program was needed to aid the researcher to organise and arrange statements, code them and develop factors and themes. Nvivo version 8 appeared to be appropriate to analyse data for this study and produce 'nodes'. Nodes are similar to themes and factors in qualitative data analysis and Nvivo enables the researcher to read a document file and identify factors from the statements.

Transcripts and the documents were entered into the QSR NVivo data management program, and a comprehensive process of data coding and identification of themes was undertaken, which will be discussed in the next section.

7.1.4 Process of coding the transcripts

Coding for this study was performed manually and later confirmed and edited through the use of Nvivo8 to identify or confirm theoretical concepts from the literature—discussed in chapters 2 and 3 of this dissertation.

As soon as the transcripts for this study were reviewed and spell checked, printed copies of transcripts were developed for manual coding. The transcripts were scanned and the main points highlighted. Subsequently, the transcripts were read through carefully and key words relating to themes and factors from the conceptual model developed for this study were underlined. A list of factors was compiled manually and sorted by importance and frequency of use.

It was necessary for the researcher to review the transcripts more than ten times to be able to identify the factors from the transcripts that were earlier developed for the conceptual model. Once all the factors were listed, the researcher merged and categorised the factors in order to create themes. Thereafter, a set of concepts, which were identified as individual nodes by Nvivo, were grouped under high order sets as a category (Strauss & Corbin 2008). Categorising factors to develop themes was a time consuming stage of data analysis, therefore, the researcher ensured that the statements were assigned under relevant factors which were later organised into a hierarchy or tree to develop themes.

Since this study followed the recommendations of Strauss and Corbin (2008), the name of a category is logically chosen and depends on the perspective of the analyst, the focus of the research and the research context. However, there may be subjective bias in using Nvivo in terms of researcher assumptions coming from the conceptual model. In order to minimise the bias the researcher attempted to review the transcripts continuously to identify factors not previously addressed in the literature.

According to NVivo 8, the term 'node' is basically used to represent anything the researcher may refer to in a project, which includes concepts, abstract ideas, places, and people being studied. For this particular study, the term 'nodes' is similar to the term *factors* that was identified from the literature and shaped the conceptual model. Thus, these two terms will be used interchangeably in this chapter.

The QCR tutorial notes state that 'nodes are containers for ideas and concepts and hold references to the passages of document text that you code at them'. Each reference is unique at each node. Each reference indicates a particular statement from the transcript that is relevant to a specific node (factor). For example 'Volume control' indicates 15 references which means 15 separate statements are assigned under this node (factor). If only one reference is coded it signifies that particular factor was found one time in the transcripts and the relevant statement was assigned under that particular factor. Coverage shows the percentage of the document that was covered for a specific node (factor). A summary report on all coding with the number of sources and references is provided in Appendix D of this dissertation.

Several of the themes and related factors identified during the analysis were changed, deleted, merged or regrouped as the body of evidence was growing.

It is noted that the themes and factors (father and child nodes) emerged from data, guided by the conceptual model and neither the software nor the researcher coded them randomly.

The following section reviews the data analysis results from the observations and focus group sessions through two research sites in Australia and India. The following section also presents a detailed description of factors and themes identified from the transcripts.

7.2 Data analysis results (India)

The research question and relevant sub questions were investigated during focus group sessions with the use of an instrument which was developed based on the conceptual model. The investigation resulted in identifying themes and related factors under that theme, details of which are presented in the following sub-sections.

7.2.1 System quality

During the focus group sessions, the participants highlighted the quality of overall system as an important aspect. System quality is extensively mentioned in the literature and employs the definition by Delone and Mclean (2002). According to literature, system quality focuses on the desired characteristic of the information systems which produce information (Delone & Mclean 1992). Moreover, studies on system quality may be associated with system performance and user interface. In this study, system refers to the telehealth system where a digital stethoscope is deployed. Statements that addressed the characteristic of the system linked with its quality and detailed the characteristics of DS were grouped together in order to explain the overall system quality. Thus, system quality is a theme that corresponds with the definition found in the literature and includes particular factors unique to this study.

System Quality	
Factor	**Reference(s)**
DS Quality	229
Usefulness	105
Ease of Use	18
Education Friendliness	16
Response Time	14
Reliability	8
Total References for System Quality = 390	

Table 7.1: Tree factors for System Quality

Table 7.1 indicates the theme (parent node) 'System quality' and related factors (child nodes) are sorted based on the references. The factors include usefulness, ease of use, echo challenger, education friendliness, response time, reliability and DS quality. DS quality itself appeared to be explained by several factors mainly related to characteristic of DS, which will be discussed in section 7.2.1.6 of this chapter. This study is not concerned with general telehealth system quality, but focuses on the DS used in a telehealth setting and its quality.

7.2.1.1 Usefulness

Participants placed significant emphasis on the usefulness of the system while discussing the system quality aspects. Usefulness was cited frequently in the transcripts. This term proved to be the most important factor among all other factors, identified with 105 references. This factor contains all statements made by participants by either directly mentioning the word ‘usefulness’ or using the synonym for this term.

In their discussions, participants compared the digital stethoscope with similar devices such as echo and conventional stethoscopes. They identified systems where they considered the deployment of DS useful as follows:

- Digital stethoscopes appear to be a useful tool to help clinicians diagnose a heart failure, whereas echo cardiographs may not be helpful in similar cases. ‘A stethoscope will say whether a patient is in heart failure or not’. (Reference 3)
- Using the echo cardiograph may not help doctors diagnose the breathlessness of a patient, whereas digital stethoscopes will be useful: ‘Echo cardiograph or simple reports you cannot say that the patient is breathlessness. Most of the patients come up with breathlessness. It may be because blood pressure problem or cardiac problem. So we definitely we need a stethoscope’. (Reference 4)
- A number of participants found digital stethoscopes more useful in comparison with traditional ones. ‘But I think this is very good, compared to other conventional stethoscopes’. (Reference 6)
- One clinician advised that learning echo sounds would be difficult for students and digital stethoscopes will be a useful option compared with echo. ‘The DM students they would have had some echo sound will be very erratic, then it is difficult to learn, which they are supposed to learn, the sound will be very erratic, then it will be very useful’. (Reference 85)

According to focus group transcripts, participants identified the capability of a digital stethoscope as a device that can be used for different purposes as a useful characteristic. One participant expressed that ‘DS will be more useful for patients in ICU’ (Reference 7). Another participant described the use of a digital stethoscope as a useful device for rural doctors as, ‘If you have to help the rural doctor or a primary care physician such product will very definitely be useful’ (Reference 10). Many of the interviewees mentioned the usefulness of using digital stethoscopes in various telehealth settings such as telecardiology. There is evidence from the transcripts that

‘The telecardiology, definitely it will be useful, suppose you are going for a screening camp, you can just record it and suppose you have a doubt, means you can always send it across. That way it will be useful and it cannot be used for all patients, very difficult, only for specific patients that we have a doubt, we want a second opinion, then it is very useful’ (Reference 13); or, ‘For telemedicine, it is a benefit, a great gift’ (Reference 37).

Moreover, participants found digital stethoscopes a useful device for doctors with hearing problems, telemedicine setting, students’ learning, conducting medical exams, and obtaining a second opinion from another doctor.

During the focus group discussion, participants identified disadvantages of the DS. A few clinicians indicated that a digital stethoscope may not be a useful device for specific usages, namely:

- for regular use (Reference 31)
- use of stethoscope itself to make an incorrect diagnosis (Reference 69)
- a stethoscope alone may not be that useful. But if it could be stethoscope and ECG (Reference 71).

7.2.1.2 Ease of use

Clinicians found ease of use an important issue when discussing system quality. In particular, this factor evaluates the level of ease-of- use of DS and its features as a new technology. Any statements that identified confusion regarding DS functionality and its features were taken into account. The participants expressed their opinions on whether the system (DS used in telehealth) is easy to learn, or complex. Participants evaluated the ease of use of DS itself in telehealth and their responses yielded 18 references.

Some of the participants stated that they struggled to use DS. They discussed various functions and special features that would be available for each DS. The DS was not considered to be a straightforward device to be used in a telehealth setting and this was evident from the transcripts as follows:

- ‘What do these stands for? W, B and M, any idea?’ (Reference 2)
- ‘What’s this one, the readings on the top? This letter R?’ (Reference 3)

- ‘Again using the buttons of the stethoscope was also difficult’. (Reference 14)
- ‘It is cumbersome to switch it on’. (Reference 15)

Complexity of design, including too many options, was another issue that some statements addressed. For example, ‘If the person sees this much of equipments he will get scared’. (Reference 6)

7.2.1.3 Education friendliness

Statements that addressed the use of DS for education purposes were grouped under the factor ‘Education friendliness’. This particular characteristic of DS was discussed among participant and cited 16 times.

During focus group discussions, several clinicians expressed their interest towards the practice of DS for teaching purposes. They found DS to be an appropriate device to be used in education institutions, for example, one participant stated, ‘Again for teaching purposes only, I don’t think of any other need’ (Reference 6). Since learning the heart and lung sound is a difficult skill to acquire, doctors highlighted the importance of using digital stethoscopes for education purposes in order to capture body sounds and share the sound with students during a medical course. Another response from the transcript mentioned: ‘The importance of this stethoscope is for medical students especially the postgraduates’ (Reference 12). Participants placed particular emphasis on a recording facility which could make the digital stethoscopes an ideal tool to record and play selected sounds for educational purposes. Moreover, at least one participant addressed the importance of using the digital stethoscope for distance education.

7.2.1.4 Response time

Participants addressed the importance of a quick response time in hearing the captured information from the digital stethoscope through the telehealth system. Participants discussed whether a delay in receiving information from the system (specifically sound) was an issue. The majority of participants declared that ‘delay’ may not be very important in receiving the information from the digital stethoscope though a telehealth system. This was expressed as. ‘Even if there is a delay it should not matter because all the sounds should be delayed to the same length isn't it' (Reference 2). Another participant stated, 'Delay! It makes no difference' (Reference 3).

Some of the responses showed clinicians' preference towards a real time system with minimum delay. This is clearly expressed by the statement, 'See what we have done perhaps for the first time is we may be able to transmit in real time, with a video conference system, and a surgeon or a specialist on the other end can listen to the heartbeat and any other body noises' (Reference 13).

A few participants believed an acceptable delay time could be up to two seconds; another placed emphasis on universal delay time; and another mentioned that immediate response with minimum delay is the preference. Differing viewpoints regarding delay time was evident from the transcripts as follows:

- 'Two seconds may not matter'. (Reference 8)
- 'You can send data to the doctor, you can send the details immediately without any delay, immediately, you can get his opinion across the table'. (Reference 11)
- 'Universal delay for all the beat, cardiac cycle'. (Reference 5)

7.2.1.5 Reliability

This factor reviewed the statements addressing the level of trust towards the system. Only eight references relating to reliability of the system in use were identified from the focus group transcripts. While discussing characteristics of an unreliable system, the majority of participants expressed issues of trust regarding DS battery life and charging while being used in a telehealth platform. This was expressed as a situation may arise where the DS does not give an accurate picture when batteries are getting low, for example, 'So I think same thing we may get in but that we can experience only by using it for long periods' (Reference 4). Therefore, battery life and system reliability appeared to have a tense link with each other and underpin the reliability factor.

Participants made comparisons between DS and conventional stethoscopes in terms of reliability and may consider conventional stethoscopes to be more reliable as they may not share the problems common with electronic devices, such as power/battery chargers. They also expressed their concern regarding using an electronic device which has limitations. This was evident from the transcript where one participant responded: ‘Once we are used to this, and if it gets repaired then we feel totally handicapped. Whereas the conventional stethoscope we seldom come across any problem’ (Reference 5).

One participant indicated that the DS may not be reliable for use in ambulances via connection to a telehealth platform. This was expressed as, ‘You have to stop the ambulance, ensure some proof and then transmit it. I don’t think that is possible’. (Reference 1).

7.2.1.6 DS quality

When discussing quality, participants cited various characteristics of digital stethoscopes 229 times. All references to DS quality were grouped together and named as ‘DS quality’. This theme is underpinned by 16 factors that together could explain the quality issues regarding a digital stethoscope (see table 7.2).

DS Quality	
Factor	**Reference(s)**
DS design	56
Recording facility	36
Amplification	25
Ear &head piece	24
Connectivity	21
Visual display and editing software	16
Volume control	15
Battery life	14
Comfort	13
Frequency mode	9
Total References for DS Quality = 229	

Table 7.2: Tree factors for DS Quality

The factors under this theme were identified as recording facility, amplification, ear/head piece, connectivity, visual display/editing software, diaphragm design, battery life, volume control, comfort, DS weight, chest piece, frequency mode, DS shape, tube shape and length, DS size and DS base material. Participants discussed a range of quality related issues after testing the DS and during the focus group discussions. The next sections will review the most referenced DS quality issues which have been sorted based on frequency of citation of each factor.

Recording facility

Participants showed high interest toward a recording option for a digital stethoscope. This factor appeared to be the most popular topic during focus group discussions regarding DS quality and was cited 36 times. From clinicians' perspective, having a recording option would be highly desirable for a digital stethoscope and considered an advantage over a conventional one. This was evident by the statement, 'That's a fantastic (option for) usage' (Reference 3). Various benefits of a recording option for digital stethoscopes identified by participants include the ability to:

- expand medical records;
- review and confirm a diagnosis;
- be used for difficult medical cases; and
- be utilised for teaching purposes.

One of the outcomes of this option identified by clinicians was the capability to produce a consistent form of electronic data that could be stored along with other electronic medical records of each patient. This advantage was expressed as, 'Basically you have an electronic medical record, we also do have and currently we are just scanning all our records, keeping them in digital format, because it is the easiest thing to do' (Reference 8).

Moreover, recorded sound can be stored, reviewed and help the clinician to proceed with diagnosis after visiting the patient. This is supported from the transcripts with the statement, 'Yes, exactly, and for even medical record point of view you can always store the information, just in an electronic format, and then you can differentiate whether this is a murmur or not' (Reference 6). A recording option is also considered an advantage for teaching purpose as mentioned by a participant: 'So if you have recording provision, then you just put the stethoscope and the sound is transmitted and this will be useful for teaching' (Reference 30).

Participants highlighted the advantage of a recording option for a digital stethoscope to be used in a telehealth setting—expressed, for example, by one participant as, 'Maybe for telemedicine, if it is having other provisions for recording, for storing of discussions and it can be transferred to the computer then it is very useful' (Reference 22).

Amplification

Amplification is an option capable of changing and increasing the amplitude of a signal, in particular, sound. Within 25 references to this aspect, some participants expressed their feedback with positive opinions towards amplification, for example, ‘Amplification is OK’ (Reference 5); and ‘The advantages number one, definitely the amplifier part of it is very good’ (Reference 15).

The majority of those participants who discussed DS amplification expressed their dissatisfaction toward the tested DS in terms of amplification. Those clinicians found it ‘too amplified’ (Reference 7) or ‘distract the reality’ (Reference 10).

It appeared that the tested DS not only amplified the body sound, but also unwanted sounds. Therefore, participants complained about unwanted sounds being amplified along with heart and lung sounds. Unwanted sound may include any additional sound such as friction noise. One of the respondents commented that, ‘But on the other side what I found was, the amplification, and we hear the additional sounds’ (Reference 18). Another similar comment was made: ‘But here, with the amplification what happens is, even that friction noise is that comes in between your heart sound. That is the bit of a problem, that one problem I found’ (Reference 20).

Additionally, one of the participants suggested that ‘Under high frequency amplification should not happen’ (Reference 24). Another participant suggested a solution to control the amplification via a ‘Touch sensor or a distance sensor so it starts switching on the amplifier only when it touches the skin’ (Reference 13).

Ear and head piece

Participants discussed the importance of the ear piece for digital stethoscopes and expressed their views regarding the quality of ear/head pieces. Clinicians emphasised the importance of a well-fitted ear piece to obtain a good result from the system. This was expressed as ‘the ear plugs are so very important. Because if it is nice fitting into your ear’s auditory canal, then you know it filters out everything from outside’ (Reference 7). Softness and comfort of the ear piece also appeared to be an important issue for clinicians in evaluating DS quality. For example, responses to this issue include: ‘Ear piece should be little soft’ (Reference 11); and ‘I am comfortable with this ear piece’ (Reference 12). It was found that hardness of material in the ear piece, especially when fitted to the ear lobes, would impact on clinicians’ comfort and may cause pain. For example, one participant expressed the view that ‘the ear piece is also so hard. And if we keep the ear piece for a long period, then naturally a pain is produced’ (Reference 16).

Connectivity

Clinicians discussed the capability of digital stethoscopes in connecting it with other devices via cable or wireless. Participants believed there are advantages in being able to connect digital stethoscopes other devices or systems such as a computer, laptop, PDA, iPhone or a telehealth system. Participants expressed their view toward connectivity as ‘...the previous ones (DS) had only the infra-red connectivity to the laptop, and that has been changed in the current generation’ (Reference 20); or another clinician expressed that ‘(connectivity to the) telemedicine department. I think you said you have a provision you can connect it to a computer, then there is a provision to monitor, then it can be transferred to anywhere else’ (Reference 10).

Visual display and editing software

Visual display and editing software were two issues discussed during focus groups, but the researcher decided to merge these two topics into one factor. Unlike conventional stethoscopes, most of the digital ones have a digital display to help the user track the device status, and includes adjustments such as sound volume and recording. Moreover, a DS may include special software which analyses the sound and provides the clinicians with a graph for further assessment. Participants found additional software and digital display an advantage over conventional stethoscopes, a view supported by the statement of one participant that ‘there is not much of a graphical thing as compared to these stethoscopes, but patients are only thrilled in seeing the heart rate coming as display’ (Reference 15). Another participant expressed his interest toward visual display as ‘the display is one of the major advantages’ (Reference 12).

According to participants’ statements, various use of visual display includes ‘here you have a display to see the blood pressure and pulse that is not available in normal stethoscopes’ (Reference 11). One participant also raised the reliability aspect of using a visual display by stating: ‘The only thing is I have a doubt now, that suppose if the battery is low or is getting weak, whether it will give correct reading or not' (Reference 6).

During focus group discussions, participants expressed their expectation of a digital stethoscope as a device comparable with electronic devices available in the market such as smart phones. One clinician suggested that 'the commercial instruments available electronically like an iPhone, if you switch it on you can see the reading displayed you can see a digital display, this may be available in future (for digital stethoscopes). Those things are just coming new, when a patient who has a chest pain these things may be useful than the heart sound. See these are commercially available; getting the signals would be more useful rather than listening to heart sounds' (Reference 16).

Volume control

Participants stated the necessity for digital stethoscopes to be fitted with volume control. Increasing the volume would be necessary in situations where clinicians have difficulty obtaining an audible sound. Also, this option may help those doctors with hearing problems, which was evident from the statement, 'Looks like maybe yes, though somebody has impaired hearing, may be the volume would be better' (Reference 2). All other statements were positive towards a volume control option for digital stethoscopes.

Battery life

Participants expressed their concern regarding using DS as a digital device dependent on batteries. The following issues were raised during the focus groups which are grouped under the 'battery life' factor:

- **Battery dependency**: This is a problem with almost all electronic devices that use batteries. Clinicians did not like being involved with extra effort such as exchanging and checking batteries during their practice. The following comment supports this view: 'The battery, as we have to keep changing the batteries very often, it is a cumbersome process' (Reference 7).
- **Type of battery**: Participants suggested common types of batteries available in the market should be used, for example, 'If you design something for the periphery, AA or AAA which are easily available nowadays' (Reference 2).

- **Battery longevity**: The life of the battery appeared to be an important consideration for clinicians. Participants had doubts about the reliability of a digital stethoscope as a result of low battery levels. For example, one participant expressed the view, ‘Suppose if the battery is low or is getting weak, whether it will give correct reading or not!’ (Reference 3). On the other hand, another participant believe the battery longevity problem is common with any electronic medical device: ‘I think all the battery operated systems you know, to our experience in the field of medicine, it is not giving correct pictures when batteries are getting low’ (Reference 5).
- **Battery level indicator**: Clinicians believe a battery level indicator similar to the ones available for mobile phones is desirable for a digital stethoscope. This was expressed as ‘The major disadvantage in this stethoscope there is no indication for the battery level. So you do not know if there is a low battery level’ (Reference 9).
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Comfort

Comfort refers to anything that is relaxed, easy and devoid of pain. In this particular study, comfort refers to the degree to which clinicians felt relaxed while using DS. Only a few clinicians addressed this factor while discussing DS quality.

One participant expressed the opinion that ‘Comfort means it should not be painful to the ears; it has to fit correctly into the ear. You should not feel uncomfortable. Some stethoscopes the pin tension will be more; it will be uncomfortable when you wear it’ (Reference 3).

Frequency mode

Participants discussed frequency mode as an added option for digital stethoscopes to change the mode from high to low and vice versa. However, one of the participants did not find this option to be essential for DS and stated, ‘The frequency I don’t think we would be using so much to make a clinical decision’ (Reference 3).

DS overall design

While discussing DS quality, participants addressed specific features for DS that together could explain the design of a DS. This factor reviews all other factors related to the design of a digital stethoscope and include diaphragm design, DS weight, DS shape, tube length and shape, DS size and DS base material (see table 7.3).

DS Design	
Factor	**Reference(s)**
Diaphragm Design	16
DS Weight	12
Chest Piece Design	8
DS Shape	7
DS Size	5
DS Tube Length and Shape	4
DS Base Material	4
Total References for DS Design = 56	

Table 7.3: Tree factors for DS Design

- **Diaphragm design**: Participants consider that the diaphragm is the main part of the stethoscope as it absorbs the sound from the heart and lung. They expect to have both the bell and the diaphragm option for a digital stethoscope. Moreover, the participants suggested various diaphragm designs for paediatric and adults (References 6, 13 and 15).
- **DS weight**: Clinicians showed reluctance to use heavy stethoscopes. They compared DS with the conventional stethoscope and believe the digital ones were slightly heavier. They consider that the heaviness of a stethoscope could

be a problem in certain circumstances, for example, one participant said, ‘You place this on the neck continuously for some time, then you feel the heaviness on the neck’ (Reference 5). Heaviness may be relative to participants’ use of a conventional stethoscope over a period of years. This point is expressed as, ‘We are already used to lighter stethoscopes, first thing is it is too heavy for me, and you know, weep the stethoscope around the neck, all the time’ (Reference 8). During focus group discussion and testing of digital stethoscopes, participants found heaviness in their ears, neck and pocket (References 8, 9 and 11).

- **Chest piece design**: Participants tested digital stethoscopes and made comment about placement of the chest piece, its design and quality with 8 statements. According to these statements, the chest piece needs to fit properly on the patient. This not only relates to the skill of clinicians, but also the shape of the chest piece. One of the participant commented that ‘The chest piece has to fix in. Snaggy fitting into the chest wall, one thing I felt was in that, difficult fitting’ (Reference 1). Clinicians were generally happy with the chest piece design and quality of digital stethoscopes they tested, although they did indicate that a thick chest wall may prevent the chest piece from picking up the sound adequately (Reference 2).
- **DS shape**: Participants offered ideas regarding the shape of digital stethoscopes, for example, one participant commented, ‘I am not saying very crude, but sophistication’ (Reference 1). During focus group discussions the majority of participants expressed dissatisfaction with the shape of one DS being tested. Their dissatisfaction related to the inappropriate shape of the digital stethoscope which prevented it resting properly on patients. One clinician stated: ‘It was never resting on your neck. And the part of the stethoscope was actually hanging down and as a part it was away from your body’ (Reference 4). Participants did not like the shape of stethoscopes which stayed away from their body or tended to be detached from the body.
- **DS size**: Although only five statements related to the size of the digital stethoscope, the message was clear regarding appropriate size of DS. Participants did not like to use a cumbersome, bulky, huge stethoscope and preferred the size of their current conventional stethoscopes. One of them

suggested, ‘You can minimise the box and other set up. It is going to be a cumbersome product for a doctor to handle it’ (Reference 1).

- **Tube length and shape**: Only a few participants discussed tube length and shape as a factor in DS quality. Participants displayed no preference regarding the length and shape of the tube and only commented that if the DS transfers the sound properly, then tube length and shape does not matter. One clinician explained his preference in tube length as, ‘No not at all. Previously we used to say the shorter the tube the better will be the acoustics, but nowadays whatever may be the length of the tube, ultimately the comfort of the doctor, only then you can pick it up and interpret it correctly’ (Reference 1).
- **DS base material**: Clinicians preferred very soft material to be used in the design of the base of a digital stethoscope. One participant stated: ‘Aluminium will not conduct sound to the extent. Stainless steel will be good’ (Reference 1).

7.2.2 Information quality

Several factors were identified from the transcripts that could relate to the quality of information in the form of either input or output in the telehealth system where a DS is deployed.

According to the information systems success model, information quality means the measures of information system output (Delone & Mclean 2002). Information quality measures are subjective because they are derived from the user perspective. Information quality refers to the quality of the information produced by a system (Hu 2003). For this particular study, the system means the telehealth system and information refers to the received sound.

Information Quality	
Factor	**Reference(s)**
Input Quality	81
Output Quality	95
Total References for Information Quality = 176	

Table 7.4: Tree factors for Information Quality

This study is concerned with the quality of sound produced by digital stethoscope via telehealth. Since particular body sounds such as heart sound is captured by DS and transmitted through the telehealth system and received by clinicians at the other end, there would be factors that explain the quality of input to the system and factors linked with the information received from the system. Thus, input and output quality should be reviewed separately to obtain an overall assessment of quality of information produced by the system (see table 7.4).

7.2.2.1 Input quality

Input quality involves factors that may affect the quality of captured information by the system as soon as DS is used on a patient. Therefore, the amount of noise and the skill level of the user are associated with information captured and transmitted through a telehealth system.

Input Quality	
Factor	**Reference(s)**
Noise	59
Skill – level of user	22
Total References for Input Quality = 81	

Table 7.5: Tree factors for Input Quality

Table 7.5 indicates 'Input quality' as part of the hierarchy developed from the transcripts and guided by the conceptual model. According to Table 7.5, the theme *information quality* is explained by two factors, including noise and skill-level of user. On the right hand side, references assigned to each factor are illustrated. Both factors that contribute to the input quality are discussed in the following sections:

Noise

Noise can be defined as a sound that is loud, unpleasant, unexpected, or undesired. Noise is a disturbance, especially a random and constant disturbance that obscures or reduces the clarity of a signal (TheFreeDictionary 2010). 'Noise' appeared to be the main issue affecting input quality among other child nodes, with a total 59 references. During the focus group interviews, participants referred to 'noise' as an external disturbance which could affect their perception toward the quality of information produced by the system.

Noise can be generated by the system itself, or by interference from external sources. According to transcripts, different types of 'noise' as external disturbance may include: noise from a patient's body, noise caused by body hair, cloth sound, chest piece movements, noise from the environment, or any kind of noise common with digital devices. According to this study, participants used different words with similar meanings to express their unsatisfactory view toward what they received from the system. Those words include noise, magnified sound, disturbance, fluctuating, muffled and wheeze.

Participants were sensitive towards the noise from the system while testing the digital stethoscopes. Some of the statements that identified noise as an important factor include ‘There is too much noise in this …, too much in this..., there is a lot of disturbance in this digital stethoscope’. (Reference 5, 6 & 18)

Participants not only identified noise, but also distinguished between types of noise. The following statements identify different types of noise that may affect the quality of information received from the system:

- ‘But only thing is little bit of hair noise’ (Reference 8 - 0.04% Coverage)
- ‘The noise is more, even if you talk something, it is magnified’ (Reference 9 - 0.03% Coverage)
- ‘I could not hear even a slightest of the noise. Slightest of the noise, I couldn’t hear the heartbeat. I could hear only the surrounding sounds’ (Reference 21 - 0.07% Coverage)
- ‘That is the only problem in the higher is that the body noise. Now when he tried it the only thing he could hear was the body noise. Clothes sound or if the cloth is removed then there is a body hair or the skin contact noise’ (Reference 26 - 0.09% Coverage)
- ‘Then when you move your stethoscopes, if he is a hairy person or so, when you move it lot of disturbances heard’ (Reference 37 - 0.04% Coverage)
- ‘In fact the background noise is too much’ (Reference 39 - 0.02% Coverage)

Participants conveyed their ideas to reduce or eliminate noise and disturbances other than that coming from patients’ hair or clothes by comments such as, ‘This has to be corrected’; ‘There is a lot of extra noise that you need to cut off’; and ‘Lot of background noises which have to be decreased’.

After the transcripts were further reviewed, it was possible to identify linkages between some of the external disturbance (noise) and amplification. It appears that some clinicians found the ‘amplification’ feature on digital stethoscopes increased the level of noise and disturbance. This is supported by the statements: ‘Only thing is little bit of hair noise is also so much amplified’ (Reference 8 - 0.04% Coverage);

and ‘that friction noise we generally don’t hear it very clearly, but here, with the amplification what happens is, even that friction noise is that comes in between your heart sound. That is the bit of a problem, that one problem I found’ (Reference 33 - 0.11% Coverage).

The child node ‘Noise’ appeared to be the most important node according to participants’ statements and accounted for 2.71% of statements from the entire transcripts.

Skill-level of user

Clinicians placed emphasis on the level of skill required in using a digital stethoscope to make a diagnosis. The researcher grouped all statements addressing the skill and expertise required in using a DS to identify and understand the correct body sound and named this group ‘Skill-level of user’. This factor was referred to 22 times by the clinicians and developed 1.66% coverage.

For this study, ‘skill’ specifically refers to skill of auscultation and skill of placing stethoscope in the right position. According to literature, auscultation is the diagnostic technique of listening to the various internal sounds made by the body, usually with the aid of a stethoscope (Bates 1995). The skill of listening to body sounds via a stethoscope is called auscultation by the medical references. Auscultation is perhaps the most important and effective clinical technique that clinicians will ever learn for evaluating a patient’s respiratory function—which was evident from the transcripts. Participants stated the importance of auscultation as ‘...you have to auscultate. In clinical medicine that is important’ (Reference 3 - 0.07% Coverage); and ‘How to hold a stethoscope, where to auscultate, a doctor should know’ (Reference 6 - 0.03% Coverage).

This aspect is further evidenced from the focus group transcript by the statement, ‘If the clinicians place the stethoscope in a wrong place, they could not hear any sound’ (Reference 8 - 0.03% Coverage) which resulted in further discussion about the misplacement of the DS. Clinicians require training to be able to place the digital stethoscope on the correct spot on a patient’s body. This has been recorded in transcripts as, ‘If you place the stethoscope in the wrong place, we could not hear any sound’ (Reference 2 - 0.03% Coverage). This aspect is further supported by clinicians stating: ‘And clinicians have to be trained, if you put it in the wrong position you may get disorders’ (Reference 3); and ‘If you can hold the probe the correct way, you should hear the sound Reference 10’.

7.2.2.2 Output quality

Clinicians use digital stethoscopes in order to make diagnoses and they may use the device via a telehealth platform. The process includes the capture of information including heart sound, lung sound or abdominal sound via the device and sending it through communication technology to be received by doctors at the other end of the system. In order to explain the broad term of output quality of the system where DS was deployed, three relevant factors were identified from the transcripts: sound audibility, clarity, and quality.

Output Quality	
Factor	**Reference(s)**
Sound Audibility	67
Sound Clarity	15
Sound Quality	13
Total References Output Quality = 95	

Table 7.6: Tree factors for Output Quality

According to table 7.6, the theme (parent node) ‘Output quality’ includes three factors (child nodes) and are sorted based on the frequency of statements addressing each factor. As discussed earlier, there are aspects that may influence the information quality when capturing the sound. Input quality aspects, along with output quality aspects, may explain the overall information quality received from the system.

In particular, clinicians expressed the view that they would like to receive audible, clear and quality sound from the system. The following sections review the findings that focus on these three factors.

Sound audibility

According to Alexander et al (2009), audible sound to be heard by humans is a pressure wave with a frequency between 20 Hz and 20,000 Hz. Results from this study correspond with the definition of audible sound that is found in the literature—a sound that is heard or that can be heard (American Heritage Dictionary 2006). The most important issue for participants regarding output quality was the audibility of the received sound, with 67 references noted. Participants heard different sounds such as heart, lung, abdominal and murmur. However, some of the participants stated that they were unable to hear the sounds from the DS. Nevertheless, the sound could have been captured and transmitted properly; but the clinicians may not have been able to hear audible or proper sounds from the DS for various reasons. A summary relating to the aspect of poor audibility identified by clinicians is as follows:

- ‘Even in this the audio is very faint’. (Reference 9)
- 'What is missing is the audibility itself’. (Reference 12)
- ‘Yes I didn’t pick up any sound’. (Reference 16)
- ‘The audio system should be improved’. (Reference 21)
- ‘I could not hear to any sound’. (Reference 40)
- ‘I suppose I don’t have any murmurs. I am not able to hear anything’. (Reference 74)

Audibility not only refers to hearing normal body sounds but, as highlighted by participants, that special heart sound named murmur is important to be heard via DS. Murmur refers to extra heart sounds that are produced as a result of turbulent blood flow sufficient to produce audible noise (Kent 2007). As was evident from the transcripts, murmur was mentioned several times, linked with sound audibility. In the context of telehealth, capturing the sound of a murmur emerged as a very important issue to clinicians. As one doctor stated: ‘If your stethoscope misses a murmur when a doctor [is] sitting on the other end then it has no value’ (Reference 35). In relation to the importance placed on hearing the murmur, it does, however, take time for doctors to gain the special skills required to be able to hear and recognise murmurs and distinguish them from a normal heart sound. This is supported by the comment, ‘Cardiac murmurs it takes five to ten years listening, with confidence, at least five years’ (Reference 38).

The level of skill required by doctors to recognise the murmur was not the focus of this theme, however, the capability of DS to provide suitable and usable information appeared to be important to participants.

Sound clarity

Sound clarity, along with audibility, was identified as one of the factors that could explain the quality of received information from the users’ perspective. Sound clarity was referred to 15 times in the transcripts. The degree of transparency of sound from participants’ perspective was merged during the focus group sessions. Clinicians were seeking clear and distinguished sounds to be able to make a diagnosis which was expressed as, ‘The clarity is what happens, you can exactly differentiate between the number of heart sounds and the type of murmurs’ (Reference 9).

Participants in the focus group sessions expressed diverse opinions regarding sound clarity. While the majority of participants expressed ambiguity regarding what they heard—for example, ‘It is very faint’ (Reference 3) and ‘Heart sound is also not at all clear’ (Reference 11)—some found the sound acceptable and clear: ‘Clarity is there’ (Reference 8).

Sound quality

There were 13 references by participants to the importance of sound quality during the focus groups sessions. According to participants, reasonable quality of sound is desired but a few participants found the quality of sound to be artificial and poor in comparison with traditional stethoscopes. Opinions included, ‘The sounds are too artificial there’ (Reference 4); and ‘quality is very poor compared with ordinary stethoscope, it is very, very poor’ (Reference 3).

Clinicians attempted to capture specific sounds such as lung sound with the DS and send it via telehealth network, but the final information received from the system contained the actual body sound plus extra noise, disturbance, other body sounds and murmur. Therefore, the quality of received information from the system was linked with various factors that were discussed in section 7.2.4.2 of this dissertation.

7.2.3 Use

The term 'use' was derived from the research question and conceptual model. Use indicates the degree to which a digital stethoscope is used and the frequency of use by clinicians. Delone and Mclean (2002) also define 'use' as an intention to use a technology. For the purpose of this study the term also includes intention to use. Four factors were derived from the transcripts which were relevant to the theme 'Use'. These are cost, training, acceptability and DS lifetime.

Use	
Factor	**Reference(s)**
Cost	50
Training	25
Acceptability	10
DS life time	5
Total References for Use = 90	

Table 7.7: Tree factors for information quality

Table 7.7 shows the theme (parent node) and related factors (child nodes) and the references for each factor are shown on the right side of the table. As can be seen, 'cost' has the highest reference among other factors (50), which means cost was addressed 50 times in separate statements from the transcripts. The next important node is 'Training' which yielded 26 references, followed by 'acceptability' with 10 references, and the node least referred to is 'DS life time'.

Building the tree nodes helped formulate the main ideas and the research questions to be answered for this study. Each of the mentioned child nodes were named after finding frequency of using the exact term or similar term by the participants in their statements. For example, any statement that addressed cost, price, pay, Australian dollar, Indian Rupee, costly, expensive, financially affordable, purchase, money and similar words were carefully reviewed and the sources were searched many times for the above words and allocated under the parent node ‘cost affordability’. The same approach was followed to build up the categories, grouping nodes with the same concept and naming the parent nodes as a subcategory of tree node. Naming the parent node was based on the preliminary framework developed based on the literature. The name of each parent node is arbitrarily chosen to describe the contents of free nodes in general.

Each factor (child node) is reviewed below; and statements that address the above factors are included in the following sections.

7.2.3.1 Cost

Cost appeared to be an important issue for Indian participants in terms of intention to use the DS in a telehealth system. According to table 7.1, a total of 55 references were coded for cost at 2.31% coverage of total transcripts. Participants indicated that DS is a very useful device in telehealth, but their intention to buy and use it is limited by cost aspects. As pointed out by a participant, ‘Definitely it will help in the treatment sir, but cost is important in our country’. Participants also said they would compare telehealth technology costs with quality. This was indicated by participants as, ‘So only specific areas where the investment is less, sustainability more, it is possible, that’s why teleradiology is a low cost investment, ... that is sustainable one’.

One of the participants added, ‘It is a very different state in India. Unless the government has put in lot of money, like Australia, where bandwidth and everything is dedicated for this, then it is ok’, therefore, unlike Australia, Indian participants identified the need for government financial support in buying equipment and organising the platform—which would perhaps lessen their resistance to accepting and using DS.

A strong statement was made by a group of participants—‘Just in case this is introduced in the market the first thing we are concerned about is the cost’. Moreover, the participants believe that ‘For us the main constraint will be the price.

If you reduce the cost then you will get a market. And the target audience will be these people. Not a go and approach anyone just like that'.

7.2.3.2 Training

Basically, 'training' refers to the level of knowledge, skills and practice towards using digital stethoscopes. Training emerged as the second most important factor underpinning the theme 'use', with 26 references from the participants. Training, along with other three factors could explain the intention and level of use of the DS by clinicians. Participants addressed the necessity of training in general, including the following points:

- Acquiring expertise in positioning the DS on patients
- Sufficient training to make diagnoses through received sounds
- Extending individual skill levels to work with different features of digital stethoscopes.

At least three participants referred to the term 'training' as obtaining special skills to use a digital stethoscope properly and make a diagnosis, moreover, clinicians addressed the issue of special training to position the stethoscope and make a diagnosis from what they hear. Therefore, training specifically refers to special skills required by clinicians to be able to work with a new improved digital stethoscope, its features and connect it to a telehealth platform.

Without training, clinicians may not automatically know how to use a digital stethoscope within a telehealth context to receive good quality sound and make diagnoses. 'You can't straight away use this stethoscope, and switch to that and expect to make the same diagnosis immediately' (Reference 21 - 0.04% Coverage). Based on participants' responses (0.98%), the role of training emerged as significant, and was addressed with statements such as, 'We train the people, without training we don't allow the people to take the image' (Reference 5 - 0.03% Coverage).

Participants' views regarding training have been reviewed and grouped into two main categories as follows:

Digital stethoscopes are considerably different to traditional ones in terms of the whole system in capturing sound and the features of the device. Therefore, clinicians may find themselves as naive users of a new technology and may find it difficult to work with a digital stethoscope and connect it to a telehealth system. This is evident from the transcripts by the statement, for example, ‘Again using the buttons of the stethoscope was also difficult. Maybe over a period of time, you start to learn to use’, Reference 15 - 0.05% Coverage. Participants highlighted their need to learn about working with DS in the following two statements: ‘If there is a manual which will tell you what is sufficient for whole thing’, Reference 16 - 0.03% Coverage; and ‘If you add on digital technology, they will also learn about digital technology. That is what the trend is; it is called updating yourself for the new trend’, Reference 25 - 0.05% Coverage.

A few participants stated that they did not see a necessity for training because of their level of education, for example, ‘I think for the level of doctors’ knowledge, regarding the stethoscope use, there is no need to have training. Reference 14 - 0.04% Coverage’.

7.2.3.3 Acceptability

Acceptability addresses the extent to which clinicians are likely to accept and use the new technology. The new technology refers to digital stethoscope connected to a telehealth system. The participants commented on issues that may influence their acceptance of the technology and few referred to barriers against acceptance. Totally, ten references were identified during the analysis that addressed acceptability, which covers 0.30% of the data source.

For this research, acceptability refers to an overall positive perception towards DS which was referred to 10 times according to table 7.1. Participants found DS to be a useful, worthwhile, improved new technology and felt comfortable with it; therefore, they expressed positive views to accepting such a device and using it in their daily workplace.

In contrast, those users who found the device unfamiliar with their routine job claimed that they may reject its use, with one participant commenting, ‘Yes, because we are used to this stethoscope, something new is difficult to accept’.

The following points are extracted as evidence from the transcripts in terms of acceptability. The numbers in the brackets show the frequency of topic discussed or addressed by the participants.

- Participants claimed that if they were satisfied with the overall result of testing each digital stethoscope, they may accept it in their workplace. 'Definitely, if the product gives the good result, as of any other brands in the market, it will have a good welcome from all the doctors' (Reference 1).
- Clinicians confirmed the importance of training and receiving updates regarding their skills by statements such as, 'We should accept the new technologies only then we can update our skills too' (Reference 2).
- Some of the participants addressed the issue of overall improvement in testing DS and expressed this as, for example, 'Yes, it is acceptable, all we need is to improve, it is acceptable, but we need to improve' (Reference 8).
- While, the majority of responses were positive towards acceptance, a few participants highlighted the issue of resistance to new technology. These participants prefer to use their old conventional stethoscope because they are familiar with it. These participants demonstrated reluctance in accepting the new device with statements such as, 'because we are used to this stethoscope, something new is difficult to accept' (Reference 3).

7.2.3.4 DS lifetime

The digital stethoscope's 'life time' also emerged as an important factor for clinicians in accepting and using the device. A few clinicians mentioned the importance of keeping a digital stethoscope for more than five years, expressed from the transcripts by 'I don't know what exactly its life (time) is because I have been using this (traditional one for) almost ten years'. Consequently, this participant is indicating that he did not consider the 'lifetime' an issue to be considered before accepting and using a DS.

Another participant indicated that 'both of them (stethoscopes) I used about a year or so only. Longevity is one, the other things the previous ones had only the infrared connectivity to the laptop, and that has been changed in the current generation'. This participant was concerned about the changes in technology and lifetime of DS.

7.2.4 Service quality

During the focus group sessions, only a few participants addressed the importance of follow-up services as an important issue in using digital stethoscopes—especially in a telehealth setting. Service quality was mentioned in the literature and employs the definition by Delone and Mclean (2002) as the overall support delivered by the service provider. This definition was taking into account for this study.

'Follow up service' appeared to be the only factor that explains the service quality theme. Figure 7.8 indicates the service quality as a parent node (theme), including one child node (factor) which was referenced only 6 times from the transcripts.

Service Quality	
Factor	**Reference(s)**
Follow up Services	6
Total References for Service Quality = 6	

Table 7.8: Tree factors for Service Quality

According to literature, service quality may be measured through assurance, responsiveness and follow-up service (Delone and Mclean 2002). Consequently, all statements that addressed follow-up service or maintenance were grouped and allocated under the factor 'Follow up service'.

7.3 Data analysis results (Australia)

Once the collected data from Indian institutions were analysed, both observational and focus group data collected in Australia were analysed and findings are revealed in this section.

7.3.1 Observational data (Australia)

7.3.1.1 Introduction

Participants from three hospitals in Queensland tested the three digital stethoscopes individually and through the telehealth platform.

The first participant from hospital 1, a doctor, tested all three DS and provided feedback later during the focus group session—which is discussed in section 7.3.2 of this chapter. The remainder of the doctors and nurses attended the session later in the morning and were observed using the DS and their comments about digital stethoscopes' usage were documented. The participants from hospital 2 tested the stethoscopes and were observed for about half an hour in separate rooms prior to providing their feedback during group interaction. Finally, a group of five nurses and one doctor from hospital 3 participated in this study and used all three digital stethoscopes on a patient (a research team member) and then moved to the next room to assess the sound received from the same digital stethoscopes through a telehealth platform.

As participants for this study were clinicians, mainly doctors, it was very difficult to have the doctors in the same room at the same time to test the DS. Despite doctors being regularly called out for urgent calls and, on occasions, having to leave the observation room for up to two hours, the researcher managed to record and observe every moment of their usage while in the room. Moreover, the researcher attempted to minimise any potential bias through electronically recording observations for future review.

7.3.1.2 Analysis of observation

The first step in qualitative analysis for this study was 'reading' the observational notes and watching the video records. The observational notes were mainly scanned and keywords relevant to the research question and the conceptual framework were identified and highlighted. After reviewing notes several times, the researcher was able to identify particular factors in terms of the research question. The frequency of occurrence of each key word was considered and prepared manually from the researcher's notes. Initial analysis of collected data through observation in Australia resulted in the following findings:

- Clinicians without or with limited experience in working with DS demonstrated a lack of confidence toward usage and need time to adjust to new technology.
- However, one of the doctors, who was well-experienced in using DS and appeared to be an expert in working with telehealth technologies, expressed high interest in testing, using and comparing all three DS. He spent additional time testing and assessing all the features of DS and comparing the design and fitting with his conventional one. He demonstrated advanced skills regarding assessing DS from different aspects, for example, on different patients or recording the sound and comparing it with real-time output.
- According to clinicians' reactions, the DS appeared to be a straightforward tool with easy-to-use features in comparison to others. Clinicians showed faster and reasonable adjustment with the new technology and its facilities and functions compared to other devices.
- Participants struggled extensively to achieve proper positioning of the DS head to satisfy the other end.
- Participants observed having difficulty in correctly positioning digital stethoscopes, particularly on patients with a hairy chest.
- Providing a suitable output for the other end was challenging for most of the clinicians.
- Clinicians expressed annoyance when crackling occurred.
- When sound crackling and breaking occurred, clinicians expressed their extreme dissatisfaction and had to hold the device away from their ears.
- Participants did not show any concerns about whether the low quality output was due to telecommunication interruptions, or the DS itself was not able to produce reasonable sound quality. They only struggled to receive satisfactory output.
- Almost all participants' concerns were due to the quality of sound they were receiving and this was demonstrated by facial expressions, pauses, head movements or adjusting the volume control.

- It was not clear to the researcher whether crackling was due to the telecommunication and wireless modem quality or the quality of the earpieces.
- Output quality of all three DS was sufficient for clinicians to make diagnoses, however, they showed frustration when testing DS through telehealth.
- At least half of the participants complained about background noise they were receiving, which was a distraction in making a diagnosis.
- More than half of the clinicians showed frustration in wearing two of the DS in terms of the earpieces. Despite difficulty in fitting the earpieces, they were satisfied with the earpiece size and design.
- Participants who expressed satisfaction with DS features and earpiece design were not necessarily happy with the output quality they received and vice versa.
- The majority of participants demonstrated their satisfaction while using one particular DS through the telehealth platform.

The following section will review the Australian focus group data analysis via the use of Nvivo8.

7.3.2 Focus groups data (Australia)

This section identifies the themes that emerged from the analysis of the collected data during focus group sessions in Australia. This section reviews the themes and factors (father and child nodes) which emerged from Australian data, guided by the conceptual model. As discussed in a previous section of this chapter, the name of each theme and relevant factors were logically chosen and depended on the perspective of the analyst, the focus of the research and the research context. The same technique used in analysing Indian data is used for the Australian one.

7.3.2.1 System Quality

As mentioned earlier in this chapter, system quality focuses on the desired characteristics of the information system which produces information, particularly ease of use, functionality, reliability, flexibility, data quality, portability and integration (Delone & McLean 2003, 1992). Statements that addressed the characteristics of system linked with its quality and the characteristics of DS were grouped together in order to explain the overall system quality.

System Quality	
Factor	**Reference(s)**
DS Quality	167
Usefulness	17
Ease of Use	16
Timeliness for Diagnosis	12
Education Friendliness	11
Response Time	3
Reliability	2
Flexibility	2
User Friendliness	1
Total References for System Quality = 231	

Table 7.9: Tree factors for System Quality

Table 7.9 indicates the theme 'System quality' and related factors. The combined factors of usefulness, ease of use, timeliness for diagnosis, education friendliness, response time, flexibility, user friendliness and DS quality explain system quality. A similar approach to that discussed in previous sections to grouping and naming the factors was followed. Each factor will be reviewed in the following sections.

Usefulness

Apart from DS quality, usefulness emerged as the most frequent topic addressed by participants, with 17 references. Participants used the words *good*, *better* and *useful* to explain the usefulness of a digital stethoscope. According to transcripts, participants found DS a useful device for rural areas, pre admission or pre anaesthetic and teleconferencing. For example, 'The electronic stethoscopes via teleconferencing and all sort of things experiences will be very useful' (Reference 12); 'They might use it in pre admission or pre anaesthetic type thing where the doctor's in Toowoomba' (Reference 14); and 'For the rural areas where they might have a really old patient, they don't have a clue what's wrong with them, and doing these things may be very useful' (Reference 17). One clinician believed DS to be a useful tool for his practice: 'Necessarily I would require one to assist my practice' (Reference 7).

Finally, one participant suggested that the system should be integrated with radiology to be more useful (Reference 9).

Ease of Use

Generally, clinicians preferred the DS to be less complicated, and requiring less effort to use. One of the participants expected to use a DS with an easy interface. This was expressed as 'the user interface will get easier' (Reference 7).

Participants were interested in the availability of a DS with different options and functions. For example, participants asked, 'What's "W Bell"' (Reference 13), and 'How do you turn this on?' (Reference 16).

Clinicians referred to the degree of effort required to wear and use the DS with one commenting, 'It is quite easy just to put it on the chest' (Reference 11).

Timeliness for diagnosis

The appropriateness of DS in making a diagnosis was raised during focus groups and identified as a factor related to system quality. Statements displaying a positive attitude toward the capability of DS to help clinicians make diagnoses were identified from the transcripts and are summarised as follows:

- Clinicians were happy with the received heart sound through the telehealth system and were able to make a diagnosis.
- DS appeared to be an interesting tool to be used in remote diagnosis.
- DS needs to be an easy device to use to make a diagnosis from what can be heard.
- DS should facilitate assessment by clinicians.

7.3.2.1.4 Education friendliness

As with the Indian participants, Australian clinicians also highlighted the importance of education friendliness during focus group sessions. Participants discussed the use of DS for educational purposes, and one participant suggested the use of DS for medical schools 'when as a med student, it would be handy if you could have a recorded ones to listen to them' (Reference 7). Another clinician recommended the use of DS for cardiologists and expressed this as 'some cardiologist may also want to store a sound file for teaching purposes' (Reference 9).

7.3.2.1.5 Response Time

Only three participants mentioned the importance of receiving sound through the telehealth system in real time. As evident from the transcripts, one of the clinicians suggested real time use of DS as, 'I think that will be ideal because if you are doing in real time, you are doing something , you can be asked to listen longer or putting it on' (Reference 2).

7.3.2.1.6 Flexibility, reliability and user friendliness

Only two participants discussed flexibility and reliability; and one clinician identified user friendliness of DS during focus group discussions. Participants were looking for a reliable, flexible DS with more user-friendly features, evidenced by the following views:

- 'Now I can see that is more flexible' (Reference 1 - 0.03% Coverage).
- 'I am not convinced in there, Reliability' (Reference 1 - 0.03% Coverage).

7.3.2.2 DS quality

Since DS quality was addressed through 167 references during focus group sessions, this factor became a sub category of 22 other factors that together could explain DS quality (see table 7.10).

DS Quality	
Factor	**Reference(s)**
DS Design	53
Ear &Head piece	25
Volume Control	18
Amplification	17
Recording facility	12
Editing Software	8
Telehealth Compatibility	7
Battery Life	6
Connectivity	5
Hearing Impaired Friendliness	4
Shock Proof	3
Noise Filtering	3
Wireless DS	2
Foldback Option	2
Position Locator	1
Visual Display Quality	1
Total References for DS Quality = 167	

Table 7.10: Tree factors for DS Quality

Factors that together could explain DS quality include ear and head piece, volume control, amplification, DS shape, recording, DS size, software, DS weight, telehealth compatibility, battery life, diaphragm, connectivity, DS material, hearing impaired friendly, DS length, shock proof, noise filtering, DS life, foldback option, visual display quality, wireless DS, comfort and position locator. Each of these factors will be reviewed in the following sections.

Ear and head piece

Participants noted the quality of earpiece as an important issue when discussing the quality of DS. Clinicians did not like the current earpieces with the digital stethoscopes they tested. One clinician stated, ‘Perhaps I didn’t like the earpieces on that one as much’ (Reference 1). Another participant mentioned ‘The earpieces, that one didn’t do very much for me’ (Reference 4). Basically, clinicians were looking for a comfortable earpiece to wear, for instance, one commented: ‘This was much more comfortable in the ears as well as the Littman’ (Reference 8). Participants also addressed the need to properly fit earpieces in their ears for best result. ‘I feel this is good, the ear piece seal very well’ (Reference 11).

One of the participants addressed the dislodgement of earpieces from the ears. Another clinician stated that earpieces do not sit very well and feel heavy, maintaining ‘they dislodge, but hanged and you can hear around them’ (Reference 14).

Volume control

Volume control appeared to be a noteworthy option for a digital stethoscope according to the transcripts. Participants expressed that when working with a digital stethoscope, it was useful to be able to change the volume to have better control on what could be heard. These claims are supported by the statements: ‘Let’s see, right … that’s got a volume control’ (Reference 1); and ‘Yeah, the sound up and down, that will be useful’ (Reference 8).

One of the clinicians addressed the need for volume control to distinguish the heart sound from the noise as, 'But you know, I turn them down, the crackling disappears, and you can still hear the heart sounds' (Reference 2).

Another participant was not able to find the volume control and asked, 'How do I turn it down?!!! I have got it so loud' (Reference 16).

Amplification

After testing all three DS, a number of the participants provided negative feedback about amplification, for example, 'I don't necessarily need amplification' (Reference 6). Clinicians mentioned that amplification would not be a useful option for digital stethoscope. When the amplification was turned off, they showed increased satisfaction and stated that the sound was better received. 'But with the amplification off, it was more natural, it was easier to distinct it. Hear sounds distinctly' (Reference 15).

Recording facility

Almost all the participants who discussed the recording facility found it an interesting and useful option for a digital stethoscope. Participants found the recording facility useful for keeping a record of the sound file to send to other centres or review it at a later time.

Software

Clinicians suggested that additional software could enhance the value of working with digital stethoscopes and help them expand their findings from a patient's heart/lung sound. For example, one of the tested DS provided phonocardiography software to help the clinicians edit and visualise the sound. Participants addressed the importance of such an option for a digital stethoscope. They suggested that this additional option could enhance their diagnoses. One of the participants commented, 'They could enhance the analysis. Somebody said if you have a layer of knowledge management system, behind it. Good, you can review it' (Reference 1). Another participant stated: 'I suppose if you had a digital analysis of that sound to compare to pathology I mean that would be a beneficial thing' (Reference 2).

Telehealth compatibility

The digital stethoscope was recognised by clinicians as a valuable tool in helping patients in remote areas. At least seven clinicians addressed this aspect and the need to use DS in telehealth. Participants mentioned that digital stethoscopes need to be compatible with telehealth systems and be able to get connected in order to transmit the sound. One of the participants commented: ‘I am 100% convinced with my clinical role the digital is; I can see its role in telehealth setting’ (Reference 5). The necessity of using digital stethoscope via telehealth to diagnose patients in remote areas was supported by one of the participants stating: ‘With those able to listen to murmur then we can decide because some people would have told them murmur in young life, would listen it, it is not murmur then I could have told them how not to bring them in to have them listen and she had to come from Tara which is not far away…that would have potentially be able to save her’ (Reference 7).

Battery life

Since digital stethoscopes are dependent on batteries, the lifetime of batteries is an important consideration according to participants. Six clinicians conveyed their concerns regarding battery life—which could impact on patient diagnosis. However, participants were aware this kind of problem exists with other electronic devices and one of them stated that ‘there is always problem with batteries and malfunctions, that sort of typical thing’ (Reference 5).

Diaphragm

The participants discussed the digital stethoscope diaphragm from two different aspects as follows:

- **The way to use the diaphragm:** Participants discussed the fact that the level of pressure on diaphragm could change the frequency transmission. For example, ‘If you push lightly, you get a light frequency transmission, if you push heavy, you get high frequency transmission’ (reference 5).
- **Diaphragm design:** Participants also addressed the design of the diaphragm. ‘I think the Thinklab had all the buttons on the actual diaphragm build in it’ (Reference 9). Moreover, one of the participants stated that there is no need for a bell at all when there is a tuneable diaphragm. Participants tended to

compare the shape of DS diaphragm with traditional ones and one participant expressed the view: 'That's interesting. It's very convex, isn't it? The others are quite flat, very traditional' (Reference 2).

Connectivity

Connectivity means the capability of a digital stethoscope to connect to other devices. One participant was concerned about the infrared option, stating 'I am not sure that has the technology works with necessarily with the infrared one' (Reference 3). Based on the transcripts, the following features are expected in a digital stethoscope:

- The ability to upload data
- A Bluetooth option
- A USB port/connection.

Chest piece design

The chest piece consists of two sides that can be placed against the patient's body for sensing sound. Only a few of the clinicians addressed the importance of chest piece design for a DS. One participant mentioned the need for different sized chest pieces which was expressed in the transcripts as, 'You are gonna run for a paediatric one, you'd need to have a head that is going to be about the size of that bell there' (Reference 1). Comparing three tested DS, participants did not find any difference among them and stated that they are all reasonably comparable.

Hearing impaired friendly

Participants discussed whether the DS would be a usable device for clinicians with hearing problems, especially in older doctors. One of the participants mentioned the possibility of increased uptake by doctors with hearing problems. This is supported by a statement from the transcripts: 'I've got a colleague here who uses one...she finds it better because she has some hearing impairment, because she has some troubles hearing them, she uses a digital stethoscope' (Reference 2). One of the participants, a cardiologist, has a hearing problem and found the DS essential for his practice, commenting: 'I've got lots of low tone... so I do have a deafness problem... it's not...I've known that for a long time from my childhood' (reference 4).

Shock proof

Shock proof explains the extent to which a digital stethoscope would be able to absorb shock without being damaged. Participants were concerned about the robustness of DS if dropped. According to transcripts, participants found the traditional stethoscope reasonably strong and expected the same strength with a digital stethoscope. One participant commented, 'I would feel that the traditional one would be more robust, if I dropped it. It is likely to be coming out! I don't know. What kind of shock proofing, everything! The digital ones have got the saying' (Reference 1).

Noise filtering, fold back option and wireless DS

Only a few participants briefly addressed these factors during the focus group discussions. A summary of clinicians' perception toward these factors are as follows:

- Participants believe noise filtering in the DS is vital for better heart sound.
- One of the participants suggested having a fold back option to be able to use as a traditional one if a DS ran out of batteries.
- According to statements, at least one participant questioned the existence of a tube to connect the earpieces and the bell. Another participant stated, 'Why we can't have a wireless system?' (Reference 2)

Position locator and visual display quality

One participant discussed the capability of DS in finding the right position on a patient's chest for the best sound capture. This was evident from the transcripts as: 'Can you put a pressure instrument and have a light or something that tells you when you got a you know, appropriate skin position , you know, that sorts of thing?'

Another participant suggested the benefit of having a small screen TV screen sitting at a 5 mt or 2 mt distance with high quality to enhance use of DS via telehealth systems—expressed as 'I think small screens will never give you, will never, you never get the same feel' (Reference 1`).

DS Design

This section will review all factors that together could explain the design of a digital stethoscope and includes DS shape, size, weight, material and length (see table 7.11).

DS Design	
Factor	**Reference(s)**
DS Shape	14
DS Size	11
Diaphragm Design	9
DS Weight	8
Chest Piece Design	4
DS Material	4
DS Tube Length	3
Total References for DS Design = 53	

Table 7.11: Tree factors for DS Design

DS Shape

The shape of DS emerged as a popular topic and was referenced 16 times during focus group sessions. Participants discussed proper shape and design of a chest piece for paediatrics. 'You are gonna run for a paediatric one' (Reference 3). Moreover, the participants indicated that minor shape and design problems with DS were insignificant, unless it affects the ability to hold the device comfortably. This view was expressed as, 'I think the main thing is that it is comfortable to hold' (Reference 4).

A few participants conveyed the view that they did not mind working with a DS with a slightly different shape to their conventional stethoscope.

DS Size

Participants displayed a preference for the size of a DS to be similar to the size of a conventional device. One participant addressed the issue of DS size for children by saying, ‘You want something with a smaller head that can get between children’s ribs’ (Reference 5). Moreover, clinicians suggested a small size DS for their daily practice; although one participant believed that size may not be important in a telehealth setting by the statement, ‘Given the way telehealth works, it doesn’t necessarily have to be as portable as these you’ve got...you’re not carrying it around you know’ (Reference 11).

DS Weight

DS weight was considered important by some of the participants. All three DS were tested by clinicians who deemed the tested DS heavy and would expect a lighter device for their practice, supported by the statement: ‘The weight well, I think you know they are all heavy’ (Reference 3).

DS Material

DS material was another topic discussed in the focus group sessions. One participant suggested a better polished DS. Another clinician demonstrated satisfaction by expressing an optimistic view and using positive words such as *better* and *nice* in relation to one DS which had a better material and had a double rubber finish. Stainless steel was suggested as an option for material, but not essential.

One of the participants compared the three DS and stated ‘You know two of these look need better finish than the third’ (Reference 2).

DS Tube Length

Only a few participants addressed DS tube length during their discussion and did not regard tube length as an important design aspect of a DS. Only one participant was interested in shorter DS tube evidenced by the comment that ‘the expensive traditional ones, the shorter they are, the better they sound…because you have less distance’ (Reference 2).

7.3.2.2 Information quality

Information quality has been defined and discussed in the previous section. The same technique used for the Indian data analysis is used in this section to identify the theme 'Information quality' from the transcripts. Input and output quality and their related factors are reviewed separately to provide an overall explanation of quality of information produced by the system (see table 7.12).

Information Quality	
Factor	**Reference(s)**
Input Quality	87
Output Quality	72
Total References for Information Quality = 159	

Table 7.12: Tree factors for Information Quality

According to the transcripts, 'information quality' emerged as the most important theme from the users' viewpoint. This theme and its related factors have been discussed during focus group sessions and resulted in 159 references. Noise, skill-level of user, sound quality and audibility together could explain the quality of information produced from DS via a telehealth system.

Input Quality

In order to explain input quality through focus group discussions, two related factors were identified from the transcripts. 'Noise' and 'skilled-level of user' together appear to have an effect on input quality according to participants' statements (see table 7.13). These two factors will be reviewed separately in the next section.

Input Quality	
Factor	**Reference(s)**
Noise	79
Skill – level of user	8
Total References for Input Quality = 87	

Table 7.13: Tree factors for Input Quality

Noise

While discussing information quality, clinicians were mainly concerned about the noise that affects the quality of received sound from the DS. 'Noise' holds the highest referred factor according to transcripts, with 79 references.
According to transcripts, 'Noise' may refer to any kind of disturbance such as background sound, chest hair, crackling, pitch, whistling or anything that may interfere with the heart or breathing sound.

The following section will review clinicians' perceptions toward noise.

Pitched noise: One participant expressed concern about pitch noise as, '(There is) pitch noises from his heart that I could hear' (Reference 5). Another clinician stated, 'so there was a heart pitched, whistling sort of at the back ground with the 1st one, was a little distracting, The 2nd one had a lower pitch' (Reference 12).

Whistling: Whistling occurred during testing DS which disturbed participants' hearing; and a whistle interfered with hearing the lung and heart sounds. For example, one clinician declared it 'has that whistling in the background, which is annoying, which may interfere with the heart patients' (Reference 34).

Physical disturbance: participants discussed the fact that physical disturbance caused by patients' clothes or chest hair was an issue. One clinician stated, 'I think the problem is with all these are for someone with a hairy chest, you also find the sound with the hair chest rubbing on the diaphragm that is quite distracting as well' (Reference 13). Another clinician believed the disturbance could be caused by moving the chest piece on the patient's body. He said, 'There's a lot of scratchy since I move it. It seems very scratchy' (Reference 27).

Background sound: Clinicians identified background sound as one of the causes of noise produced during testing DS. According to transcripts, one participant expressed the view that 'there is some kind of weird deep sound at the background' (Reference 14). Background noise seemed to be a controllable aspect for some of the participants, with one stating: 'as you listen for a longer time there was, as you increase the loudness, you got a lot more background noise, so the signal noise ratio went up' (Reference 19).

Other noises: Other noises apart from those previously identified and discussed were also addressed by the clinicians. One of the clinicians identified the external sound coming from the crowd present in the room as interfering with his hearing. This was expressed as, 'I could hear you talking every now and then in the background. I could hear that you were talking. But a lot of wind tunnel noises. Lot of noise' (Reference 79). At least one of the participants alluded to electronic disturbance: 'But that one had electronic interference as well' (Reference 32).

Skill-level of user

This term has already been explained in section 7.2.2.1 of this chapter. Moreover, Australian participants explained that 'Skill-level of user' could also depend on their knowledge in using a stethoscope in order to distinguish between heart sounds, breathing sounds and murmur.

One of the nurses stated that 'One of the hardest things in the world is to find the heart beat and breath sound' (Reference 7). Clinicians believe that not only do they rely on their medical knowledge, but also on the quality of the sound produced which would enable them recognise the correct sound from the DS. This was evident from the transcripts as 'I really had lot of trouble distinguishing which was heart noise and which was background noise, very much low in sound quality, in general I think it was really difficult to distinguish between sounds, I was not technically experienced with this' (Reference 2).

One of the doctors made reference to the usefulness of DS in helping users improve their level of skill in distinguishing different sounds received by DS. This doctor suggested that by recording the sound and sending it to other colleagues, it would enable doctors to receive the feedback which could help them distinguish different sounds. This was expressed as 'maybe that people become to rely on it too much, letting other people make decisions about what they are hearing. Rather than developing their own clinical experience. I can't say for sure. Maybe the opposite should be true. More people listening in, you could improve your skills, because you are getting more appropriate feedback. But you might deskill because you rely on someone else to make decisions in relate to make patients' diagnosis' (Reference 3).

Output Quality

Output quality is explained through two related factors named as 'Sound quality' and 'Audibility', which will be reviewed in the next section (see table 7.14).

Output Quality	
Factor	**Reference(s)**
Sound Quality	42
Sound Audibility	30
Total References Output Quality = 72	

Table 7.14: Tree factors for Output Quality

Sound Quality

Sound quality was the second important topic discussed by participants during focus groups. After testing all three DS, participants advocated the necessity to receive and hear various body sounds with a high level of quality.

One of the participants compared all three DS and mentioned that 'all three of them seem to deliver reasonable, uh, versions of heart sounds' (Reference 1). Moreover, participants expected to receive clear and smooth sounds from the DS.

Participants addressed the quality of sound and tried to rank the sound quality by using the terms *poor*, *worst*, *better*, *well* and *good*. For example, one of the clinicians mentioned that 'unfortunately the sound quality is very poor' (Reference 10). Participants expect a DS to produce a higher quality sound than a traditional stethoscope. One participant was satisfied with the quality of sound in comparison with a traditional stethoscope, supported by his view that 'for me these are much better than that stethoscope...than the manual one...much better' (Reference 42).

Sound Audibility

This factor was the third important theme discussed and was referred to by participants 30 times. As discussed in the previous section of this chapter, 'Audibility' refers to sound that would be loud or clear enough to be heard by a human.

Participants tested three different stethoscopes, and the results of their evaluation regarding the audibility of the sound received by DS showed that the majority of participants were able to hear different sounds. Participants' perception toward audibility of sound is summarised as follows:

- 'I can hear the breath sounds as well. We are able to hear the lung, hearts, sounds' (Reference7).
- 'I could hear your heart sounds quite clearly' (Reference 26).

Participants made an assessment of the audibility of sounds by using the terms *quiet* or *loud*. For instance, one comment was: 'the 2nd one, louder, but with initially a thought of oh yeah, I can hear better,' (Reference 5).

7.3.2.3 Use

Similar to discussion earlier in this chapter, the term 'Use' refers to the degree to which a digital stethoscope is used and its frequency of use by clinicians. Five factors emerged from the transcripts that could explain the theme 'Use'—'Intimacy toward traditional', 'Intention to use', 'Cost', 'Training' and 'DS Lifetime' (see Table 7.15)

Use	
Factor	**Reference(s)**
Intimacy Toward Traditional	21
Intention To Use	16
Cost	14
Training	5
DS Lifetime	2
Total References for Use = 58	

Table 7.15: Tree factors for use

Intimacy towards traditional

Participants expressed their closeness and comfort with their conventional stethoscope during focus group discussions. This factor, with 21 references, appeared to be an important issue from clinicians' viewpoint when discussing usage of digital stethoscopes. This factor refers to the positive feeling that clinicians experience toward the device. Moreover, this term refers to the degree of familiarity of the user with the device.

Participants expressed their attitude toward the DS and compared it to the conventional stethoscope in terms of familiarity. Participants displayed a preference to using a DS very similar to their traditional stethoscope. This preference is substantiated by a comment from the transcripts: 'I think the similarity to normal stethoscopes is very important, familiarity to the user' (Reference 6). Another participant showed his satisfaction with one of the tested DS which had a similar design to his conventional stethoscope. He stated his intention to use that particular DS since it did not look unfamiliar to him: 'The earpieces, they are sort of similar to the non electronic ones' (Reference 15).

However, the majority of participants indicated they would prefer using their traditional stethoscope instead of DS in the future. A summary of related statements is as follows:

- 'I'm currently using [one in] my entire practicing career and I'm very happy with it, and I'm reasonably good with it. So I would probably stick with traditional' (Reference 1).
- 'I think I use a traditional one' (Reference 3)
- 'I would pick my normal stethoscope, because of the familiarity' (Reference 8) .

Clinicians explained their reasons for choosing a traditional stethoscope over a digital one during focus group discussions. One clinician addressed comfort as an issue by saying, 'You tend to pick the one that you feel most comfortable with because that is the psychology of life' (Reference 9). Similarly, another participant explained his choice with the reason being 'Because I'm a lot more comfortable with it and there is none of these drawbacks' (Reference 17).

Participants discussed the likelihood of extensive usage of DS among clinicians and suggested that should digital stethoscopes replace traditional ones at medical colleges and schools, it would result in better outcomes in terms of familiarity. One of the participants stated that 'it is a feeling of competency and psychology and economy of psychology as well. The psychology is that you're going to do something that you are most familiar with because it makes you feel competent and second of all you don't have to think about it as much, therefore you use it' (Reference 10).

Intention to use

It was explained in the previous section of this chapter that the term 'use' was derived for the scope of this study and corresponds with the definition found in the literature. Delone and Mclean (2003) believe that 'Intention to use' is an attitude, whereas 'use' is a behaviour, and intention to use will focus on users' attitude toward using a technology in the future. Since the majority of participants have not used DS, 'intention to use' appears to be an aspect that could explain the usage of DS in a telehealth setting. Intention to use DS was addressed by clinicians during focus group discussions and a review of intention to use DS by clinicians is provided, including reasons for using or not using DS in the future.

Participants compared and tested three different digital stethoscopes within a telehealth setting and later discussed whether they would accept and use DS in the future. The majority of participants stated that they did not intend to use digital stethoscopes for their daily practice. This was evident from the transcripts in the form of statements such as, 'So I would probably stick with traditional' (Reference 2). Conversely, only a few participants showed a positive intention to use DS in the future which was evident from the transcripts as, 'Digital one? Yes, yeh, I would use that' (Reference 7).

Some of the participants were undecided about their intention to use DS in the future and would need a convincing reason to do so.

One participant mentioned one condition that may influence his decision to use DS in the future, expressed as 'You know, if you could just listen to something and record it and just dump it onto a monitor in order to play it for medical students or transmit it, then that might be a reason for me to use one' (Reference 4). Similarly, another clinician stated that 'Well I think, that physicians are inherently conservative creatures, and you know, you know we do what we learn, and we teach what we learned, rather than necessarily changing. Um…I would have to be convinced that it's genuinely better' (Reference 5).

Cost

Clinicians held a discussion about the price they were willing to pay for a DS. According to transcripts, participants would expect a reasonably priced device, for example, one clinician stated that 'it would need to be reasonably priced and convenient' (Reference 3). However, a diverse price range was proposed by participants. Doctors, nurses and medical students all had different ideas about a reasonable price for a DS. One doctor stated 'I think a thousand will be a nice round number. But I think that's depending on the budgetary constraints… you can sneak a thousand dollars through any department, but you can't sneak five thousand' (Reference 10). Nurses and medical students suggested a similar affordable price, but one lower than what doctors suggest. Supporting this from the transcripts is, 'You'd have to come down to the 200 or 300 level' (Reference 11). However, one participant suggested that money would not be a problem at all in relation to intention to use if the company takes responsibility for the purchase.

Training

Only a few clinicians addressed the importance of training when discussing DS use. For example, one participant had concerns in learning to work with DS and expressed that 'do you know...are there any instructions to go with this about how hard you press to?' (Reference 5).

DS lifetime

This factor was addressed only twice during the focus group discussion. Participants did exhibit concerns regarding the longevity of DS. One clinician expressed the viewpoint, 'I am wondering how long it's going to be before putting DS in the bin and reaching for point-and-click ultrasound'.

7.3.2.4 Service quality

During focus group discussions, only a few participants addressed the importance of service quality when using DS in a telehealth setting. The term 'Service quality' was derived in the scope of this study and corresponds with the definition found in the literature and discussed in the previous section of this chapter.

Service Quality	
Factor	**Reference(s)**
Warranty	2
Total References for Service Quality = 2	

Table 7.16: Tree factors for Service Quality

Participants also referred to the term 'warranty' while discussing the service quality (see table 7.16).

7.3.2.4.1 Warranty

This factor emerged only twice during the focus group discussions. One doctor mentioned that ‘my stethoscope was broken and, I couldn’t get it repaired there’s all it was wrong in that was in this part! The spring in here was broken, that was all that wrong with that, and they would not repair that’ (Reference 1). Therefore, service warranty in case of any damage to DS was an important issue from the participants’ point of view.

7.4 Summary of findings

Clinicians’ perceptions of using digital stethoscopes in a telehealth context were investigated through observation and focus groups within two cases in Indian and Australian healthcare institutes.

All themes from the findings				
India			**Australia**	
Theme	***Total references***		***Theme***	***Total references***
System Quality	390		System Quality	231
Information Quality	176		Information Quality	159
USE	90		USE	58
Service Quality	6		Service Quality	2

Table 7.17: Themes that have been identified based on analysis of transcripts

Table 7.17 is a representation of identified themes through analysis of transcripts for each case. Several factors underpinning each theme were identified and the total number of referenced factors under each theme is indicated in table 7.17.

A summary of findings under each theme will be reviewed in the following sections.

7.4.1 System quality

Findings under this theme highlighted the importance of several factors that together explained system quality. A summary of factors identified for each case follows.

7.4.1.1 India

Based on analysis of collected data in India, 390 references were identified for system quality via its related factors.

- DS quality was the most frequent factor discussed by clinicians under this theme. Participants explained their perception of system quality though discussing various characteristics of DS such as recording facility, amplification, ear and head piece, connectivity, visual display and editing software, volume control, battery life, comfort, frequency mode, chest piece and DS overall design.
- Usefulness of DS was the most important issue addressed by Indian clinicians. Usefulness of DS for various usages was identified by participants.
- Digital stethoscopes were perceived to be a useful device for doctors with hearing problems, telemedicine setting, students' learning, conducting medical exams, obtaining a second opinion from another doctor and for use in remote access health sectors that are connected via a telehealth system.
- Digital stethoscopes were found to be a useful device for clinicians, especially in the pre-admission sector of anaesthetics. Additionally, the findings suggest that digital stethoscopes are useful in telehealth systems, particularly for clinicians in emergency departments to monitor patients.
- Ease of use was also important from clinicians' perspective. Since some participants struggled to understand the features of DS and properly use the device via telehealth, a straightforward and easy to use DS is advocated.
- Reliability and response time were also factors discussed under system quality, however, there were fewer references to this factor than to those mentioned above.

7.4.1.2 Australia

From the analysis of the collected data in Australia, system quality was referenced 231 times.

- Similar to the Indian case, DS quality (containing DS design) appeared to be the most important factor relating to system quality. Participants identified the same factors as the Indian case study, with the addition of hearing impaired friendliness, shock proof, noise filtering, foldback option, and position locator.
- DS was addressed as a useful medical technology for rural areas, educational purposes such as in medical schools, pre admission, pre anaesthetic, telehealth (in general) accompanied with teleconferencing; and could be integrated with teleradiology.
- Clinicians addressed ease of use of DS, incorporating level of effort in wearing it and ease-of-use of its features.
- Clinicians highlighted response time, timeliness for diagnosis, flexibility, reliability, and user friendliness as factors that were important in addressing system quality.

7.4.2 Information quality

In both cases, factors were identified to explain the quality of input to the system and output from the system.

7.4.2.1 India

- Amount of noise and skill level of user influenced the quality of captured sound.
- Noise was generated by the system itself, from a patient’s body, a patient’s clothes and the environment.
- Skill of clinician in positioning the DS properly on patients was an important factor impacting the quality of input to the system.
- Output quality was explained through sound quality, audibility and clarity.
- Clinicians need the output sound to be audible and clear enough, with reasonable quality, to be able to make a diagnosis.

7.4.2.2 Australia

- Similar to the Indian case study, level of noise and the skill of user impacted the quality of input to the system.
- Clinicians identified various types of noise as pitched noise, whistling, physical disturbance (such as chest hair and clothes) and background noise.
- Superior skill of user was required in order to not only capture normal heartbeat, but also any heart abnormality such as murmur needed to be captured and sent through the system to the other end.
- Clinicians require sound that is clear, smooth, of reasonable quality and loud enough to be received from the system to make a diagnosis.
- Sound audibility and quality together explained the quality of output from the system.

7.4.3 Use

7.4.3.1 India

- Cost is regarded as the most important factor that clinicians directly addressed which would impact their intention to use DS.
- Clinicians highlighted the importance of training prior and during use of DS in order to improve their knowledge in positioning the DS, improve skills to make a diagnosis from the received sound, and acquire specific skills to work with added features of the DS.
- The life time of DS was also considered a factor which could impact on level of use.
- Clinicians discussed the extent to which they were likely to accept each stethoscope and use it in their daily practice via telehealth.

7.4.3.2 Australia

- Feeling familiar with a medical device is a very important factor influencing the level of usage of the medical device, in this case, a digital stethoscope.
- For Australia, cost and training were less important factors directly impacting on usage in comparison with the Indian case study.

- Clinicians need compelling reasons to encourage them to use DS in the future.
- Australian clinicians mostly highlighted their intentions rather than any other factor when discussing usage.

7.4.4 Service Quality

For both cases, service quality was addressed briefly. Only follow-up services and warranty appeared to be an issue for some of the clinicians.

7.5 Chapter summary

This chapter provided findings from the analysis of collected data through observation and focus groups. The focus group data was obtained from both India and Australia, whereas, the observation data was only collected from Australia. Since Nvivo8 was utilised for the purpose of analysis in this study, all transcript data was imported into Nvivo and analysed. This chapter identified certain themes and related factors from the transcripts. Each theme and its factors were reviewed and discussed extensively to be able to identify the important aspects that could explain the usage of digital stethoscopes from clinicians' perspectives. Usefulness, sound audibility and noise appeared to be the most important issues according to Indian participants; whereas noise, sound quality and audibility were identified as the most frequently raised factors by Australian participants.

In Chapter 8 the results from this chapter will be discussed against findings from the literature. The next chapter also investigates the factors that influence the usage of digital stethoscope by clinicians in a telehealth setting through interpreting the findings which were introduced in this chapter. Moreover, a revised version of the conceptual framework will be introduced based on the findings of this study.

CHAPTER 8: DISCUSSION

8.1 Introduction

This chapter seeks to answers the research question and sub-questions by discussing the findings from the previous chapter. The chapter begins by giving an overview of the main findings of this study, followed by a comparison of findings from both Australian and Indian health institutes.

The conceptual framework which was developed based on literature review allows the researcher to interpret the findings; moreover, new themes and factors that were not identified from the literature review will be highlighted in this chapter.

Finally, a revised conceptual framework will be presented as an outcome of this study.

8.1.1 Hermeneutical interpretation

This study employs a hermeneutical approach for interpreting and discussing the research findings. Myers (1997) suggests that hermeneutics can be seen as a specific mode of analysis in an IS study. Within hermeneutics, the researcher is able to make sense of the whole and the relationship of people, organisation and information technology (Myers 1997). The Oxford dictionary defines hermeneutics as 'of interpretation', taken from the original Greek *hermeneutikos* (Turner, 1987, p. 284). Hermeneutics in sociology means understanding and interpreting social events by analysing their meanings to the human participants and their culture (cited in Van Manen 1990).

As discussed in chapter 3 of this dissertation, the purpose of this interpretive research was not to discover universal law, but to seek to understand a particular situation within two case studies conducted in Australia and India. Christopher, Richardson and Christopher (2001, p20, cited in Willis 2007) state, 'Hermeneutics sees the pursuit of truth as essential to human existence, but suggests we can never have certainty we have found truth'. Therefore, the researcher attempts to offer best accounts, best interpretation and best arguments.

Jarvinen (2004) suggests within-case analysis as a key step in analysis. Moreover, this author recommends that researchers select pairs of cases and then list the similarities and differences between each pair. This tactic was employed in this study in which the researcher looked for subtle similarities and differences between the two cases.

Chapter 7 of this dissertation identified specific themes and their underlying factors which explained those themes in detail.

The following sections attempt to establish interlinking between those themes within two case studies; moreover, the researcher will answer the research sub-questions through hermeneutical interpretation of the data analysis results.

8.2 Implications of findings

This section discusses the implications of the findings presented in chapter 7 of this dissertation.

India	
Usefulness	105
Sound Audibility	67
Noise	59
DS Design	56
DS Design Include:	
Diaphragm Design	16
DS weight	12
Chest Piece Design	8
DS Shape	7
DS Size	5
DS Material	4
DS Tube shape and length	4
Cost	50
Recording facility	36
Amplification	25
Training	25
Ear & Head piece	24
Skill-Level of user	22
Connectivity	21
Ease of use	18
Education Friendliness	16
Visual display and editing software	16
Volume Control	15
Response Time	14
Battery Life	14

Australia	
Noise	79
DS Design	53
DS Design Include:	
DS Shape	14
DS Size	11
Diaphragm Design	9
DS Weight	8
Chest Piece Design	4
DS Material	4
DS Tube Length	3
Sound Quality	42
Sound Audibility	30
Ear & Head Piece	25
Intimacy towards traditional	21
Volume Control	18
Amplification	17
Usefulness	17
Intention to Use	16
Ease of Use	16
Cost	14
Recording Facility	12
Timeliness for Diagnosis	12
Education Friendliness	11
Editing Software	8
Skill-Level of User	8

Sound Quality	13		Telehealth Compatibility	7
Comfort	13		Battery Life	6
Acceptability	10		Training	5
Frequency Mode	9		Connectivity	5
Reliability	8		Hearing Impaired Friendliness	4
Follow up Services	6		Response Time	3
DS Life time	5		Shock Proof	3
			Noise Filtering	3
			Wireless DS	2
			Reliability	2
			Warranty	2
			Flexibility	2
			Foldback Option	2
			DS lifetime	2
			Visual Display quality	1
			User Friendliness	1
			Position Locator	1

Table 8.1: Comparison table for quality factors identified for this study

8.2.1 System quality

It should be noted that the evaluation of a telehealth system in general was not within the scope of this study, rather this study is concerned with the operation of a DS within a telehealth system.

Primarily, a DS is assumed to be a useful device and clinicians will perceive the system as high quality. This implication is based on interpretation of Indian clinicians' statements. As indicated in table 2.5, literature also revealed the importance of usefulness as a key evaluation criterion. Moreover, perceiving usefulness of a technology may have a positive impact on intention to use, as suggested by Davis (1989) and also addressed in other studies from the literature

(Chau & Hu 2002; Pare, Sicotte & Jacques 2006). According to the findings from this study, clinicians found the DS to be a useful device and believed that using the DS within the telehealth system could assist them in diagnosis and overall job performance. Moreover, use of a telehealth compatible DS would make it possible for a patient with a heart murmur who resides in a remote area to be diagnosed by a specialist in a metropolitan/city based hospital. Consequently, use of a DS in telehealth appears to be a useful technology to save patients' time, as patients are the ones who do the travelling to receive specialist medical care.

Similar to the conventional form, a digital stethoscope is an essential device for doctors in their daily practice in order to make diagnoses; not only to monitor heart sounds, but also to listen to lung sounds. ECG and echo cardiograph may not replace DS because DS could be a multipurpose and useful medical tool to be used in various medical settings such as ICU and in different locations such as regional and remote telehealth systems. Moreover, senior doctors and medical students would be likely regular users of this device because of its potential. This particular DS capability has not been available with conventional stethoscopes. Therefore, DS would be a useful device in Australian rural area via telehealth connection.

As addressed by clinicians, it may be beneficial to integrate the use of DS via a tele-radiology system. Usage of DS may be considered for various telehealth setting; either real time or stored and then forwarded, as clinicians in Australia and India were unconcerned with a delay in receiving the sound. However, clinicians prefer to use a real-time system. They may also benchmarked DS with other similar devices such as echo. Few studies addressed medical devices such as DS, echo and ECG being used as real-time transmission in order to increase the timeliness and accuracy of diagnosis; also clinicians may benefit from real time connection in order to remotely consult the patient's medical history for a second opinion (Lewin et al. 2006; Reicher et al 2009).

Clinicians demonstrated a positive attitude to acceptance and usage of DS for their daily practice in the future as they recognise DS as a useful device—especially in a telehealth setting. From clinicians' viewpoint, factors identified in this study that could affect the level of usefulness of a DS over conventional stethoscopes include recording option, connectivity, visual display, supporting software, volume control, noise filter, wireless feature, battery level indicator, and fold back option. Therefore, clinicians in this study may accept and use a DS which has these features.

No formal study of great sample size has investigated usefulness of DS or discussed its impact on the acceptance and level of usage. However, there are studies that suggest the factors which are the barriers to acceptance of technology by physicians need to be studied and identified (Yarbrough & Smith 2007; Lapinsky et al. 2004).

One of the issues highlighted in the review of the literature and in chapters two and three was ease of use. Digital stethoscopes were not considered by clinicians in India to be a straightforward and easy-to-use device. This is in contrast to previous studies such as that of Hu et al. (1999) and Kim et al (2010). In their study, Hu et al. (1999) suggested that ease of use would not be an important issue in evaluating telehealth systems because the physicians as the users can understand the new technology quickly. Similarly, Kim et al (2010) assert that physicians comprehend new technologies faster than the average population, and perceived ease of use may not be an important factor to physicians when comparing other factors such as usefulness of technology. Contrastingly, a study by Kowitlawakul (2011) investigated intention to use technology by nurses and suggests that perceived ease of use is highly impacted by perceived usefulness. Kowitlawakul (2011, p 416) contends that the nature of the population might well play a role for this contradictory result.

In this study, clinicians include both nurses and physicians. Clinicians are known as fast learners; however, in this study, clinicians appeared to be confused with working with various options of DS. The complexity of the design may have caused the clinicians to be uncertain in using DS. It was also observed that Australian participants spent some time to understand the functionality of DS and also struggled to understand the purpose of each key and the various options of the DS. However, this finding may not imply that the situation would remain constant. Clinicians may become used to working with DS after a period of time and find it easier if they adopted and used DS in their daily practice. Similarly, Koekemoer and Scheffer (2008) mention that the simplicity of use of a particular medical technology in a telehealth setting resulted in that device being capable of a quick set-up time and could be used by clinicians with only basic training. If DS manufacturers provide a detailed and comprehensive manual it may resolve similar problems and result in successful acceptance and use of DS by clinicians.

Apart from usefulness, overall quality of DS as a technology was identified as an important issue in system quality assessment. Design is a core characteristic of DS quality based on the findings of this study. Therefore, DS producers may also consider that the design of DS would be an important issue from the clinicians' perspective. The findings of this study imply that an acceptable DS may have the following design characteristics:

- Available in a variety of sizes, for example, a design suitable for both paediatric and adults would be advantageous.
- DS should rest nicely and sit comfortably on a user's neck.
- Rather than being bulky and huge, it should be close to the size of a conventional stethoscope.
- DS should incorporate soft material such as double rubber. It is recommended this kind of material be used in parts such as earpieces.
- It may be beneficial to design a shock-proof DS as they are more vulnerable to damage by falls in comparison to conventional ones because of they are essentially a sensitive electronic device.

Findings from this study show that design of the chest piece could be an important aspect affecting usage from clinicians' perspective. The findings imply that to gain acceptance from clinicians the shape and design of the chest piece needs to be appropriate to sit properly on the body without being too curved to develop a gap between the DS and the patient's body. The chest piece should also be available for paediatric usage.

Earpiece design needs to be considered by DS manufacturers as it appears to be a significant aspect in rejection of usage by clinicians. If the device fits snugly into a clinician's auditory canal, then it may filter unwanted sounds such as other people chatting or noises coming from other medical devices in the room from the physical environment,. The material used in the manufacture of the ear pieces is also an important aspect. Hard material could cause pain in clinicians' ears since they wear stethoscopes regularly during their practice. Australian clinicians expressed dissatisfaction with the design and fitting of one of the DS ear pieces. This difficulty was also confirmed during observation. The ear piece holds one of the highest referenced factors by Australian clinicians, which suggests it has a high impact on acceptance and usage of DS. Thus, inappropriate ear pieces could result in problems in receiving proper sound which may impact on correct diagnoses. Ear pieces should fit inside the ears well and need to be soft enough not to harm clinicians' ears. If DS are used via telehealth, a well-fitted device should also be used at the end location to obtain the best result from the captured and transmitted sound.

The above design characteristics have not been addressed significantly in other studies as one of the acceptance and usage factors, however, LeRouge et al (2004) mentioned 'ergonomic design' as a system quality factor that impacts on the usage of medical technologies in telehealth settings.

The majority of design characteristics identified in this study were addressed in the preliminary conceptual model based on DS manufacturers' product information.

According to the Indian case, clinicians would prefer to wear a comfortable DS. Comfort concerns the earpieces and the way it feel in the clinicians' ears. Although earpiece design may be problematic and cause pain in the ears, clinicians should make sure that they wear DS correctly as some DS earpieces may be designed slightly differently to conventional stethoscopes. Somewhat similarly, Yarbrough and Smith (2007) suggest that the level of comfort physicians have with technology would be a factor in their acceptance of technology.

The recording option of DS appears to be the most advantageous feature identified in this study over a conventional stethoscope. This study suggests that DS featuring a recording option may entail the following benefits:

- A copy of captured sound could be stored and later sent to other clinicians for review of diagnosis
- Multiple copies of data could be provided for different medical cases
- A copy can be stored and used for education and training purposes
- The recorded information could form part of a patient's electronic medical record.

Similarly, Harsola, Thale and Panse (2011) in their study suggested the development of a digital stethoscope with recording options so that physicians could record and retrieve the data for future references.

Moreover, a recording facility is suggested as an option for DS to make it an ideal tool to record and play selected sounds for educational purposes.

Earlier in this section reference was made to DS being a useful device for educational purpose. This could be used not only for real time education, but the usage of DS could store and forward types of learning by capturing abnormalities such as murmur by an expert cardiologist, recording it and sending it to medical students or other clinicians to practise their skills. DS have the potential to be introduced and used as a main component for tele-education courses, especially medical courses.

Amplification was an available option for all tested DS in this study. As shown in the previous chapter, this feature was discussed extensively by clinicians in India and Australia. The majority of dissatisfaction with amplification may relate to the fact that either this is a useless option, or it requires special skills to control amplification of the sound through a digital stethoscope. Clinicians who tested DS for this study showed more satisfaction when they set the amplification to the 'off' position. If added to DS, this option needs to be controlled by users. Therefore, training in use of this option would be recommended.

This study suggests that a usable DS should only amplify body sounds, rather than amplifying both the body sounds and unwanted sounds such as background noises. This feature would lessen user dissatisfaction. Participants complained about unwanted sounds being amplified along with heart and lung sounds. This was observed with Australian clinicians where crackling occurred or other noises were received from the system, resulting in clinicians becoming very annoyed and having to take the DS away from their ears.

A solution to control the amplification could be a touch sensor or a distance sensor so it starts switching on the amplifier only when it touches the skin. A noise filter option could also be considered in the design of a DS.

This study implies that DS may be a useful medical device for clinicians with hearing problems. Similarly, Belloni et al (2010) suggest the development of a new digital stethoscope would help physicians with acoustic diseases. In this study, a volume control appears to be an essential feature required by users of DS, especially for senior doctors or clinicians with impaired hearing. This option should be designed very simply and straightforwardly. A reversible option for frequency mode may be an option for a quality DS. Reviewing the literature did not identify this particular factor as part of DS quality and may be unique to this study.

The findings of this study suggest if a DS does not have the capability to be connected to other devices and systems then its use may be rejected by clinicians in telehealth settings. A usable DS would be expected to have the ability to upload the captured sound either via Bluetooth or a USB. An infrared technology may not be an advantage for a DS anymore since in Queensland, Australia as it is not compatible with the Queensland telehealth system. Reichert et al (2009) mention simplicity of connection as one of the most important features in medical device profiles; moreover reconnections need to be easy to avoid loss of valuable time by clinicians. Therefore, a Bluetooth medical device profile that allows connecting a telehealth device, including DS, to a computing unit is suggested. Bluetooth technology appears to be an advantage for DS as it allows the use of wireless, non-bulky and transportable medical technologies in emergency situations via telehealth; this aspect was also briefly addressed in the literature (Reichert et al 2009).

Another advantage of DS is its compatibility with advanced global technology, especially in telehealth systems. Logically, if a digital stethoscope does not have improved technology and features, it may fail to be used by clinicians for a longer time due to incompatibility with similar improved technologies used in medical practices. Also, a DS with no physical tube which connects the earpieces wirelessly to the chest piece may be an option to be considered for future DS development. Similarly NASA has developed the wireless 'LifeGuard' system. This real time system is a lightweight, portable device that enables physicians to check the health and safety of explorers in remote locations by monitoring vital parameters such as heart rate, blood pressure, electrocardiogram, breathing rate, and temperature (NASA 2011).

Based on the findings of this study, it is suggested a DS have a digital display option so clinicians can track the status of the device such as mode, amplification, volume level and player. By adding other options to DS such as special software, it will be possible for clinicians to see and read the graphs developed based on the heart sound data. This may enhance their ability to make a more accurate diagnosis and their options will not be limited to listening only to the captured sound. They will also be able to evaluate the heart and lung sound by reviewing a visual conversion of sound signals as wave forms. Harsola et al (2011) suggest development of a digital stethoscope which includes a graphic LCD accompanied software so clinicians are able to plot the graph and make diagnoses based on visual and audio representation. Also, Belloni et al (2010) suggest the use of auscultation management software tool in their study, which allows management, visualisation and playback of the heart sound.

Closely linked with the notion of reliability, is battery longevity and level of battery dependency from clinicians' perspective. Battery life is recognised as a common issue with all electronic devices, especially medical technologies (Microsemi Corporation 2011; Mudawi & Kaye 2008). However, DS as a medical instrument should be highly trusted, especially in emergency situations. Clinicians may be interrupted while using DS by low level of battery, leading to difficulties in making a diagnosis. Clinicians may not be able to afford to use an unreliable, battery-dependent device when making diagnoses. It may also be a stressful situation for clinicians to choose to use a digital stethoscope despite its advantages over a conventional one. A solution would be the addition of a battery level indicator to increase clinicians' trust toward DS and decrease their stress—but consequently increase the quality of the system to be used by clinicians.

Moreover, the process of changing a battery should be easy and quick as clinicians' time is highly dedicated to medical tasks and, most of the time, they are involved in life saving situations. Another solution to the battery problem would be a fold back option so the user could use a DS as a conventional one in the event of battery failure.

Reliability of system in use has been extensively mentioned in IS and telehealth evaluation studies (see table 2.5). Unexpectedly, the term 'reliability' of the DS in a telehealth setting was not seen as a significant issue by participants in both case studies. This may be because the DS was not tested with real patients in special situations like a medical emergency, and therefore, clinicians did not foresee the importance of the term reliability. While findings from this study showed that clinicians' interest is more toward DS quality rather than reliability (see table 7.1 and table 7.8), one previous study attempted to address a similar (but not exact) issue. In their study of assessment of radiology imaging technology, Pare et al (2005) indicate that reliability was not significantly linked to clinician satisfaction and image quality appeared to be a more important factor from clinicians'' perspective.

However, there was another factor identified by clinicians associated with their trust toward the system and the impact on reliability, namely, battery life. Battery life as a characteristic of a DS was discussed earlier in this section. Battery life and system reliability appear to have a close link with each other. Therefore, clinicians expressed concern regarding using an electronic device while it has limitations such as dependency on batteries. Battery life appeared to be an important issue in other studies conducted within medical technology context. For example, a study by Bleser et al (2010) suggests that battery life plays an important role in the accuracy of the Medication Electronic Monitoring System. Moreover, Microsemi Corporation (2011) indicates medical portable devices used in telehealth must be capable of running from their own batteries for long periods to maintain a high level of autonomy. Nevertheless, it appears from the literature review that no study has raised this particular issue in a telehealth system.

Implication of findings reveal that battery life is linked with DS quality and could affect reading of visual display and influence the overall trust and reliability of system. In Australia, timeliness of DS as a medical device to aid clinicians in making diagnoses is a quality issue. Timeliness itself is a factor that is influenced by other factors according to findings of this study. If a DS is easy to use, capable of capturing and sending quality sound and compatible with the telehealth systems, then it could be an appropriate medical device for telehealth in making diagnoses. The benefits of using DS has been experienced in a Canadian health service, as the provincial manager for Alberta Clinical Telehealth and, as a 20-year cardiac nurse says, 'digital stethoscopes are as effective for diagnosing heart and lung issues as their non-digital counterparts' (Alberta Health Services 2011)

8.2.2 Information quality

This study demonstrates that the quality of information received from the system is very important for users and could impact their perception toward accepting and using DS in a telehealth setting. According to the findings of this study and evident in the previous chapter, 'noise' is the most frequently discussed topic and appears to have a high impact on clinicians' acceptance and intention to use. Similarly, this attribute has been identified from the literature, for example, Schmidt et al (2007) mentions that one of the problems related to the analysis of recorded heart sounds is that they often are contaminated with background noise and noise caused by friction between the stethoscope and the skin.

It should be noted that according to findings of this study the quality of received sound from DS through a telehealth system could be influenced by other factors, most importantly noise. Noise and the skill-level of users had an impact on the quality of captured sound via digital stethoscope in both cases in India and Australia.

Body sounds such as heart sound will be captured and transmitted through communication networks, while disturbance and noise could occur during sound capturing and transmission. As mentioned by clinicians, output quality could be defined as sound audibility, clarity and quality. However skill-level of users and noise have a direct effect on audibility, clarity and quality of produced sound.

Disturbance is not always from the device or a patient's body: it could be produced by the physical environment where the DS is used. Therefore, a quiet room is required for examining the patient.

The skill of the clinician in positioning the chest piece on the correct spot of the patient's body is very important in providing satisfactory results for the user at the other end of the system to hear a quality, audible and clear heart sound to make a diagnosis. Since Australian participants were observed to experience the impact of background noise on the quality, clarity and audibility of heart sound received from DS via telehealth network, they were unable to make a diagnosis based on what they heard. This suggests that background noise could change the quality of heart sound, and make clinicians at the other end of the system distracted—leading to a failure to make a diagnosis. Consequently, clinicians may perceive DS as a useless device to make a diagnosis via telehealth; and may decrease their level of trust toward this technology and reject its usage. However, it should be noted that clinicians may be satisfied with a DS's features and design, but these factors would not be enough for accepting and using the DS via a telehealth system.

The literature also addressed the importance of the impact of the physical environment on the quality of telehealth systems. LeRouge et al (2004, p 4), suggest 'telemedicine information quality attributes should include attributes that facilitate capturing appropriate input for collaborative communication for example aspects of the physical environment'. The findings of this study suggest in order to minimise disturbance, the examination room should be sound proof and, if possible, quiet during use of DS. A position locator manual is required if the skill of the clinician using the stethoscope is inadequate. Moreover, intensive training would teach DS users about the process of controlling preventable unwanted sound and noise produced from a patient's body and clothes or from the environment in order to make the other end user satisfied with the quality of the received sound. Also superior attention is required to use DS in terms of moving and holding the chest piece on a male patient with a hairy chest to minimise the disturbance for usage at the other end of the system. Similarly, Visagie et al (2009) purport that the reason for noisy and poor quality of sound is that the DS did not make sufficient contact with the patient's body. Additionally, a usable DS from clinicians' perspective should be able to control and remove unwanted body sounds such as gastric or bowel noise for better usage and only amplify heart or lung sound rather than unwanted noises. Bellondi, Giustina and Malcangi (2010) propose a new digital stethoscope to be developed with enhanced performances in environmental noise reduction via a distortionless electronic filter.

Noise and external disturbance were not the only factors which influenced the quality of received information from the system from clinicians' viewpoint. The skill of placing a DS in the right position and auscultation appeared to be important attributes in satisfaction levels of information quality. Clinicians' skills in using stethoscopes properly for these purposes appear to be an issue affecting the quality of information received from the system. Placing a stethoscope in the wrong position could result in poor quality information, particularly in relation to heart and lung sounds. Similarly, Visagie et al (2009) indicate the reason for excessive noise might be that the digital stethoscope was not placed on the exact auscultation point.

All these issues relate to the level of skill that a clinician has already gained in the proper use of a conventional stethoscope; and the same skills could be applied when using a DS. It should be noted that when used via telehealth, the person who places a digital stethoscope on the patient to provide information for doctors at the other end may not necessarily be a doctor—they could be a nurse. Therefore, the skill level of positioning a stethoscope and auscultation could vary among clinicians. This has been observed in Australia where nurses spent more time and effort to hear patient's heart sound, especially a patient with a heart murmur, via DS and provide satisfactory sound for the doctors at the other end of telehealth system. The findings of this study confirm the findings from the literature. For example, in their study, Dahl et al (2002, p229) suggest the main difference between a real clinical versus a telemedicine consultation for the cardiologist is the fact that in the latter, the cardiologist has to rely on the sounds selected and recorded by somebody else, possibly with less experience.

Telehealth managers should pay attention to the skill level of the clinician who places a DS via telehealth in order to provide the doctor at the other end with clear, audible and high quality sound to make a diagnosis. Although clinicians may require years of practice to acquire the skill to distinguish different sounds, for instance a murmur, through DS, the appropriate positioning of the DS and capturing suitable sounds could affect the quality of sound and, consequently, impact on the clinician's ability to recognise the correct sound.

A recording option for DS could provide the opportunity for clinicians to practise and improve their skill by recording the body sound and sending it through to experts for assessment. The value of such skills that clinicians should gain in advance to be able to use stethoscopes properly and make a diagnosis is substantial. Despite these factors that impact the quality of input to the system, clinicians expect to obtain audible, clear and high quality of sound from the system to be able to make a diagnosis.

Sound audibility is regarded as one of the most important factors from the perspective of Indian clinicians (second most important according to table 8.1) that underpins the quality of output. Received sound not only needs to be audible, but clarity is also very important. Similarly, digital stethoscopes are being used at several Alberta Health Services facilities and the provincial manager for Clinical Telehealth asserts, 'The quality of the sound is amazing, our physicians are extremely impressed. It truly does sound like the patient is right there' (Alberta Health Services 2011).

Of course, if clinicians at the receiving end cannot hear anything from their earpieces it would result in a complete failure to use the system. Of prime importance for users (and which was observed in Australia) is the ability to receive an output from the system. Clinicians may need to be given instructions by telehealth technical managers on how to use the system properly. This study implies basic technical actions that may be required for successfully using the system and receiving the captured sound via telehealth from the earpieces. These include:

- turning on the DS
- connecting the ear pieces
- checking the volume level; and
- checking the compatibility of DS with the telehealth system.

These outcomes were derived from the findings of observation and analysis of transcripts. As stated in the previous chapter, one doctor was unable to hear any sound, which was the result of testing a DS which had been turned off. Contrary to a conventional stethoscope, a digital stethoscope may not be usable immediately it is placed on a patient, therefore, this device—as with many other electronic devices—has limitations and special methods of usage.

This study shows that a DS with a very low level of volume could emit a faint sound. Moreover, use of low quality ear pieces or earphones could result in poor audibility and dissatisfaction among clinicians.

An infrared DS may not provide information for the 'other end' clinician, despite the DS itself capturing the body sound perfectly and satisfying the clinician examining the patient. Observed clinicians in Australia received audible sound from DS, but the device failed to connect to the telehealth system and send the information through the communication network to the receiving doctor. Obviously, health managers would not like to experience rejection from clinicians in using DS in telehealth setting because of failing to follow basic and simple steps in operating the technology.

Even though, failure to follow the above instructions may impact on clinicians' satisfaction with the received information, the quality of input could impact particular sound that is expected to be audible enough. For example, if a nurse did not have enough skill to place the DS on the right spot to capture and send the sound of a murmur to a doctor at the other end, it results in the failure of the doctor to diagnose the murmur. Although special skills are needed by doctors to recognise the murmur, a system where DS is deployed may fail to provide an audible murmur to enable the doctor to make a diagnosis.

Conventional stethoscopes are known to provide sound closely mirroring natural body sounds. Received sound from a telehealth system where DS is deployed should not be artificial; rather it needs to be clear, high quality and natural.

Findings from this study confirm the literature, for example, Squibb (1999) recommends that the captured sound should be as close to the natural audio level as possible. Additionally, LeRouge (2002) in her study highlighted that higher levels of audio clarity are required with specialised equipment such as electronic stethoscopes. Therefore, in order to successfully use a digital stethoscope to make a diagnosis, particular aspects of output information need to be considered. These include sound quality, sound clarity and sound audibility—all of which contribute to the overall quality of received information from the system.

8.2.3 Use

A number of factors identified in this study and reviewed in section 8.2.1 and 8.2.2 of these chapters had a direct or indirect impact on the level of use of digital stethoscopes by clinicians in Australia and India. Findings from this study imply that information, system and service quality factors influence the usage of DS. Moreover, by cross tabulating the transcripts via Nvivo, it was possible to identify the linkage between intimacy toward traditional devices, price, DS lifetime and training and intention to use which lead to actual usage. However, there are another four factors from the Indian study and four factors from the Australian study that directly affect the usage which will now be discussed.

Cost of DS is an important issue for Indian clinicians when considering usage in their daily practice or via telehealth system. Extensive use of DS and similar medical equipment in Indian telehealth systems could depend on price. Findings of this study show a tight relationship between cost and acceptability, which consequently influences the intention to use the DS. While cost has a high effect on Indian clinicians' usage of DS, Australians revealed moderate attention toward DS price. This may be because of the differences in health systems, budget and management between these two countries. In Australia, health sectors receive government budgets and rebates for e-health and telehealth projects. For example, $120.5 million has been provided in the Commonwealth Government's budget to fund new Medicare rebates for telehealth services (Dearne 2011). Therefore, successful introduction and usage of DS for Australian telehealth sectors could be less dependent on affordability, whereas different impact of cost on usage may be applied in India. It should be noted that the above factor would have less impact on a doctor's usage of DS since doctors are willing to pay for an expensive DS, whereas this may not be the case with nurses or medical students. This could be due to the fact that doctors have higher incomes and are more able to afford an expensive DS.

Literature also addressed the issue of cost. Yarbrough and Smith (2007) conducted a systematic review of the literature on physicians' acceptance of technology. They revealed that cost might not be an important factor in the level of acceptance by physicians in health organisations. They suggest in their study that where technology is not individually financed by physicians or is already in place, then cost may not be a barrier to technology acceptance.

Training prior and during use of a DS is another key factor that needs to be considered by health managers in India. Clinicians could be trained for improved and accurate positioning of DS on patients. Providing simple instructions would be an option.

Clinicians who are responsible for making diagnoses from the system's output must have received adequate training during their study at medical school, however, special training could be required for proper use of the system and to distinguish between different noises and body sounds. Training appears to play a key role in the successful adoption of DS in India, despite the fact that a few doctors may find it a useless service because of their level of education. Stevenson (2008) conducted a telehealth case study and highlights the importance of training for clinicians when introducing new telehealth systems. Moreover, the study by Stevenson (2008) suggests further training, particularly for the mechanism of using telehealth systems, use of room, telehealth technologies such as cameras, and any display systems.

Contrastingly, in the Australian study, training was not frequently mentioned by clinicians, although the need for adequate training has been identified indirectly from interpretation of the findings. Australian clinicians showed a high interest in ease of use of DS in this study. Additionally, according to data analysis of observation and focus groups, clinicians' efforts in understanding DS features revealed their confusion regarding connecting DS to the system and appropriate usage of DS via telehealth system and the fact that they may need training prior to use this new medical technology, namely, the digital stethoscope.

Providing medical training in order to make diagnoses would be a controversial issue and fundamental topic for clinicians at medical schools—but this aspect is not within the scope of this study. Furthermore, literature identified that it is difficult for physicians to acquire skills to identify abnormalities and no commercial device exists to assist them with this skill (Kokemoer & Scheffer 2008; March et al 2005; Obaidat 1993).

Findings from the Australian case study showed strong intimacy toward conventional stethoscopes and clinicians expressed the view that a traditional stethoscope is simple to use, comfortable and straightforward. Therefore, if clinicians reject the use of DS it could be an indication of their doubt toward this new technology since they may have the impression that the DS could be less comfortable and more complicated for them than the traditional one.

Subsequently, intimacy toward a device emerged to be an important aspect for clinicians in accepting and using the new DS. They need to feel some intimacy with the DS in order to accept and use it. To enable this, a solution is recommended based on the findings of this study. An extensive utilisation of digital stethoscopes at medical colleges and schools is suggested to replace traditional types of stethoscopes to generate the same intimacy toward DS over a period of time and enable graduate clinicians starting their professional job to be familiar with DS and use it via telehealth systems.

Clinicians need to psychologically feel close and comfortable with a device to accept it and use it. Furthermore, if a DS looks similar to a traditional one from all aspects including design and method of use, there may be an increased chance of it being accepted and used by clinicians in telehealth systems. Similarly, a study by Lapinsky et al (2004) stresses the importance of familiarity with the technology which will probably increase the level of acceptance by physicians.

Despite high levels of education among clinicians, especially doctors, special training in using a DS would be highly recommended based on findings of this study. Training is required for positioning the DS on patients and working with various features of DS itself. Indian clinicians showed more interests toward receiving training, whereas in Australia clinicians briefly addressed the term training during focus group discussions. However, based on interpretation of their statements, Australian clinicians indirectly addressed the need for training. While discussing ‘skill-level of user’ and ‘ease of use’, clinicians suggested training as a solution to increase the skill of positioning DS on patients; also proper training could decrease their level of anxiety toward the complexity of DS. Training for cardiac tools has been addressed in the literature in order to have better usage of medical tools to make a diagnosis. For example, Xie et al (1988) in their study highlighted the importance of training for physicians using the ultrasound stethoscope. Also, Stevenson (2008) highlighted the term training for developers and researchers as a necessity to be provided for clinicians to prepare them in the use of advanced generation of telehealth systems in a tertiary healthcare setting. By providing training in the mechanism of using telehealth, Stevenson (2008) and his research team identified that clinicians were able to very quickly understand the system and its mechanism.

Since clinicians in their daily practice tend to use their conventional stethoscope as long as it continues working (which may be for up to ten years), they may expect the same longevity from DS.

Unlike earlier medical technologies such as conventional stethoscopes, which were thrust upon the health community and commonly used, digital stethoscopes have not been available to be used individually or via telehealth systems. Clinicians raised issues that may encourage them to accept the new technology in their workplace. Overall satisfaction with testing the product appeared to lead to acceptance. Although satisfactory results were important for the participants to accept the device within a telehealth system, clinicians also pointed out the importance of training or updating their skills.

Feeling familiar with a new technology may result in increased acceptance. For example, if users feel the same familiarity that they feel with conventional stethoscopes then they may adopt the DS. Since the majority of participants indicated they did not intend to use DS in the future then the factors that could influence their intention needs to be reviewed. Training, price and intimacy with traditional devices appear to be barriers to acceptance and use of DS.

It would appear from the comments by clinicians that they need to be convinced regarding adoption of the DS. This means that they may not choose to use DS based on their previous perception toward DS, thus, a high quality marketing push may be required to challenge their resistance toward using DS and educating clinicians on the advantages of DS.

Since DS are not extensively used among clinicians in Queensland Health and particularly within Qld Telehealth, clinicians' attitude toward using this medical technology could be an important issue that impacts the level and frequency of usage in the future. Based on findings from the exploratory Australian case study, the majority of clinicians showed little interest in using DS for a variety of reasons. Some of them were unconvinced about the device and many of them showed their disappointment with the received quality of sound through the system. Moreover, the usefulness of DS needs to be highlighted and clinicians should be made aware that the use of DS could bring benefits to them and their patients by increasing the quality of healthcare.

It appears that once clinicians perceived DS as a better device in comparison to a traditional stethoscope, and provided they have a similar look and design, then they may accept and use it in the future.

Additionally, if clinicians perceive a DS as a useful and easy to use medical technology, then it may be possible that they will use it in the future. The findings from this study that identified the factors that impact the information and system quality should be considered as the factors influencing clinicians' intention to use a DS in the future.

Similarly, the interpretation of Indian case study findings reveal that if clinicians find DS a useful technology, and is compatible with global advanced technology, comfortable to use, have familiar feeling towards it, are provided with adequate training and feel satisfied with the quality of received information through the system, then it is likely that they will accept it and use it in their daily workplace and within telehealth systems in the future. Since one participant expressed conservatism, this may explain that clinicians could be resistant to changing their routine, daily practice and use of every-day devices. It should be noted that feeling unfamiliar with DS a new medical technology could be a barrier to acceptance and usage.

8.2.4 Service Quality

Quality of service received from the system provider or health management group did not appear to be an important issue affecting the usage of DS by clinicians. Follow up services such as maintenance and warranty could be an advantage for the users of DS via telehealth systems.

8.2.5 User satisfaction

This study explored the clinicians' perception, either satisfied or dissatisfied, of using digital stethoscopes via telehealth. In this study the term 'user satisfaction' was interpreted based on clinicians' expectation of information quality, system quality and service quality. However, as discussed in chapter 2 of this dissertation, studies from the literature have investigated clinician satisfaction of using technology from various aspects. A number of studies have suggested a high rate of effectiveness of telehealth technology in terms of user satisfaction (Gustke et al, 2000; Melcer et al, 2002; Bynum et al, 2006; Gaggioli, 2005; Olver, 2000; Tang et al, 2006). Literature suggests user satisfaction as one of the most popular criterion telehealth evaluation studies tended to assess.

Similarly, findings of this study explored clinicians' satisfaction or dissatisfaction toward using DS though focus group discussion and observation. There are no specific criteria or instruments suggested to evaluate user satisfaction, hence, this study shows that in order to understand and evaluate clinicians' satisfaction of using a medical technology, information quality and system quality needs to be evaluated. It is possible that if clinicians are satisfied with the system quality, information quality, and service quality of deployed DS in telehealth setting, then their level of overall satisfaction would be highly rated and may impact on their intention to use the system in the future for their daily practice.

The top five mentioned factors within the Australian case were noise, DS design, sound quality, sound audibility and ear and headpiece design and quality. The five most important factors identified by Indian doctors were usefulness, sound audibility, noise, DS design and cost (see table 8.2).

Five most referenced factors from the findings				
India			**Australia**	
Factor	***Total references***		***Factor***	***Total references***
Usefulness	105		Noise	79
Sound Audibility	67		DS Design	53
Noise	59		Sound Quality	42
DS Design	56		Sound Audibility	30
Cost	50		Ear & Head Piece Quality	25

Table 8.2: Comparison table for top five referenced factors

As inferred from the findings, Australian clinicians were not interested with details such as design features, connectivity, or compatibility with a telehealth system. Rather, they were concerned about the quality of output from the system and all factors that could affect their diagnosis. On the other hand, Indian clinicians expressed concern regarding both quality of output from the system and their level of acceptance and use of DS being affected by some design features—as well as cost considerations. Level of affordability to purchase a device and use it would be an issue in countries like India, whereas, Australian clinicians do not generally face the same lack of financial resources.

Acceptability was a factor only addressed within the Indian case study. However, Australian clinicians indirectly addressed accepting a DS while discussing their intention to use. It should be noted that 'Intimacy toward traditional stethoscope' appears to be a unique factor for Australian clinicians that influenced their intention to use DS in the future, whereas Indian clinicians did not address this issue. This may be due to the fact that Indian clinicians are more likely to accept and use new technology and have less attachment to their medical devices and are more open to accepting new technologies such as a digital stethoscope in their daily practice.

The rest of the factors were common with the Australian case. However, a couple of factors appeared to be unique for the Australian case, namely, timeliness of diagnosis, hearing impaired friendliness, shock proof, noise filtering, foldback option, user friendliness and position locator.

8.3 Answering the research question and sub-question

This study has provided data that made it possible to address the research question: 'What are the clinicians' perceptions of using digital stethoscopes in a telehealth context?' and the related sub-questions. A conceptual framework was used as a guide to explore the research questions under the two case studies in this interpretivist study.

Perceptions of clinicians from both case studies appeared to be consistent, as discussed in the previous section.

Subquestion1: What issues contribute to information quality and system quality of deployed digital stethoscope in telehealth setting?

This study identified the factors that could contribute to information quality and system qualities of deployed digital stethoscopes in a telehealth setting (refer to chapter 7 and section 8.2). Factors that influenced clinicians' intention to use the DS were also investigated, identified and discussed (refer to section 8.2.3). Factors that together explain system quality of telehealth system where DS is deployed are indicated in the following box:

- **Usefulness,**
- **Ease of Use,**
- **Education Friendliness,**
- **Response Time,**
- **Reliability**
- **Timeliness for Diagnosis**
- **Flexibility**
- **User Friendliness**
- **DS Quality,**
    - **Recording facility,**
    - **Amplification,**
    - **Ear &Head piece,**
    - **Connectivity,**
    - **Telehealth Compatibility**
    - **Visual Display and Editing Software,**
    - **Volume Control,**
    - **Battery Life,**
    - **Comfort,**
    - **Frequency Mode**
    - **Hearing Impaired Friendliness**
    - **Shock Proof**
    - **Noise Filtering**
    - **Wireless DS**
    - **Foldback Option**
    - **DS Design**
        - **Diaphragm Design,**
        - **DS Weight,**
        - **Chest Piece Design,**
        - **DS Shape,**
        - **DS Size,**
        - **DS Tube Length and Shape,**
        - **DS Base Material**

→ System Quality

Also, this study indicates that factors named as input quality may impact the quality of output from the system that together explain the information quality. This is indicated in the following box:

- **Skill – level of user**
- **Noise**

→

- **Audibility Quality**
- **Clarity Quality**
- **Sound Quality**

→ Information Quality

Subquestion2: What issues influence clinicians' satisfaction and intension to use DS?

As discussed in section 8.2.5 of this chapter information system and service quality—identified as themes in this study through interpretation of clinicians' statements and observations of their usage—were found to influence their level of satisfaction with the system directly or indirectly. Therefore, all factors identified in this study under each of these themes explain the clinicians' perception of usage of DS via telehealth and associated level of satisfaction or dissatisfaction with the system.

A summary of the most important issues identified in this study that specifically address this research question are provided as follows:

Each of the following boxes contains factors and themes identified in this study. The arrows mean that a particular factor could have influenced another factor or a theme.

DS Quality → Satisfaction → Use

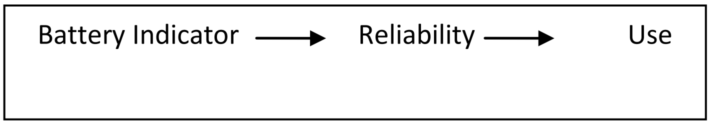
If clinicians are happy and satisfied with the DS quality, including all DS design features, the level of usage of DS may increase.

Training → Perceive Ease of Use → Satisfaction → acceptance → Use
Training → Skilled-Level of user → Input Quality → Output Quality → Satisfaction → Use

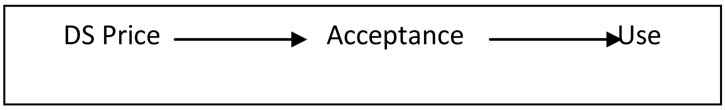
Adequate and proper training in working with the features of the DS and also utilising the DS via a telehealth setting may impact the quality of the information generated from the system and lead to higher user satisfaction and a higher level of usage. Thus, clinicians may find DS easy to use and this would enhance their confidence to accept and use DS in their practice via telehealth.

Intimacy toward DS → Intension to use → acceptance → Use

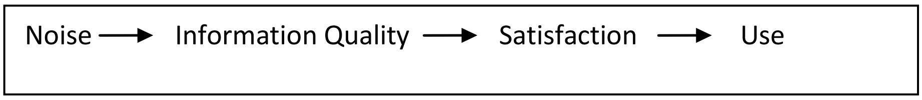
This study revealed that high intimacy toward the usage of a conventional stethoscope in countries such as Australia may lead to rejection of the use of a digital stethoscope. Therefore, if that same intimacy can be generated towards the DS, acceptance and intention to use DS in the future by clinicians may increase.



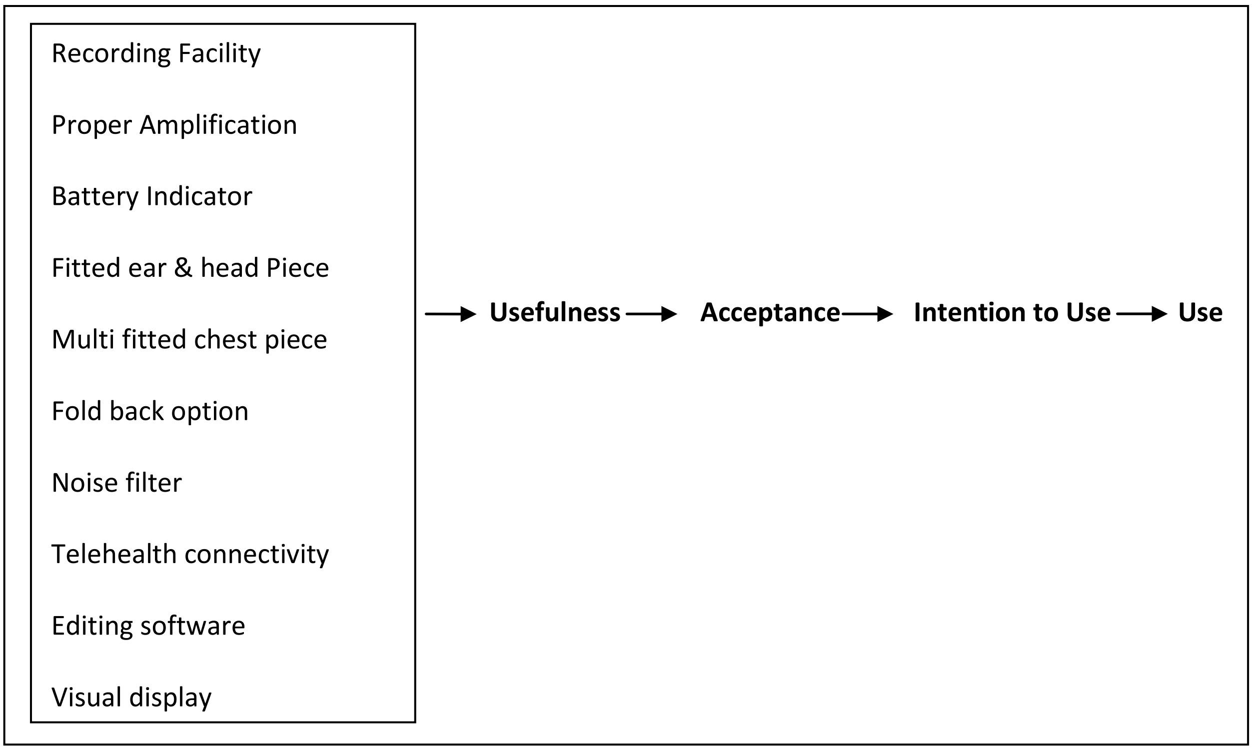
Battery indicator option for DS may provide high level of trust toward the system. Therefore, clinicians may find DS a reliable medical device to be trusted and used.



DS price, particularly in certain countries such as India, could be an important issue impacting the level of acceptance and use of DS.



Preventing noise, either from the environment or from the system itself could lead to enhanced clinician satisfaction of quality of received information from the system and may lead to a higher level of acceptance and DS usage.



A DS which provides a recording facility, proper amplification, battery indicator, fitted ear and head piece, multi fitted chest piece, fold back option, noise filter, telehealth connectivity, editing software and visual display would be perceived as a useful device by clinicians which may lead to a higher level of acceptance and intention to use.

Subquestion3: Is there a potential relationship between the level of clinicians' satisfaction and their intention to use digital stethoscopes in a telehealth context?

A potential relationship between the level of clinicians' satisfaction of the deployed DS in telehealth setting and their intention to use this medical technology was identified. There was a strong link identified between the themes 'satisfaction' and 'use' in this study. While exploring their experience, feeling, perception and level of satisfaction toward DS, clinicians either directly mentioned their intention to use DS in their daily practice or interpretation of their statements entail the likelihood of their usage of DS in future. Factors that could influence levels of satisfaction would be almost similar for both Indian and Australian clinicians, except for some minor differences that have been addressed in section 8.5 of this chapter.

8.4 Conceptual framework to evaluate usage of DS

Preliminary conceptual model

Figure 8.1 depicts the conceptual model for this study which is adapted from TAM and the IS Success model.

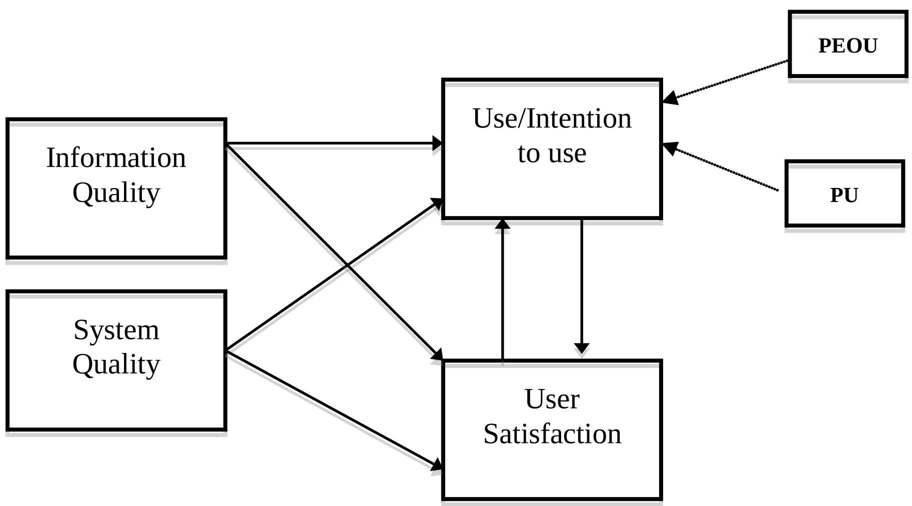


Figure 8.1: Preliminary conceptual model developed for this study

The conceptual model was developed to guide the data collection for this study. According to this model and based on literature review, information quality and system quality appeared to impact the use and user satisfaction of an information system. Moreover, perceived ease of use and usefulness—Technology Acceptance Model (TAM)—also appears to influence the level of acceptance and usage of technology. Within each element of this conceptual model, sets of factors were identified based on reviewing relevant studies discussed in chapter 3 of this dissertation. Consequently, a preliminary framework to assess the usage of a new medical technology (digital stethoscope) in a telehealth setting was developed (see table 8.3). This preliminary framework was designed mainly based on specific attributes of the IS success model such as system quality, information quality, user satisfaction and system use; TAM; and studies that focused on telehealth systems evaluation models along with digital stethoscope technical features.

<table>
<tr><th>Domain</th><th colspan="2">Factors</th></tr>
<tr><td rowspan="2">System Quality</td><td>DS design features and characteristics</td><td>Dimension, weight, base material, colour, diaphragm design, volume control, chest piece design, chest piece material, headset design, headset material, ambient noise filter, battery life, recording facility, connectivity, handy shape, complexity, rational design</td></tr>
<tr><td colspan="2">Reliability, interoperability, ease of use, ease of learning, convenience of access, usefulness, flexibility, reliability, response time, availability, security</td></tr>
<tr><td rowspan="2">Information Quality</td><td>Input quality</td><td>Quiet/sound proof, suitable temperature</td></tr>
<tr><td>Output quality</td><td>Sound quality/clarity, sound accuracy, sound sufficiency, sound timeliness</td></tr>
<tr><td>User Satisfaction</td><td colspan="2">Overall satisfaction</td></tr>
<tr><td>Use</td><td colspan="2">Level of use, frequency of use, perceived ease of use, perceived usefulness</td></tr>
</table>

Table 8.3: Preliminary conceptual framework

Following data collection and analysis, factors that appeared to be important from the clinicians' perspective that may impact their usage of DS were identified and indicated in table 8.1 of this chapter. Through interpreting the findings, some of the factors from table 8.1 were confirmed; some were never or only briefly addressed; and some new factors emerged to be unique for this study in comparison with the factors from the preliminary conceptual framework. However, the majority of those new factors identified for this study were later confirmed by a second review of the literature. Specific factors from the conceptual framework including interoperability, convenience of access, availability, security, flexibility, suitable temperature and DS colour were not addressed or only mentioned briefly by clinicians in this study.

Only those factors which were frequently addressed by participants have been taken in the revised conceptual framework. For example, according to the IS literature, flexibility was a significant factor for system quality (Maryati 2006, Tang et al 2006; Delone & McLean 2003) and was therefore included in the preliminary conceptual framework for this study. However, participants in this study did not consider flexibility of the system to be a significant issue that would impact their usage. Flexibility was identified by only two references in the entire transcripts. However, it may be addressed as an important factor within a different context. It should be noted that this factor or any other factors that were not addressed by participants could be identified as important issues if participants were studied for a longer period of time, for example, through an ethnography study.

New model identified in this study

According to the findings of this study, the conceptual model remained almost the same except for a few changes. Perceived ease of use and usefulness has impact on 'use', but through system quality. Service quality, which was not considered in the conceptual model, has been addressed in this study, therefore, it was one of the elements added to the new model.

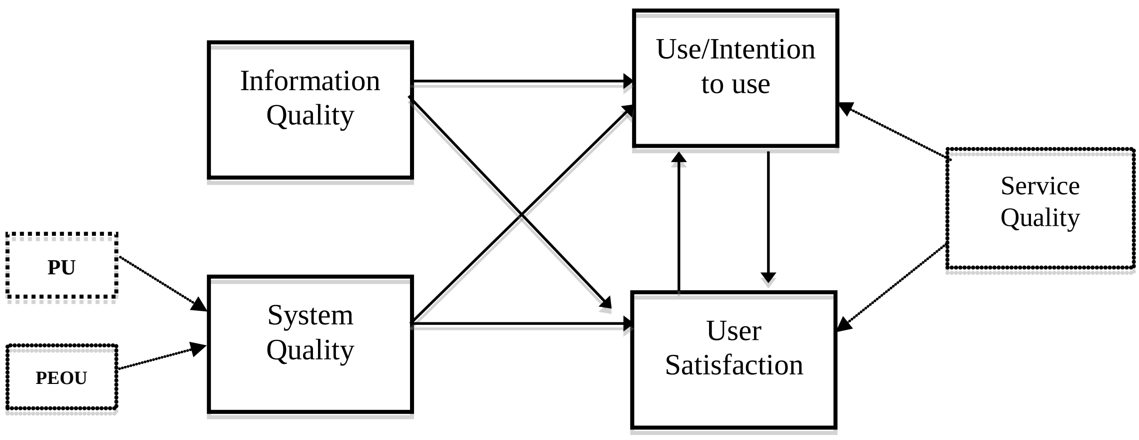


Figure 8.2: Conceptual model developed for this study

The following are factors identified during this study which were not included in the preliminary conceptual framework discussed in chapter 3 of this dissertation and shown in table 8.1 of this chapter. Factors include sound audibility, noise, DS tube shape and length, amplification, training, skill-level of user, education friendliness, comfort, acceptability, frequency mode, follow up services, intimacy toward traditional, cost, telehealth compatibility, hearing impaired friendliness, shock proof, wireless DS, warranty, foldback option, DS lifetime, visual display quality, user friendliness and position locator. These new factors have been reviewed and discussed in chapter 7 and section 8.2 of this chapter.

One outcome of this study is a revised conceptual framework. This framework is represented in table 8.4. The association of each of the themes from table 8.4 such as information quality, system quality, service quality, user satisfaction and ease of use is indicated in figure 8.2 of this chapter.

Less important factors that contain fewer references in this study are shown in *italic* font. Factors shown in table 8.3 have now been incorporated into the revised conceptual framework to evaluate the usage of digital stethoscopes within a telehealth setting (see table 8.4).

<table>
<tr><th><u>SYSTEM QUALITY</u></th><th><u>INFORMATION QUALITY</u></th><th><u>SERVICE QUALITY</u></th><th><u>USE</u></th></tr>
<tr><td>• DS Quality

Recording facility, amplification, Ear &head piece design and quality, connectivity, volume control, visual display quality, editing software, battery life, comfort, frequency mode, hearing impaired friendliness, shock proof,
Other design factor: Noise filtering, DS lifetime, foldback option, wireless DS</td><td>• Input Quality

Noise, Skilled -level of user</td><td>• Follow up Services

•Warranty</td><td>• Intimacy towards traditional

• Training

• Price

• DS lifetime</td></tr>
<tr><td>• DS Design

DS shape, Diaphragm design, weight, size, shape, tube length, DS Material, chest piece design</td><td>• Output Quality

Sound Audibility ,Sound Quality, Sound Clarity</td><td></td><td></td></tr>
<tr><td>• Usefulness</td><td colspan="3" rowspan="7">Conceptual Framework to evaluate the usage of Digital Stethoscopes within a Telehealth systems</td></tr>
<tr><td>• Ease of use</td></tr>
<tr><td>• Timeliness for diagnosis</td></tr>
<tr><td>• Education friendliness</td></tr>
<tr><td>• Response time</td></tr>
<tr><td>• Reliability</td></tr>
<tr><td>• Other factors: Flexibility and user friendliness</td></tr>
</table>

Table 8.4: Conceptual framework developed based on findings of this study

8.5 Chapter summary

This chapter has presented the interpretation of the findings in response to the research question and sub-questions. Summaries of the most important issues identified in this study that specifically address the research questions were also discussed in this chapter. This study shows that the findings from both Indian and Australian cases are consistent, with the exception of a few factor differences. The preliminary conceptual model that was developed based on the literature review to guide the data collection remained almost similar, but the factors have been changed. A conceptual framework was introduced in this chapter to be used to explain clinicians' perceptions and evaluate the use of DS in a telehealth setting.

In the next and final chapter of this dissertation, key recommendations based on findings from this study will be provided. Implications for theory and practice will be reviewed. Finally, limitations of this research and suggestions for future research will be discussed.

CHAPTER 9: CONCLUSION AND FUTURE RESEARCH DIRECTIONS

9.1 Introduction

This exploratory research study has been carried out within both Indian and Australian health institutions in the Information Systems and Telehealth disciplines, exploring clinicians' perceptions of using digital stethoscopes in a telehealth setting. Within the context of this dissertation the term usage is seen to be influenced by a number of other themes and factors identified from the literature and confirmed in this study. The dissertation has explored the relationship between information quality, system quality, service quality and their impact on the level of clinicians' satisfaction and usage of the system.

The key premise informing this research has been that understanding the users' perceptions towards a particular medical technology is required prior to the successful implementation of a telehealth system where Digital Stethoscopes (DS) are deployed. Therefore, to explore how clinicians perceive a digital stethoscope as a medical technology, this study has examined the possible influences on clinicians' satisfaction and intention to use. Perceptions towards DS have been investigated through two different case studies; one study carried out in a developed country, Australia, and the other in a developing country, India. This study found that clinicians' perceptions towards the medical technology appeared to be consistent within both case studies, except for some aspects such as cost and design aspects (refer to section 8.2).

Key findings from this study will be briefly addressed in this chapter to bring the research to a conclusion. Theoretical contributions of this study also will be given. This chapter will outline the practical outcomes of this dissertation. The limitations of the research findings and suggested areas for future research will be also addressed in this chapter.

9.2 Key findings

The findings of this study in response to the research question have been discussed in the previous chapter. The key findings of this study are highlighted as follows:

- Usefulness, ease of use, DS quality, sound quality and audibility attributes appear to be the factors that have significant impact on the extent to which a digital stethoscope is accepted, understood and will be used;
- Medical devices such as digital stethoscopes should be compatible with the telehealth systems within which they are used;
- If a DS is easy to use, capable of capturing and sending quality sound, and compatible with the telehealth system, then it may be an appropriate medical device for telehealth use;
- DS could be used for educational purposes, via telehealth settings, in hospital emergency departments, at pre-anaesthetic divisions and integrated with teleradiology;
- The information quality, service quality and system quality of a telehealth system where a DS is deployed appears to have an impact on the level of user satisfaction and, consequently, may influence clinicians' intention to accept and use the DS in their daily practice; and
- DS quality, training, DS ease of use, output quality and noise filter specifically may influence the level of the clinicians' satisfaction.

The relationship between these findings and the extension of each mentioned factor has been discussed extensively in chapters 7 and 8 of this dissertation. The following sections will summarise the contributions that this dissertation makes to theory and practice.

9.3 Implications/Contribution to theory

This dissertation contributes to the current body of knowledge of Information Systems Success Model. As such the dissertation contributes to both telehealth and Information Systems disciplines. This study has involved the development of a conceptual model in which elements from the Technology Acceptance Model (TAM) by Davis (1989), Information Systems success model by Delone & McLean (1992 & 2002) and a number of telehealth systems evaluation models (as discussed in detail in chapter 3) have been brought together in order to explore the usage of DS in telehealth. Delone and McLean's IS success model (1992) has been used in this study to examine the factors that influence the use of DS within the context of telehealth, along with two factors from TAM which are perceived 'ease of use' and perceived ‘usefulness’. According to the literature, a wide range of factors covered in the IS success model influence the system use; also two mentioned factors from TAM impacts the user’s intention to use the technology. The result of this study confirmed the majority of factors suggested in Delone and McLean’s model to be relevant to evaluate usage of DS via telehealth systems. However, factors from this model did not appear to be enough to explain the usage of the system where DS is deployed with clinicians as the users. Additional influences were also identified and discussed in section 8.7. Also, this research contributes to existing studies into telehealth evaluation, summarised in table 3.1 of this dissertation, by confirming some of the evaluation criteria introduced in those studies that are shown in table 8.3.

The findings from this study have contributed to the current body of knowledge in the following ways:

- The notion of sound quality and the potential impact the skill-level of the user may have on the quality of the received sound from the telehealth system where DS is deployed;
- The characteristic of DS design as a medical technology on clinicians’ satisfaction levels;
- All factors that influence the intention to use DS via a telehealth system; and
- Potential link between clinicians’ satisfaction and their level of acceptance and intention to use DS.

This dissertation contributes to the existing knowledge of ‘technology acceptance’ by Davis (1989) and ‘use’ by Delone and McLean (1992; 2002), however, acceptance and intention to use the DS was introduced uniquely for the first time in this study. Based on the findings of this study, a conceptual framework (see section 8.7) has been introduced which can be used to evaluate the usage of DS via telehealth settings. However, this framework was developed based on two cases, one in India and the other in Australia, so further research involving more cases may allow this model to be generalised. For example, if this model could be tested in a developed country where there has been an established telehealth system for some time and within which DS has been extensively used, then it may provide a better understanding about elements of this framework while evaluating a system in use.

9.4 Implications for practice

Benbasat and Zmud (1999 p. 4) discuss that much information system academic research lacks relevance to practice. The authors explain, 'It is possible to gain insights into what managers find to be interesting and important' (Benbasat and Zmud 1999 p.4). A topic can be interesting and relevant to practice but it does not assure that the research content will be used in practice. This study is extremely relevant to practice because, as identified in the literature, telehealth systems have been rapidly increasing in number and usage in Australia over the last decade. Improving access to health care for patients particularly brings benefits in countries where the traditional delivery of health services is impacted by distance and lack of local specialist clinicians to deliver services (Yellowlees, 2000; Queensland Government 2006).

Exploring clinicians' attitudes and perceptions toward the use of DS could make a practical contribution, particularly in Queensland, Australia, since to date DS has not been extensively used in Australia, and particularly within Queensland Telehealth. Therefore, this research has attempted to provide practical outcomes. The results of the study have contributed to the following areas regarding DS in a telehealth platform:

- **System input and output quality:** The quality of the information received from the telehealth system where DS is deployed is very important for clinicians and could impact their level of acceptance and use. To successfully make a diagnosis using a digital stethoscope, particular aspects of the output information need to be considered. These include sound quality, sound clarity and sound audibility, all of which contribute to the overall quality of received information from the system. Since the quality of received sound from a DS through a telehealth system could be influenced by other factors such as noise and the skill-level of users, the input quality needs to be considered as an important factor and controlled to achieve a better result. Disturbance to the system could be generated from the patient's body and also from the environment. Therefore, this study suggests that in order to minimise any disturbance a soundproof examination room should be provided. Also, the digital stethoscope needs to be placed on the exact auscultation point.

- **DS quality:** Since design appeared to be the core characteristic of DS quality, this study addresses practical implications for technical features of the DS. To improve the potential usage of DS, this study suggests that the earpiece and headpiece needs to be comfortable. Problems associated with these aspects may impact the ability of clinicians to make a correct diagnosis. Therefore, ear and headpieces should fit inside the ears well and need to be soft enough so as not to harm clinicians' ears. Moreover, the chest piece could be available in different sizes for different sectors such as paediatrics. If the chest piece sits properly on the body without being too curved to develop a gap between the DS and the patient's body, it could be accepted by clinicians for use. This study suggests other technical features of the DS that may need to be considered to make it easy to use, namely, battery indicator, fold back option, shock proof, volume control, recording facility, Bluetooth connectivity, visual display and editing software.
- **Training:** Training provided to clinicians is one of the concerns of this study. Even if a noise free transmission of captured sound via the telehealth system resulted in a high quality sound, clinicians still may experience difficulties in hearing and recognising a particular heart sound. Consequently, this issue may result in an incorrect diagnosis. Therefore, training of clinicians who will be responsible for placing the stethoscopes at the other end of the telehealth system, which may be kilometres away from where the doctors are waiting to receive the sound through the system, would be highly recommended. Using a conventional stethoscope is considered a straightforward part of a routine medical examination, whereas there are a number of factors associated with and influencing the usage of DS via telehealth.

The next section will review the limitations of this study and a number of areas for future research will be suggested.

9.5 Limitations and suggestions for future research

Similar to any study, limitations have been identified with this research. This section will review the limitations of this study in terms of the conceptual model, data collection method and findings. Suggestions for future research from each of the above aspects will be discussed in this section.

- Firstly, this study did not involve testing the DS on ‘real’ patients. Rather, tests were carried out by clinicians on clinicians. Since the majority of the clinicians who played the role of patient did not have any health issues, the tested DS only captured body sounds of healthy persons. The test may not have involved a full range of symptoms associated with the heart and lungs. Future research should involve testing the DS on actual patients in order to identify any problems not revealed in this study associated with either the use of the DS or diagnosis. Testing DS on real patients may allow clinicians to use their medical skills and the technology judiciously to understand real patients’ sounds. Moreover, this study highlights Gururajan’s (2007) suggestion that by using an accurate and effective stethoscope, high quality data could be collected from patients which, in turn, can directly lead to better patient management.
- As discussed in chapter one of this dissertation, the scope of this project is not with patients as part of the user group to be studied. As mentioned in chapter two of this dissertation, patient satisfaction appeared to be the most popular criteria that previous telehealth evaluation studies tended to assess. Also, patients are the users of the system who directly benefit from the telehealth system and enhance their medical assessment and diagnosis over remote distances. Therefore, future studies could be carried out to seek patients’ perceptions of using telehealth systems where a DS is deployed and evaluate their level of satisfaction. Also, future studies could assess the level of accuracy of diagnosis before and while using a telehealth system where DS is deployed.
- Recruitment of participants within Queensland Health was one of the challenging aspects of this study. Hence, due to doctors’ highly hectic

medical schedules, only a limited number of clinicians from the health institutions in Queensland accepted the offer to participate in this study.

In this study, the researcher had limited control on sizes of focus groups as the samples are practicing professionals and their work activity took precedence. 'Sampling is the process of selecting a sufficient number of elements from a population to represent the properties or characteristics of that population' (Sekaran, 1992; 226-227). Whilst 19 focus groups from India and 3 from Australia were conducted for this study, the researcher does not consider that the unbalanced focus group sample sizes in India and Australia would have affected the findings. Understanding complex human factors relating to clinicians' behaviour in using DS was more important than generalisability of results. The sample size for this qualitative study appeared to be appropriate since it seems to adequately answer the research question. However, future research could be conducted within either public or private health sectors with a greater number of participants over a longer period of time.

- Since this was an exploratory study, only specific elements of the IS success model were employed to guide the study, along with two elements from TAM and selected factors from telehealth evaluation studies. Future research could be conducted based on the reformulated IS success model by Delone and McLean (2002) to investigate the level of 'Net benefit' to the organisation, an element in the IS success model of using the DS. According to Delone and McLean (2002), 'Net benefit' evaluates the extent to which IS contributes to the success of individuals, groups and organizations. This element is one of the elements of the reformulated IS success model which was not taken into account in the development of the preliminary conceptual framework for this exploratory study. Those factors that were indicated in the preliminary conceptual framework, and only briefly addressed (if at all) in this study, could still remain to guide future studies. If participants from another geographical context or within other qualitative approaches such as ethnography or in-depth interviews could be studied, then those factors may emerge as significant.
- This study developed a conceptual framework to understand the issues associated with usage and successful implementation of DS in a telehealth

environment. Future study is expected to test and improve the suggested framework through quantitative methods within the healthcare profession. The findings of this study could be also used in designing a survey instrument. A quantitative study could be conducted and the statistical analysis of the findings used to confirm or refine the findings of this study. A measurement instrument related to telehealth system quality where DS is deployed could be developed to verify the interrelationship between the factors and the successful usage of system. An instrument to measure user satisfaction could also be developed and tested based on the findings of this study.

- The researcher encountered delays in receiving ethics clearance from Queensland Health—having to wait 10 months, which introduced delays to data collection and analysis in Australia. While ethical approval was an issue, the researcher suggests an alternative for future research might be collecting secondary data with health people being primary researchers in the ethics application with health agencies. Also, students studying for medical or nursing qualifications maybe considered as surrogates.
- Due to financial problems and educational commitments, the researcher was unable to travel to India. Her principal supervisor conducted the focus groups as the moderator based on the developed research protocol. In order to reduce the implications of not being present in focus groups in India, the researcher made regular communication with the research team in India and revisited the recorded video and audio sessions frequently.

9.6 Final comment

While there has been much research on implementation and usage of telehealth systems, the acceptance and usage of digital stethoscope has been underexplored, especially within the Australian context. However, this dissertation addresses the gap in the literature by presenting an exploratory study through interpretive analysis of qualitative data which enlightens the issues that may impact usage of DS. Moreover, the findings of this study have contributed to the existing body of knowledge in Information Systems and Telehealth.

It is suggested that the findings of this study are not the only answers to the research questions which the study set out to answer. However, the researcher expects that the practical outcomes of this study may benefit three different groups: health managers, manufacturers and clinicians.

This chapter concludes the dissertation by summarizing the key findings, addressing the research contributions, making some recommendations, directing research limitations, and highlighting areas for future research. Hopefully the outcome could provide the basis for future work in several areas of health informatics. Moreover, the conceptual framework developed for this dissertation will provide a starting point for further research.

REFERENCES

Abbruscato, RC 1998, *Digital Telephonic System for Stethoscope Signal Processing*, United states.

Adams, GR & Schvaneveldt, JD 1991, *Understanding Research Methods*, Longman, Inc, New York.

Alberta Health Services 2011, *Digital stethoscopes link remote patients with cardiologists*, Alberta Health Services, <http://www.albertahealthservices.ca/3810.asp>.

Alexander, M, Corrigan, A, Hankins, J, Gorski, L & Perucca, R 2009, *Infusion nursing : an evidence-based approach*, 3rd edn, Saunders/Elsevier, St. Louis, Mo.

AMD Global Telemedicine 2008, *AMD-3550 SmartSteth Digital Electronic Stethoscope*, AMD Global Telemedicine Inc., viewed 21 January 2008, <http://www.amdtelemedicine.com/products_detail.cfm?Product_ID=AMD%2D3550&Specialty_ID=CAR500>.

American Heritage Dictionary of the English Language 2006, *Audible*, 4th edn, Houghton Mifflin Harcourt Group Boston, MA

American Heritage Dictionary of the English Language 2007, *Auscultation*, 4th edn, Houghton Mifflin Harcourt Group Boston, MA

American Telemedicine Association 2007, *ATA defining telemedicine*, American Telemedicine Association, viewed 20 January 2008, <http://www.atmeda.org/news/definition.html>.

American Telemedicine Association 2011, *Home Telehealth & Remote Monitoring SIG*, American Telemedicine Association, viewed January 2011, <http://www.americantelemed.org/i4a/pages/index.cfm?pageID=3320>.

Answers Corporation 2008, *Electronic stethoscope*, Answers Corporation, viewed 10 March <http://www.answers.com/topic/stethoscope>.

Armoni, A 2000, *Healthcare information systems : challenges of the new millennium*, Idea Group Pub., Hershey, PA.

Armstrong, ML 1998, *Telecommunications for Health Professionals Providing Successful Distance Education and Telehealth*, Springer Pub. Co, New York.

Australian Bureau of Statistics 2009, *POPULATION DISTRIBUTION*, viewed Jan 2012, <http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4102.0Chapter3002008>.

Australian College of Health Informatics 2002-2011, *Structure and Policies of ACHI*, Australian College of Health Informatics, viewed July 2006, <http://achi.org.au/achi/structure&policies.html>.

Bader, GE & Rossi, CA 1999, *Focus groups : a step-by-step guide* Bader Group, San Diego, CA.

Bailey, JE & Pearson, SW 1983, 'Development of a tool for measuring and analysing computer user satisfaction', *Management Science*, vol. 29, no. 5, pp. 530-45,

Bedini, R, Belardinelli, A, Giansanti, D, Guerriero, L, Macellari, V & Morelli, S 2006, 'Quality assessment and cataloguing of telemedicine applications', *Journal of Telemedicine and Telecare*, vol. 12, no. 4, pp. 189-93,

Belloni, F, Giustina, DD, Riva, M & Malcangi, M 2010, 'A New Digital Stethoscope with Environmental Noise Cancellation ', paper presented to Proceedings of the 12th WSEAS international conference on Mathematical and computational methods in science and engineering Faro, Portugal.

Benbasat, I & Zmud, R 1999, 'Empirical research in information systems: The practice of relevance', *MIS Quarterly*, vol. 23, no. 1, pp. 3-16,

Benbasat, I, Goldstein, DK & Mead, M 1987, 'The case research strategy in studies of information systems', *MIS Quarterly*, vol. 11, no. 3, pp. 369-86,

Berg, B 2007, *Qualitative Research Methods for the Social Sciences*, 6th edn, Pearson Education, Boston.

Bindels, R, Hasman, A, Derickx, M, van Wersch, JWJ & Winkens, RAG 2003, 'User satisfaction with a real-time automated feedback system for general practitioners: a quantitative and qualitative study', *International Journal for Quality in Health Care*, vol. 15, no. 6, pp. 501-8,

Bird, A 2004, *Thomas Kuhn*, Edward N. Zalta edn, March 2010, <http://plato.stanford.edu/archives/fall2009/entries/thomas-kuhn>.

Bischoff's Medical 2008, *Stethoscopes*, Bischoff's Medical Supplies, viewed 22 July 2008, <http://www.bischoffs.com/stethoscopes.htm>.

Bleser, LD, Geest, SD, Vandenbroeck, S, Vanhaecke, J & Dobbels, F 2010, 'How Accurate Are Electronic Monitoring Devices? A Laboratory Study Testing Two Devices to Measure Medication Adherence', *Sensors — Open Access Journal*, vol. 10, no. 3, pp. 1652-60,

Bloor, M & Wood, F 2006, *Keywords in Qualitative Methods: A Vocabulary of Research Concepts*, Sage Publications, London.

Bloor, M, Frankland, J, Thomas, M & Robson, K 2001, *Focus groups in social research*, 1st edn, SAGE, London.

Boland, R & Day, W 1989, 'The experience of system design: a hermeneutic of organizational action', *Scandinavian Journal of Management*, vol. 5, no. 2, pp. 87-104, Bolton, P, Gannon, S & Aro, D 2002, 'HealthConnect: a trial of an after-hours telephone triage service', *Aust Health Rev*, vol. 25, no. 2, pp. 95-103,

Bowen, GA 2006, 'Grounded Theory and Sensitizing Concepts', *International Journal of Qualitative Methods,* vol. 5, no. 3, pp. 1-9,

Bowonder, B, Mohit Bansal, A & Sharnitha Giridhar, A 2005, 'A telemedicine platform: a case study of Apollo hospitals telemedicine project
', *International Journal of Services Technology and Management*, vol. 6, no. 3-5, pp. 449 - 66

Boyatzis, R 1998, *Transforming qualitative information: Thematic analysis and code development,* Sage, Thousand Oaks, CA.

Burns, R 1994, *Introduction to research methods,* Longman, Melbourne.

Burrell, G & Morgan, G 1979, *Sociological Paradigms and Organizational Analysis*, Heinemann.

BusinessDictionary 2010, *focus group*, WebFinance Inc., viewed January 2010, <http://www.businessdictionary.com/definition/focus-group.html>.

Bynum, AB, Cranford, CO, Irwin, CA & Banken, JA 2006, 'Effects of Telemedicine on Patients’ Diagnosis and Treatment', *Journal of telemedicine and Telecare*, vol. 112, no. 1, pp. 39-43,

Byrn, M 2001, 'Interviewing as a data collection method', viewed August 2008, <http://findarticles.com/p/articles/mi_m0FSL/is_2_74/ai_77227780/>

Callahan, PP, Waugh, PR, Mathew, GA & Granger, PR 2007, 'Stethoscopes: What Are We Hearing?', *Biomedical Instrumentation & Technology*, vol. 41, no. 4, pp. 318-23,

Cavana, RY, Delahaye, BL & Sekaran, U 2001, *Applied business research: Qualitative and quantitative methods*, Rory Wiley and Sons, Brisbane.

Cavaye, A 1996, 'Case Study Research: A Multi-Faceted Research Approach', *Information Systems Journal*, vol. 6, pp. 227–42,

Char, A, Kalyanpur, A, Puttanna Gowda, V, Bharathi, A & Singh, J 2010, 'Teleradiology in an inaccessible area of northern India', *Telemed Telecare*, vol. 16, no. 3, pp. 110-3,

Chau, P & Hu, P 2001, 'Information technology acceptance by individual professionals: A model comparison approach', *decision science*, vol. 32, no. 4, p. 699,

Chau, PYK & Hu, P 2002, 'Investigating healthcare professionals’ decisions to accept telemedicine technology: An empirical test of competing theories', *Information & Management*, vol. 39, no. 4, pp. 297-311,

Chizner, M 1996, *Classic Teachings in Clinical Cardiology: A Tribute to W. Proctor Harvey, M.D.*, Laennec Publishing, Cedar Grove, NJ.

Company, M 2006, *Sound*, Fourth Edition edn, The American Heritage Dictionary of the English Language

Corbin, JM & Strauss, AL 2008, *Basics of qualitative research: techniques and procedures for developing grounded theory* Sage Publications, Inc, Thousand Oaks, CA.

Cox, J & Hassard, J 2005, 'Triangulation in Organizational Research: A Re-Presentation', *Organization article,*, vol. 12, no. 1,

Craig, J, and Patterson, V 2005, 'Introduction to the Practice of Telemedicine', *Journal of telemedicine and Telecare*, vol. 11, no. 1, p. 7,

Croteau, A-M, and Vieru, D 2002, 'Telemedicine Adoption by Different Groups of Physicians', paper presented to Proceedings of the 35th Annual Hawaii International Conference on System Sciences (HICSS'02), Hawaii, Big Island.

Dahl, L, Hasvold, P, Arild, E, Hasvold, T, Wren, C, Hasvold, P, Arild, E & Hasvold, T 2002, 'Heart murmurs recorded by a sensor based electronic stethoscope and e-mailed for remote assessment', *Archives of Disease in Childhood*, vol. 87, no. 4, pp. 297–301,

Daly, J, Kellehear, A & Gliksman, M 1997, *The public health researcher: A methodological approach*, Oxford University Press, Melbourne, Australia.

Daly, J, Jogerst, G, Park, J, Kang, Y & Bae, T 2005, 'A nursing home telehealth system: keeping residents connected.', *J Gerontol Nurs*, vol. 31, no. 8, pp. 46-51,

Dansky, K, Jeffrey, A & Duncan, D 2005, 'Marketing Telehealth to Align with Strategy', vol. 50, no. Jan/Feb, pp. 19-32, viewed 18 May 2008, <Online ProQuest>

Darkins, AW & Cary, MA 2000, *Telemedicine and Telehealth Principles, Policies, Performance, and Pitfalls*, Springer Pub. Co., New York.

Davis, FD 1989, 'Perceived usefulness, perceived ease of use and user acceptance of information technology', *MIS Quarterly*, vol. Sep 1989, pp. 319-40,

Davis, FD, Bagozzi, RP & Warshaw, PR 1989, 'User Acceptance of Computer Technology: A Comparison of Two Theoretical Models', *Management Science* vol. 35, no. 8, pp. 982-1003,

Dearne, K 2011, 'Funds injection to spur virtual consultations: initially, rural patients will get most benefit ', *The Australian*, May 14, 2011.

DeLone, WH & McLean, ER 1992, 'Information Systems Success: The Quest for the

Dependent Variable'', *Information Systems Research*, vol. 3, no. 1, pp. 60-95,

DeLone, WH & McLean, ER 2002, 'Information Systems Success Revisited', paper presented to Proceedings of the 35th Hawaii International Conference on System Sciences, Big Island, Hawaii, USA, 7-10 January.

DeLone, WH & McLean, ER 2003, 'The DeLone and McLean Model of Information Systems Success: A Ten-Year Update', *Journal of Management Information Systems*, vol. 19, no. 4, pp. 9–30,

Denzin, N 1978, *the Research Act: A Theoretical Introduction to Sociological Methods*, 2nd edn, McGraw-Hill, New York.

Denzin, NK 1989, *the Research Act*, McGraw-Hill, New York.

Denzin, NK & Lincoln, YS 2000, *The handbook of qualitative research*, 2nd edn, Sage Publications, Thousand Oaks, CA.

Devine, J 2007, *User satisfaction and experience with a telemedicine service for diabetic foot disease in an Australian rural community*, institute of rural clinical services and teaching, NSW.

Dick, P 2000, *Evaluating Telehealth 'Solutions' A Review and Synthesis of the Telehealth Evaluation Literature*, Health Canada, Ottawa, Ontario.

Dictionary.com 2009, *Sound Quality*, Dictionary.com, LLC, viewed March 2009, <http://ask.reference.com/web?q=sound%20quality%20&l=dir&qsrc=2891&o=10616>.

Doarn, C, Anvari, M, Low, T & Broderick, T 2009, 'Evaluation of teleoperated surgical robots in an enclosed undersea environment', *Telemedicine Journal and e-Health*, vol. 15, no. 4, pp. 325-35,

Draper, B 2006, *Telephone Triage for nurses*, viewed 28 May 2006, <http://www3.uthct.edu/nursing/TELETRIAGE.ppt>.

Dufresne, JR, Carim, HM & Drummond, TE 2007, *Power management for medical sensing devices employing multiple sensor signal feature detection*, ST. Paul, MN, United States, 60/919574.

EC21 Inc 2009, *JABES Electronic Stethoscope*, EC21 Inc. , viewed July, <http://gstechno.en.ec21.com/JABES_Electronic_Stethoscope--272266_646985.html>.

Edmunds, H 2001, *The Focus Group Research Handbook*, NCT Business Books, Illinois.

eGeneral Medical 2008, *Stethoscope Manufacturer Information*, eGeneral Medical Inc., viewed June 2008, <http://www.egeneralmedical.com/stmain.html>.

Eisenhardt, KM 1989, 'Building Theories from Case Study Research', *The Academy of Management Review*, vol. 14, no. 4, pp. 532-50,

Elford, R 2007, *Telehealth in the Developing World*, viewed 01 December, <http://www.telehealth.ca/downloads/TelehealthDevelopingWorld.doc>.

Emery, S 1998, *Telemedicine in Hospitals: Issues in Implementation*, National Academies Press, , Washington, D.C.

Encyclopedia of Surgery 2008, *Stethoscope* Advameg, Inc. , <http://www.surgeryencyclopedia.com/St-Wr/Stethoscope.html>.

Field, MJ 1996, *Telemedicine: A Guide to Assessing Telecommunications in Health Care*, National Academies Press, Washington, D.C.

Fishbein, M & Ajzen, I 1975, *Belief, attitude, intention, and behaviour: An introduction to theory and research*, Addison-Wesley, MA.

Fishbein, M & Ajzen, I 1981, *Acceptance, yielding, and impact: Cognitive processes in persuasion*, Elbaum, NJ.

Fitzgerald, G & Howcroft, D 1998, 'Competing dichotomies in IS research and possible strategies for resolution', paper presented to Proceedings of the International Conference on Information Systems, Helsinki.

Flick, U 2002, *An introduction to qualitative research* 2nd edn, Sage, London.

Flick, U 2006, *An introduction to qualitative research* 3rd edn, Sage, London.

Gaggioli, A, Carlo, S, Mantovani, F, Castelnuovo, G & Riva, G 2005, 'A telemedicine survey among Milan doctors', *Telemedicine and Telecare Journal*, vol. 11, no. 1, pp. 29-35,

Gagnon, MP, Lamothe, L, Fortin, JP, Cloutier, A, Godin , G, Gagné, C & Reinharz, D 2004, 'The Impact of Organizational Characteristics on Telehealth Adoption by Hospitals', paper presented to Proceedings of the 37th Hawaii International Conference on System Sciences, Hawaii.

Gibbs, A 1997, 'Focus Group Research', *Social Research Update*, vol. 19, pp. 1-4,

Gibson, W 2006, *Thematic Analysis*, viewed March 2010, <www.ilit.org/air/files/thematic_analysis.doc>.

Global Industry Analysts 2008, *Global Stethoscopes Sales to Reach US$270 Million By 2010, According to a New Report by Global Industry Analysts, Inc.* , Global Industry Analysts, Inc. , viewed December, <http://www.prweb.com/releases/manual_stethoscopes/mechanical_stethoscopes/prweb745684.htm>.

Glossary of Meteorology 2008, *Frequency response* American Meteorological

Society, viewed 10 June 2008, <http://amsglossary.allenpress.com/glossary/browse?s=f&p=40>.

Government of India 2001, *Provisional Census Results Released*, viewed Jan 2012, <http://censusindia.gov.in/Census_Data_2001/Census_Newsletters/Newsletter_Links/News_Issue_no_1.htm>.

Grbich, C 2001, *Qualitative Research in Health: An Introduction*, 2nd edn, Allen & Unwin, St Leonards.

Greenbaum, TL 2000, *Moderating focus groups: A practical guide for group facilitation*, Sage Publications., Thousand Oaks, CA.

Griffee, D 2005, 'research tips: interview data collection', *Journal of development education*, vol. 28, no. 3, p. 36,

Grigsby, J, Brega, A & Devore, P 2005, 'The evaluation of telemedicine and health services research', *Telemedicine Journal and E-Health*, vol. 11, no. 3, pp. 317-28,

Grinnell, RM, Jr. 1993, *Social work research and evaluation*, 4th edn, F.E. Peacock, Itasca, IL.

Guba, E 1990, *The paradigm dialog* Sage, Beverly Hills, CA.

Guba, E & Lincoln, Y 1994, 'Competing paradigms in qualitative research', in NK Denzin & YS Lincoln (eds), *Handbook of qualitative research*, Sage, London, pp. 105-17.

Guilfoyle, C, Wootton, R, Hassall, S, Offer, J, Warren, M, Smith, D & Eddie, M 2003, 'Use of the Internet to optimize self-management of type 1 diabetes: preliminary experience with DiasNet', *Journal of Telemedicine and Telecare*, vol. 9, no. 3, pp. 50-2,

Gurney, T, Stenhouse, S, Gururajan, R & Hafeez_Baig, A 2009, ‘The practical issues in using existing digital stethoscopes for telehealth’, Annual International Conference on Successes and Failures in Telehealth 2009 (SFT-09), Brisbane, Australia: University of Queensland, Centre for Online Health,

Gururajan, R 2007, Development of an Improved Digital Stethoscope for Use in Telehealth and the Provision of Remote Healthcare. University of Southern Queensland, Faculty of Business,

Gustke, SS, Balch, DC, West, VL & Rogers, LO 2000, 'Patient Satisfaction with Telemedicine', *Telemedicine Journal*, vol. 6, no. 1, pp. 5-13,

Hafeez-Baig, A, Scott, A, Sarquis, C, Cockfield, G & Gururajan, R 2007, 'Global Implementation of Digital Stethoscope for Telehealth or Telemedicine: An Australian Case Study', paper presented to 5th International Symposium on Management of Technology （ISMOT’07, Hangzhou, China.

Han, S 2003, *Individual adoption of information systems in organisations: A literature review of the intention-based theory*, viewed on 20 September 2006, <iamsr.abo.fi/publications/openFile.php?pub_id=169>.

Han, S, Harkke, V, Collan, M & Tétard, F 2006, 'Usage of a Mobile Medical Information System: An Investigation of Physicians in the Military Service ', paper presented to 19th Bled eConference eValues, Bled, Slovenia.

Handa, ML 1986, *Peace Paradigm: Transcending Liberal and Marxian Paradigms*, New Delhi, India, March 20–25 1987.

Hanson, R & Chatterton, S 2005, *Evaluation Framework for the Canada Health Infostructure Partnerships Program (CHIPP)*, Toronto Ontario, Canada, October 29, 2005.

Harsola, A, Thale, S & Panse, MS 2011, 'Low cost digital stethoscope for heart sounds', paper presented to International conference and workshop on emerging trends in technology, Mumbai, India.

Haux, R 2006, 'Health information systems - past, present, future', *International journal of Medical Informatics*, vol. 75, no. 3, pp. 268-81,

Hay, I 2000, *Qualitative Research Methods in Human Geography*, Oxford University Press, South Melbourne.

Health Canada 2009, *Enhancing Access and Integrating Health Services*, Health Canada, viewed July 2009, <http://www.apps.hc-sc.gc.ca/hcs-sss/phctf-fassp.nsf/WebFactSheet/0061?OpenDocument&lang=eng&>.

Health Informatics Society of Australia 2008, *Health informatics*, Health Informatics Society of Australia, viewed December 2008, <http://www.hisa.org.au>.

Heaney, D, Caldow, J, McClusky, C, King, G, Webster, K, Mair & Ferguson, J 2009, 'The introduction of a new consulting technology into the National Health Service (NHS) for Scotland', *TELEMEDICINE JOURNAL AND e-HEALTH*, vol. 15, no. 6, pp. 546-51,

Higa-Moore, ML, Bunnett, B, Mayo, HG & Olney, CA 2002, 'Use of Focus Groups in a Library's Strategic Planning Process', *Journal of the Medical Library Association*, vol. 90, no. 1, pp. 86-92,

Hogenbirk, J, Brockway, P, Finley, J & Jennett, P 2006, 'Framework for Canadian telehealth guidelines: summary of the environmental scan', *Journal of telemedicine and Telecare*, no. 12, pp. 64-71, viewed 20 August 2007,

Hu, PJ 2003, 'Evaluating telemedicine systems success: A revised model', paper presented to Proceeding of the 36th Hawaii international conference on system sciences, Kauai, Hawaii, USA, January 6-9, 2003.

Hu, PJ, Chau, PYK, Sheng, ORL & Tam, KY 1999, ''Examining the Technology Acceptance Model Using Physician Acceptance of Telemedicine', *Journal of management information systems* vol. 16, no. 2, p. 91,

Huston, L & Huston, JL 2000, 'Is telemedicine a practical reality', *ACM*, vol. 43, no. 6, pp. 91-6, viewed 20 September 2007,

Iivari, J, Hirschheim, R & H.K, K 1998, 'A paradigmatic analysis contrasting information systems development approaches and methodologies', *Information Systems Research*, vol. 9, no. 2, pp. 164-93,

Jarvinen, P 2001, *on research methods*, Opinpaja Oy, Tampere, Finland.

Järvinen, P 1992, 'Impact of electronic markets on work', paper presented to Proceedings of the IFIP 12th World Computer Congress on Education and Society - Information Processing '92 Amsterdam, The Netherlands.

Järvinen, P 2004, *On Research Methods*, Opinpajan Kirja, Tampere, Finland.

Jennett, P 2002, *Socio-Economic Impact of Telehealth: Evidence Now for Health Care in the Future*, <http://www.ahfmr.ab.ca/grants/docs/state_of_science_reviews/Jennett_Pres.pdf>.

Jick, T 1983, *Qualitative Methodology*, Sage, Beverly Hills, CA.

Kent, M 2007, *Murmur*, 3rd edn, Oxford University Press.

Kim, J, DelliFraine, JL, Dansky, KH & McCleary, KJ 2010, 'Physicians' acceptance of telemedicine technology: an empirical test of competing theories', *International Journal of Information Systems and Change Management*, vol. 4, no. 3, pp. 210 - 25,

Kitzinger, J 1995, 'Introducing focus groups', *British Medical Journal*, vol. 311, pp. 299-302,

Klecun-Dabrowska, E, Cornford, T 2001, 'Evaluation and Telehealth—an Interpretative Study', paper presented to 34th International Conference on System Sciences, Hawaii.

Klein, HK & Myer, MD 1999, 'A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems', *MIS Quarterly*, vol. 23, no. 1, pp. 67-94,

Koekemoer, HL & Scheffer, C 2008, 'Heart Sound and Electrocardiogram Recording Devices for Telemedicine Environments', paper presented to 30th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC 2008), Vancouver, Canada, 20–25 August 2008.

Kowitlawakul, Y 2011, 'The Technology Acceptance Model: Predicting Nurses' Intention to Use Telemedicine Technology (eICU)', *Computers, Informatics, Nursing*, vol. 29, no. 7, pp. 411-8, Krueger, RA 1994, *Focus Groups: A Practical Guide for Applied Research*, 2 edn, Sage publications, Newbury Park, CA.

Kuhn, TS 1962, *The Structure of Scientific Revolutions*, University of Chicago Press, Chicago.

Kumar, R 1996, *Research methodology :a step-by step guide for beginners* Longman, Melbourne, Australia.

Kyocera Corporation 2008, *Solar glossary*, KYOCERA International, Inc., viewed 28 May 2008, <http://www.kyocerasolar.com/solar/glossary.html#B>.

Lapadat, JC & Lindsay , AC 1999, 'Transcription in Research and Practice: From Standardization of Technique to Interpretive Positionings', *Qualitative Inquiry*, vol. 5, no. 1, pp. 64-86,

Lapinsky, S, Wax, R, Showalter, R, Martinez- Motta, J, Hallett, D, Mehta, S, Burry, L & Stewart, T 2004, 'Prospective evaluation of an Internet-linked handheld computer critical care knowledge access system', *Critical Care*, vol. 8, no. 6, pp. 414-21,

LeRouge, C, Garfield, MJ & Hevner, AR 2002, 'Quality Attributes in Telemedicine Video Conferencing', paper presented to Proceedings of the 35th Hawaii International Conference on System Sciences, Big Island, Hawaii, USA

LeRouge, C, Hevner, A, Collins, R, Garfield, M & Law, D 2004, 'Telemedicine Encounter Quality: Comparing Patient and Provider Perspectives of a Socio-Technical System', paper presented to Proceedings of the 37th Hawaii International Conference on System Sciences (HICSS'04), Big Island, Hawaii

Lewin, M, Xu, C, Jordan, M, Borchers, H, Ayton, C, Wilbert, D & Melzer, S 2006, 'Accuracy of paediatric echocardiographic transmission via telemedicine ', *Journal of Telemedicine and Telecare*, vol. 12, no. 8, pp. 416-21,

Lewin Group 2000, *Assessment of Approaches to Evaluating Telemedicine*, Office of the Assistant Secretary for Planning and Evaluation, Department of Health and Human Services, Falls Church, Virginia, United states.

Lewis-Beck, MS, Bryman, A & Futing Liao, T 2004, *The Sage Encyclopedia of Social Science Research Methods,* Sage, Thousand Oaks, CA.

Linassi, G & Shan, R 2005, 'User satisfaction with a telemedicine amputee clinic in Saskatchewan', *Journal of telemedicine and Telecare*, vol. 11, no. 8, pp. 414-8,

Linassi, A & Shan, R 2005, 'User satisfaction with a telemedicine amputee clinic in Saskatchewan', *Journal of Telemedicine and Telecare*, vol. 11, no. 8, pp. 414-8,

Litosseliti, L 2003, *Using focus groups in research* Continuum, London.

Littlejohn, SW 1992, *Critical Theories*, Wadsworth Publishing Co, Belmont, CA.

Lunt, P & Livingstone, S 1996, 'Rethinking the focus group in media and communications research', *Journal of Communication*, vol. 46, no. 2, pp. 79-98,

Mackert, M & Whitten, P 2007, 'Successful adoption of a school-based telemedicine system', *he journal of school health*, vol. 77, no. 6, pp. 327-30,

Madriz, E 2003, 'Focus groups in feminist research', in NK Denzin & YS Lincoln (eds), *Collecting and interpreting qualitative materials*, 2nd edn, Sage Publications, Thousand Oaks, pp. 363-88.

Maheu, MM, Whitten, P & Ace, A 2001, *E-Health, Telehealth, and Telemedicine: A Guide to Start-up and Success*, Jossey Bass, San Francisco

Maheu, M, Whitten, P & Allen, A 2001, *E-health, Telehealth and Telemedicine*, Jossey-Bass Inc., New York.

March, SK, Bedynek, JL & Chizner, MA 2005 *Teaching cardiac auscultation: effectiveness of a patient-centered teaching conference on improving cardiac auscultatory skills*, Department of Internal Medicine, Mayo Clinic College of Medicine, November 2005, <http://www.mayoclinicproceedings.com/content/80/11/1443.full.pdf>.

Marilyn, JF 1996, *Telemedicine: A Guide to Assessing Telecommunications for Health Care*, National Academy Press, Washington, D.C. <http://www.nap.edu/openbook.php?isbn=0309055318>.

Marks, DF & Yardley, L 2004, *Research Methods for Clinical and Health Psychology*, Sage Publications London.

Markus, ML 1983, 'Power, Politics and MIS Implementation', *Communications of the ACM*, vol. 26, pp. 430-44,

Marshall, C & Rossman, GB 2006, *Designing Qualitative Research*, 4 edn, Sage Publications, London.

Maryati, MY, Paul, RJ & Stergioulas, LK 2006, 'Towards a Framework for Health Information Systems Evaluation', paper presented to Proceedings of the 39th Hawaii International Conference on System Sciences, Kauai, Hawaii, USA, 4-7 January 2006.

Maxwell, JA 2005, *Qualitative Research Design. An Interactive Approach*, Sage Publications, London.

Mea, D 2001, 'What is e-Health: The death of telemedicine? ', *Journal of Medical Internet Research*, vol. 3, no. 2, p. 22,

Medema Medical Supplies 2007, *3M Littmann Electronic Stethoscope 4100WS with Ambient Noise Reduction and Sound Analysis Software*, Medema T/A Omega

Medical Supplies Ltd, London, United Kingdom, 27 March 2008, <http://www.medema.co.uk/Stethoscopes~3M_Littmann_Electronic_Stethoscope_4100WS_with_Ambient_Noise_Reduction_and_Sound_Analysis_Software~45~738~0.htm>.

MedExSupply Medical 2008, *Thinklabs Digital Electronic Stethoscope DS32A*, MedExSupply Medical Supplies, viewed 16 May 2008, <http://www.medexsupply.com/diagnostic-supplies-stethoscopes-thinklabs-digital-electronic-stethoscope-ds32a-x_pid-4172.html>.

MedicineNet 2001, *Definition of Stethoscope*, viewed 19 February <http://www.medterms.com/script/main/art.asp?articlekey=17896>.

Melcer, T, Hunsaker, D, Crann, B, Caola, L & Deniston, W 2002, 'A Prospective Evaluation of ENT Telemedicine in Remote Military Populations Seeking Specialty Care', *Telemedicine Journal*, vol. 8, no. 3, pp. 301-11,

Merrell, RC 2009, 'Telemedicine in India: An Introduction', *telemedicine and e-Health*, vol. 15, no. 6, pp. 566-7,

Merton, R, Fiske, M & Kendall, P 1956, *The Focused Interview*, The Free Press, New York.

Microsemi Corporation 2011, 'Size, Reliability and Security: The Essential Ingredients for Medical Devices', viewed March 2011, <http://www.actel.com/interact/default.aspx?p=e369>

Miles, MB & Huberman, AM 1994, *Qualitative data analysis: An expanded sourcebook*, 2nd edn, Sage, Thousand Oaks, CA.

Moehr, JR 2002, 'Evaluation: Salvation or Nemesis of Medical Informatics?', *Computers in Biology and Medicine*, vol. 32, no. 3, pp. 113-25,

Morgan, G 1983, *Beyond Method: Strategies for Social Research*, Sage, London.

Morgan, DL 1997, *Focus groups as qualitative research* 2nd edn, Sage Publications, Thousand Oaks, CA.

Morgan, DL & Kreuger, RA 1993, 'When to use focus groups and why', in M D.L. (ed.), *Successful Focus Group*, Sage, London.

Morse, JM & Field, PA 1995, *Qualitative research methods for health professionals*, Sage, Thousand Oaks, CA.

Mosby's Medical Dictionary 2009, *Doppler echocardiography*, 8th edn, Elsevier, New York, NY.

Mudawi, TO & Kaye, GC 2008, 'Implantable cardiac devices – past, present and future', *The British journal of cardiology*, vol. 15, no. 1, Myers, MD 1997, 'Qualitative Research in Information Systems', *MIS Quarterly*, vol. 21, no. 2, pp. 241-2,

Myers, M & Avison, D 2002, *Qualitative Research in Information Systems: A Reader*, Sage Publications, London.

myStethoscope 2008, *Stethoscope Frequently Asked Questions*, myStethoscope, LLC., viewed 12 May 2008, <www.mystethoscope.com/help.php>.

NASA 2011, *LifeGuard: Wireless Physiological Monitor*, National Aeronautics and Space Administration (NASA), viewed March 2011, <http://www.nasa.gov/centers/ames/research/technology-onepagers/life-guard.html>.

Neuman, WL 2000, *Social research methods: Qualitative and quantitative approaches*, 4th edn, Allyn and Bacon, Boston.

Normandin, SR 2008, *International Quality Care Solution. Patients, Safety & Quality Healthcare.* , Lionheart Publishing, Inc., <http://www.psqh.com/janfeb08/telemedicine.html>.

Obaidat, M 1993, 'Phonocardiogram signal analysis: techniques and performance comparison', *journal of medical engineering & technology*, vol. 17, no. 6, pp. 221-7,

Oliver-Hoyo, M & Allen, D 2006, 'The Use of Triangulation Methods in Qualitative Educational Research', *Journal of College Science Teaching* vol. 35, no. 4, p. 42,

Olson, HF 1967, *Music, Physics and Engineering*, Dover Publications, Mineola, NY.

Olver, I & Selva-Nayagam, S 2000, 'Evaluation of a Telemedicine Link between Darwin and Adelaide to Facilitate Cancer Management', *Telemedicine Journal*, vol. 6, no. 2, pp. 213-8,

Ong, CS & Lai, JY 2004, 'Developing an Instrument for Measuring User Satisfaction with Knowledge Management Systems ', paper presented to Proceedings of the 37th Hawaii International Conference on System Sciences, Hawaii , Big Island.

OPPapers 2011, *Process Of Recruitment*, viewed March 2011, <http://www.oppapers.com/essays/Process-Of-Recruitment/606167>.

Orlikowski, WJ & Baroudi, J 1991, 'Studying Information Technology in Organizations: Research Approaches and Assumptions', *Information Systems Research*, vol. 2, no. 1, pp. 1-28,

Pare, G, Sicotte, C & Jacques, H 2006, 'The effects of creating psychological ownership on physicians' acceptance of clinical information systems', *Journal of the American Medical Informatics Association*, vol. 13, no. 2, pp. 195–205,

Paré, G, Lepanto, L, Aubry, D & Sicotte, C 2005, 'Toward a multidimensional assessment of picture archiving and communication system success', *International*

Journal of Technology Assessment in Health Care, vol. 21, no. 4, pp. 471-9,

Paryani, S 2006, 'A framework for evaluation of telemedicine', paper presented to e-Health Networking, Applications and Services, 2006. HEALTHCOM 2006. 8th International Conference on, 17-19 Aug. 2006.

Patel, MX, Doku, V & Tennakoon, L 2003, 'Challenges in recruitment of research participants', *Advances in Psychiatric Treatment*, vol. 26, no. 5, pp. 391-7,

Patton, MQ 1990, *Qualitative Evaluation and Research Methods* 2nd edn, Sage Publications, Inc., Newbury Park, CA.

Patton, MQ 2002, *Qualitative research & evaluation methods* 3rd edn, Sage Publications, Thousand Oaks, CA.

Powell, J, Jennings, A, Armstrong, N, Sturt, J & Dale, J 2009, 'Pilot study of a virtual diabetes clinic: satisfaction and usability', *J Telemed Telecare*, vol. 15, no. 3, pp. 150-2,

Puskin, D, Brink, L, Mintzer, C & Wasem, C 1995, 'Joint Federal Initiative for Creating a Telemedicine Evaluation Framework', *The Telemedicine Journal*, vol. 1, no. 4, pp. 393-7, OnlineProquest,

Queensland Government 2006, *Resources and success stories*, Queensland Government, , Department of the Premier and Cabinet, <http://www.smartstate.qld.gov.au/resources/about/telehealth.shtm>.

Reed, C, Burr, R & Melcer, T 2004, 'Navy Telemedicine: A Review of Current and Emerging Research Models', *Telemedicine Journal and E-Health*, vol. 10, no. 3, p. 343,

Reichert, S, Gass, R, Hajjam, A, Koukam, A & Andres, E 2009, 'An Optimized Communication for Emergency Health Situations', paper presented to Proceedings of the 2009 International Conference on eHealth, Telemedicine, and Social Medicine Washington, DC, USA.

Rice, P & Ezzy, D 1999, *Qualitative research methods: A health focus*, Oxford University Press., Melbourne.

Ruggiero, C, Sacile, R & Giacomini, M 1999, 'Home telecare', *Journal of telemedicine and Telecare*, vol. 5, no. 1, pp. 11-7,

Sable, C 2004, 'telemedicine applications in paediatric cardiology', vol. 2, no. 7, viewed March 2009, <http://www.pediatriccardiologytoday.com/index_files/PCT-JUL04-RGB.pdf>

Schmidt, S, Holst-Hansen, C, Graff, C, Toft, E & Struijk, J 2007, 'Detection of Coronary Artery Disease with an Electronic Stethoscope ', *Computers in Cardiology*, vol. 34, p. 757, Schmidt, SE, Hansen, J, Hansen, CH, Toft, E & Struijk, JJ 2010, 'Comparison of Sample Entropy and AR-models for Heart Sound-based Detection of Coronary Artery Disease', *Computing in Cardiology*, vol. 37, pp. 385-8,

Sekaran, U 1992, *Research Methods for Business*, 2nd edn, Wiley, New York.

Selltiz, C, Jahoda, M., Deutsch, M., & Cook, S. W. 1959, *Research methods in social relations*, Holt, Rinehart & Winston, New York.

Serghis, D 1999, 'Time for telehealth?', *Australian Nursing Journal*, vol. 7, no. 1, p. 16, Academic Search Premier,

Sheppard, BH, Hartwick, J., & Warshaw, P. R. 1988, 'The theory of reasoned action: A meta-analysis of past research with recommendations for modifications and future research', *Journal of Consumer Research*, vol. 15, no. 3, pp. 325-43,

Shtarkshall, R 2004, *What is a research paradigm* viewed October 2009, <http://www.docstoc.com/docs/18652270/What-is-a-research-paradigm>.

Silverman, D 2006, *Interpreting Qualitative Data: Methods for Analyzing Talk, Text, and Interaction*, 3 edn, Sage publications, London.

Simon, J 1999, *The Wilder nonprofit field guide to conducting successful focus groups*, Wilder Foundation, Saint Paul, Minn.

Smith, A, Grech, M & Horberry, T 2002, Application of the Leximancer text analysis system to human factors research, University of Queensland, <www.leximancer.com/documents/hfes2002.pdf>.

Sofsian, D 2008, *Digital Stethoscopes*, *EzineArticles*, viewed 20 Jan <http://ezinearticles.com/?Digital-Stethoscopes&id=405412>.

Spooner, SA & Gotlieb, EM 2004, 'Telemedicine: Paediatric Applications', *Paediatrics* vol. 113, no. 6, pp. 639-43,

Squibb, N 1999, 'Video transmission for telemedicine', *Journal of telemedicine and Telecare*, vol. 5, no. 1, pp. 1-10,

Stair, RM & Reynolds, GW 2008, *Fundamentals of Information Systems a Managerial Approach*, 4 edn, Thomson Course Technology, Boston.

Stead, W, Haynes, R & Fuller, S 1994, 'Designing medical informatics research and library--resource projects to increase what is learned', *Journal of the American Medical Informatics Association*, vol. 1, no. 1, pp. 28-33,

Stethocope.com 2008, *Electronic Stethoscopes*, Stethocope.com LLC, viewed 01 January, <http://stethoscope.com/index.cfm?event=CatDisplay&CategoryID=7>.

Stevenson, D 2008, 'Training and Process Change: A Collaborative Telehealth Case Study', paper presented to OZCHO 2008, Cairns, Australia, 8-12 December.

Stewart, DW, Shamdasani, PN & Rook, DW 2007, *Focus groups :theory and practice* 2nd edn, Sage Publications, Thousand Oaks

Strauss, A 1987, *Qualitative analysis for social scientists*, Cambridge University Press, Cambridge, UK.

Stryker 2003, *ACR Standard for Teleradiology*, viewed July 2008, <http://imaging.stryker.com/images/ACR_Standards-Teleradiology.pdf>.

Stuart, H 1996, 'Research interviews', *New library world*, vol. 97, no. 1129, p. 22, online PROQUEST.

Suchman, L 1987, *Plans and Situated Actions: The Problem of Human-Machine Communication*, Cambridge University Press, Cambridge.

Tang, Z, Johnson, T, Tindall, D & Zhang, JZ 2006 'Applying Heuristic Evaluation to Improve the Usability of a Telemedicine System', *Telemedicine and e-Health Journal*, vol. 12, no. 1, pp. 24-34,

Tashakori, A & Teddlie, C 1998, *Mixed methodology: combining qualitative and quantitative approaches*, Sage, Thousand Oaks, CA.

Taylor, P 2005, 'Evaluating telemedicine systems and services', *Journal of telemedicine and Telecare*, vol. 11, no. 4, pp. 167-77,

Taylor, D, Cameron, J, Walsh L, McEwen S, Kagan A, Streiner DL & MP., H 2009, 'Exploring the feasibility of videoconference delivery of a self-management program to rural participants with stroke', *Telemedicine Journal and E-Health*, vol. 15, no. 7, pp. 646-54,

The Crowley group 2008, *Glossary*, The Crowley group viewed 19 July 2008, <http://www.crowley.pl/11446.dhtml#p>.

The Everything Development Company 2006, *3M Littmann Stethoscope*, The Everything Development Company, viewed 8 March 2008, <http://everything2.com/e2node/Littmann%2520Stethoscope>.

The Pennsylvania State University 2007, *How to Use Focus Groups to Solicit Ideas and Feedback*, The Office of Planning and Institutional Assessment, viewed December 2007, <www.virginia.edu/processsimplification/resources/PennState%20Focus%20Groups.pdf>.

The Scottish Centre for Telehealth 2007, *Telehealth Evaluation*, The Scottish Centre For Telehealth and Telecare, viewed 3 July 2008, <http://www.sct.scot.nhs.uk/evaluation.html>.

TheFreeDictionary 2010, *Noise*, Farlex, Inc., Huntingdon Valley, PA <http://www.thefreedictionary.com/noise>.

Thinklabs Medical LLC 2008, *ds32a Digital Electronic Stethoscope*, Thinklabs Medical LLC viewed 11 February 2008, <http://www.thinklabsmedical.com/electronic-stethoscope/products/ds32a-digital-electronic-stethoscope-157.html>.

Trauth, E 2001, *Qualitative research in IS: issues and trends*, Idea Group Publishing, Hershey.

Travis, J 1999, *Exploring the constructs of evaluative criteria for interpretivist research*, Wellington, New Zealand.

Trochim, WMK 2006, *Positivism & Post-Positivism*, viewed July 2008, <http://www.socialresearchmethods.net/kb/positvsm.php>.

Turner, GW 1987, *The Australian Concise Oxford Dictionary of Current English*, 1st edn, Oxford University Press, Melbourne, Australia.

Tutty, L, Rothery, M & Grinnell, R 1996, *Qualitative research for social workers: Phases, steps and tasks*, Boston, Boston.

Valacich, JS & Jessup, LM 2008, *Information Systems Today: Managing the Digital World*, 3rd edn, Prentice Hall.

Van Manen , M 1990, *Hermeneutical Analysis,* State University of New York Press, New York.

Visagie, C, Scheffer, C, Lubbe, WW & Doubell, AF 2009, 'Autonomous detection of heart sound abnormalities using an auscultation jacket', *Australasian Physical and Engineering Sciences in Medicine*, vol. 32, no. 4, pp. 240-50

Voce, A 2004, *Introduction to research paradigms*, viewed May 2008, <familymedicine.ukzn.ac.za/.../Introduction%20to%20research%20paradigms.doc>.

Wallen, RD 2006, 'Acoustic Stethoscopes', *Biomedical Instrumentation & Technology*, vol. 40, no. 5, pp. 367-70

Walsham, G 1993, *Interpreting Information Systems in Organizations,* Chichester, Wiley.

Walsham, G 1995, 'Interpretive case studies in IS research: nature and method', *European Journal of Information Systems*, vol. 4, no. 2, pp. 74–81,

Walsham, G 2002, 'Cross-cultural software production and use: a structurational analysis', *MIS Quarterly*, vol. 26, no. 4, pp. 359-80,

Walsham, G 2006, 'Doing interpretive research', *European Journal of Information Systems*, vol. 15, pp. 320–30,

Wheeler, S 2006, 'Tele-triage systems', viewed 28 May 2006, Willis, WJ 2007, *Foundations of qualitative research; Interpretive and critical approaches*, sage, London.

Whiting, R, Hayes, W, Bryant , J, Fitzpatrick, B, Bailey, G, Kennedy, B & Hogg , P 2007, *TARDIS Project Report*, Department of Telehealth Services, Royal Brisbane Hospital, Queensland.

Wolff, S 2002, 'Ways into the field and their variants', in U Flick, Kardorff, EV, Steinke, I, (ed.), *Qualitative research: A handbook* Sage, London.

Wyatt, J & Liu, J 2002, 'Basic concepts in medical informatics: a glossary', *Epidemiology Community Health*, vol. 57, pp. 808-12,

Xie, F, Breese , M, Nanna, M, Lichtenberg, G, Allen , M & R, M 1988, 'Instrument stethoscope and standard echocardiographic Blinded comparison of an ultrasound', *Chest*, vol. 94, no. 2, pp. 270–4,

Yarbrough, A & Smith, T 2007, 'Technology Acceptance Among Physicians: A New Take on TAM', *Medical Care Research and Review*, vol. 64, no. 6, pp. 250-72,

Yawn, B 2000, 'Communication Telemedicine: A New Framework for Evaluation', vol. 6, no. 1, viewed 9 September 2007, Online ProQuest,

Yawn, B, Krein, S, Christianson, J, Hartley, D & Moscovice, I 1997, 'Rural radiology: who is producing images and who is reading them? ', *Rural Health*, vol. 13, pp. 136–44,

Yellowlees, P 2000, 'Intelligent Health Systems and Third Millennium Medicine in Australia', vol. 6, no. 1, viewed 20 August 2007, <http://www.liebertonline.com/doi/abs/10.1089/107830200415117 >

Yin, RK 1989, *Case study research: Design and methods*, Rev. edn, Sage, Beverly Hills Ca.

Yin, R 1994, *Case study research: Design and methods*, 2nd edn, Sage Publishing, Beverly Hills, CA.

Zuboff, S 1988, *In the Age of the Smart Machine*, Basic Books, New York.

APPENDICES

(Including all node summary and code summary files)

1. Technical features of three selected Digital Stethoscopes
2. Focus group discussions conducted in India
3. Node summary Indian focus groups
4. Node summary Australian focus groups
5. Coding summary Indian focus groups
6. Coding summary Australian focus groups

APPENDIX A: TECHNICAL FEATURES OF THREE SELECTED DIGITAL STETHOSOCPES

Dimension will focus on measurement of length, width or depth of DS. The length of stethoscope is measured from the ear tips to the tip of the chest piece. Length of a stethoscope's tube is very important to make the stethoscope usable. A stethoscope should provide sufficient reach from doctors' ears to patient chest or in some types from patients' chest to any recording facility.

Lightweight construction could be a good feature for a digital stethoscope because that makes it easier to carry. Not only is the total weight of stethoscope important to make it portable, handy and usable but the weight of chest piece should be suitable to avoid patient discomfort when putting pressure on a patient's chest, especially infants or the elderly.

Diaphragm diameter is an important feature that affects the sound pressure. MyStethoscope (2008) suggests that there will be an increase in amplitude or loudness if the sound comes through a diaphragm with a larger surface area. The sound pressure level increases with an increase in contact area on the patient, although it is suggested that a smaller diameter is better for smaller patients because the doctor can focus on sounds from a specific area of the body (Everything Development Company 2006).

Volume control can be used to increase volume for faint heart sounds, obese patients or noisy environments (Thinklabs Medical LLC 2008). Moderate volume can be used for children with loud heart sounds. Recently, ambient noise filtering has become available in some electronic stethoscopes, for example, 3M's Littmann 3000 and Thinklabs ds32a offer methods for eliminating ambient noise.

Power consumption should preferably be maintained as low as possible so the electronic stethoscope will be usable. Some stethoscopes provide automatic power-off if there is no signal after a period of time, ranging from seconds to a few minutes (Dufresne et al. 2007). **Battery life** is 'the period during which a cell or battery is capable of operating above a specified capacity or efficiency performance level. Life may be measured in cycles and/or years, depending on the type of service for which the cell or battery is intended' (Kyocera Corporation 2008). So it would be a good feature for a digital stethoscope to be capable of using long life batteries. This is due to the portable usage of DS and less dependency on permanent power supplies.

Stethoscopes could have a different **chest piece shape and material**. The material of the chest piece could be stainless steel or metal, chrome plated brass or aluminum. The design and quality of chest piece is important for better results in diagnosis. For example, stethoscopes could have a design that allows easy movement between auscultation sites. Some are designed 'to help to eliminate noise artifact and some stethoscopes could increase sound intensity when listening to low-frequency sounds due to the greater surface area of the chest piece' (Bischoff's Medical 2008). **Headset material** such as soft hypo-allergenic (Latex-free) silicone ear tips could provide superb comfort for users. 'The headphone spring provides a lighter force, the sound is clear and excess pressure to extract is unnecessary' (MedExSupply Medical 2008).

Frequency response is a 'rating that indicates the frequency range over which an instrument will respond uniformly or within specified limits' (Glossary of Meteorology 2008). It is an important parameter in evaluating the dynamic response of digital stethoscope. **Protocols**, in this case, particularly refer to data transmission protocols. It means a 'set of rules that describe the way of communication and the way in which a data transmission terminal reacts during communication' (The Crowley group 2008). Table 2.2 indicates that AMD-3550 could transmit on almost any communications platform, including 'live' and 'store and forward' IP. **Main application** area refers to specific usage of DS for particular health divisions. Stethoscopes could be used in primary care, pediatrics, or cardiology applications. But there are specific usages of stethoscope, for example, fetal stethoscopes are placed against the abdomen of a pregnant woman to listen to blood flow in peripheral vessels and the heart sounds of developing fetuses (Encyclopaedia of Surgery 2008).

Essentially, the main purpose of using a digital stethoscope is capturing sound. Digital stethoscopes could be used in telehealth systems to capture sound that could be sent through networks. It is an alternative way of transmission for the digital stethoscope to have an **audio output** option in order to transmit the captured sound to another device or a PC. Recording facilities are offered in some DS, for example, Littman 4100 offers recording, storage and playback capabilities for 6 different auscultations, each with a possible 8 seconds in duration (3M 2005). This is a useful feature because the recorded soundtrack can be downloaded onto a PC for future reference. **PC connectivity** allows the user to transmit the captured sound from a DS onto a PC so the sound could be modified, saved and transmitted through the telehealth network.

Some DS offers additional **editing software.** Thinklab ds32a offers Phonocardiography Software, which provides easy visualization and editing of heart sounds and lung, sounds recorded from the Thinklabs Digital Stethoscope. AMD SmartSteth offers specific editing software. 'The robust software package includes, among other features, signal stabilization, continuous playback, caliper isolation of signal to be analyzed, signal gain and signal filtering options, communication management and graphical waveform phonocardiogram display. The phonocardiogram display let users to see the sound to reinforce diagnostic judgments’ (AMD Global Telemedicine 2008).

APPENDIX B: FOCUS GROUP SESSIONS CONDUCTED IN INDIA

No	Date	Venue	City	Forum Strength	Participants
1	13.03.2010	Hospital1	Chennai	6 members	4 Staff Nurses
		Eye Care - Ophthalmology	Metropolitan City		1 Physician
					1 Technician
2	13.03.2010	Hospital 2	Chennai	5 members	3 Cardiologists
		Multi Speciality Hospital	Metropolitan City		2 technicians
3	17.03.2010	Medical Centre 1	Trichy	6 members	4 Staff Nurses
		Heart Foundation	Tier II City		1 Anaesthetist
		Tele Radiology			1 General Physician
4	18.03.2010	Medical Centre 2 - University	Chennai	3 Members	1 Neurosurgeon
		University	Metropolitan City		1 Technician
					1 Telemedicine staff
5	19.03.2010	Diabetic Foundation	Chennai	2 members	1 Physician
		Diabetology	Metropolitan City		1 telemedicine technician

No	Date	Venue	City	Forum Strength	Participants
6	19.03.2010	Hospital 3	Chennai	6 members	3 staff nurses
		Multi Speciality Hospital	Metropolitan City		2 cardiologists
					1 telemedicine doctor
7	22.03.2010	Medical Centre 3	Coimbatore	4 members	1 doctor
		Multi Speciality Hospital	Tier II City		2 lab in charge
					1 staff nurse
8	22.03.2010	Medical Centre 3	Coimbatore	5 members	3 staff nurses
		Multi Speciality Hospital	Tier II City		2 technicians
9	24.03.2010	Medical centre 4	Coimbatore	3members	Dr.G
		cardiologists	Tier II City		1 staff nurse
					1 Auxiliary midwife
10	24.03.2010	Medical centre 4	Coimbatore	2 member	Dr.K
		cardiologists	Tier II City		1 staff Nurse

No	Date	Venue	City	Forum Strength	Participants
11	28.03.2010	Hospital 4	Coimbatore	1 member	Dr.N
		Multi Speciality Hospital	Tier II City		
12	30.03.2010	Hospitals 5	Coimbatore	1 member	Dr.Bi
		Multi Speciality Hospital	Tier II City		
13	30.03.2010	Hospitals 5	Coimbatore	1 member	Dr.M - pulmonologist
		Multi Speciality Hospital	Tier II City		1 Attendant doctor
					2 theatre staff
14	31.03.2010	Hospital 4	Coimbatore	20members	Team of Doctors
		Multi Speciality Hospital	Tier II City		Around 20 of them
15	01.04.2010	Medical Centre & Hospital	Coimbatore	3 members	Dr.B (Cardiologist)
		Multi Speciality Hospital	Tier II City		1 staff
					1 Auxiliary midwife

No	Date	Venue	City	Forum Strength	Participants
16	31.03.2010	Hospitals 5	Coimbatore	Cardiologist	Dr.F
		Multi Speciality Hospital	Tier II City		
17	31.03.2010	Hospitals 5	Coimbatore	General Physician	Dr.Sl
		Multi Speciality Hospital	Tier II City		
18	31.03.2010	Hospitals 5	Coimbatore	General Physician	Dr.S
		Multi Speciality Hospital	Tier II City		3 duty doctors
					2 Nursing assistants
19	31.03.2010	Hospitals 5	Coimbatore	General Physician	Dr.M
		Multi Speciality Hospital	Tier II City		

APPENDIX C: CODE SUMMARY INDIAN FOCUS GROUPS

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Coding Summary

Indian Focus Groups

12/08/2011 12:06 PM

Hierarchical Name	Aggregate	Coverage	Number Of Coding References	Number Of Users Coding

Internals\\All FG in India

Document

Node

Hierarchical Name	Aggregate	Coverage	Number Of Coding References	Number Of Users Coding
Nodes\\Free Nodes\\acceptability	No	0.34 %	10	1
Nodes\\Free Nodes\\Amplification	No	0.68 %	25	1
Nodes\\Free Nodes\\battery life	No	1.11 %	14	1
Nodes\\Free Nodes\\chest piece	No	0.22 %	8	1
Nodes\\Free Nodes\\comfort	No	0.62 %	13	1
Nodes\\Free Nodes\\connectivity	No	1.11 %	21	1
Nodes\\Free Nodes\\cost	No	2.50 %	50	1
Nodes\\Free Nodes\\Diaphragm Design	No	0.85 %	16	1
Nodes\\Free Nodes\\DS base material	No	0.10 %	4	1
Nodes\\Free Nodes\\DS life time	No	0.14 %	5	1
Nodes\\Free Nodes\\DS shape	No	0.24 %	7	1
Nodes\\Free Nodes\\DS size	No	0.12 %	5	1
Nodes\\Free Nodes\\DS weight	No	0.33 %	12	1
Nodes\\Free Nodes\\Ear--head piece -head phone	No	0.95 %	24	1
Nodes\\Free Nodes\\Ease of Use	No	0.46 %	18	1
Nodes\\Free Nodes\\education friendliness	No	0.76 %	16	1
Nodes\\Free Nodes\\Follow up Service	No	0.24 %	6	1
Nodes\\Free Nodes\\Frequency mode	No	0.31 %	9	1
Nodes\\Free Nodes\\noise	No	2.71 %	59	1
Nodes\\Free Nodes\\recording facility	No	2.05 %	36	1
Nodes\\Free Nodes\\Reliability	No	0.45 %	8	1
Nodes\\Free Nodes\\Response time - delay	No	0.68 %	14	1
Nodes\\Free Nodes\\Skilled-Level of user	No	1.66 %	22	1
Nodes\\Free Nodes\\Sound Audibility	No	3.15 %	67	1
Nodes\\Free Nodes\\Sound clarity	No	0.41 %	15	1
Nodes\\Free Nodes\\Sound quality	No	0.44 %	13	1
Nodes\\Free Nodes\\Training and support	No	0.97 %	25	1
Nodes\\Free Nodes\\Tube shape - length	No	0.26 %	4	1

Nodes\\Free Nodes\\usefulness	No	5.50 %	105	1
Nodes\\Free Nodes\\Visual Display - Editing software	No	1.14 %	16	1

Hierarchical Name	Aggregate	Coverage	Number Of Coding References	Number Of Users Coding
Nodes\\Free Nodes\\Volume control	No	0.64 %	15	1
Nodes\\Tree Nodes\\information quality\Input quality\noise	No	2.71 %	59	1
Nodes\\Tree Nodes\\information quality\Input quality\Skilled-Level of user	No	1.66 %	22	1
Nodes\\Tree Nodes\\information quality\Output quality\Sound Audibility	No	3.15 %	67	1
Nodes\\Tree Nodes\\information quality\Output quality\Sound clarity	No	0.41 %	15	1
Nodes\\Tree Nodes\\information quality\Output quality\Sound quality	No	0.44 %	13	1
Nodes\\Tree Nodes\\Service quality\Follow up Service	No	0.24 %	6	1
Nodes\\Tree Nodes\\System quality\DS quality\Amplification	No	0.68 %	25	1
Nodes\\Tree Nodes\\System quality\DS quality\battery life	No	1.11 %	14	1
Nodes\\Tree Nodes\\System quality\DS quality\chest piece	No	0.22 %	8	1
Nodes\\Tree Nodes\\System quality\DS quality\comfort	No	0.62 %	13	1
Nodes\\Tree Nodes\\System quality\DS quality\connectivity	No	1.11 %	21	1
Nodes\\Tree Nodes\\System quality\DS quality\Diaphragm Design	No	0.85 %	16	1
Nodes\\Tree Nodes\\System quality\DS quality\DS base material	No	0.10 %	4	1
Nodes\\Tree Nodes\\System quality\DS quality\DS shape	No	0.24 %	7	1
Nodes\\Tree Nodes\\System quality\DS quality\DS size	No	0.12 %	5	1
Nodes\\Tree Nodes\\System quality\DS quality\DS weight	No	0.33 %	12	1
Nodes\\Tree Nodes\\System quality\DS quality\Ear--head piece -head phone	No	0.95 %	24	1
Nodes\\Tree Nodes\\System quality\DS quality\Frequency mode	No	0.31 %	9	1
Nodes\\Tree Nodes\\System quality\DS quality\recording facility	No	2.05 %	36	1
Nodes\\Tree Nodes\\System quality\DS quality\Tube shape - length	No	0.26 %	4	1
Nodes\\Tree Nodes\\System quality\DS quality\Visual Display - Editing software	No	1.14 %	16	1
Nodes\\Tree Nodes\\System quality\DS quality\Volume control	No	0.64 %	15	1
Nodes\\Tree Nodes\\System quality\Ease of Use	No	0.46 %	18	1
Nodes\\Tree Nodes\\System quality\education friendliness	No	0.76 %	16	1
Nodes\\Tree Nodes\\System quality\Reliability	No	0.45 %	8	1
Nodes\\Tree Nodes\\System quality\Response time - delay	No	0.68 %	14	1
Nodes\\Tree Nodes\\System quality\usefulness	No	5.50 %	105	1
Nodes\\Tree Nodes\\Use\acceptability	No	0.34 %	10	1
Nodes\\Tree Nodes\\Use\cost	No	2.50 %	50	1
Nodes\\Tree Nodes\\Use\DS life time	No	0.14 %	5	1
Nodes\\Tree Nodes\\Use\Training	No	0.97 %	25	1

12/08/2011 12:14 PM

Coding Summary

All Australian Focus Groups

12/08/2011 12:14 PM

Hierarchical Name	Aggregate	Coverage	Number Of Coding References	Number Of Users Coding

Internals\\All Australian FG

Document

Node

Nodes\\Free Nodes\\Amplification	No	0.99 %	17	1
Nodes\\Free Nodes\\Battery Life	No	0.26 %	6	1
Nodes\\Free Nodes\\Chest piece design	No	0.50 %	4	1
Nodes\\Free Nodes\\connectivity	No	0.27 %	5	1
Nodes\\Free Nodes\\Cost	No	1.13 %	14	1
Nodes\\Free Nodes\\Diaphragm Design	No	0.68 %	9	1
Nodes\\Free Nodes\\DS lifetime	No	0.26 %	2	1
Nodes\\Free Nodes\\DS material	No	0.24 %	4	1
Nodes\\Free Nodes\\DS shape	No	0.78 %	14	1
Nodes\\Free Nodes\\DS size	No	0.54 %	11	1
Nodes\\Free Nodes\\DS tube Length	No	0.18 %	3	1
Nodes\\Free Nodes\\DS Weight	No	0.33 %	8	1
Nodes\\Free Nodes\\Ear & Head Pieces	No	1.62 %	25	1
Nodes\\Free Nodes\\ease of use	No	0.66 %	16	1
Nodes\\Free Nodes\\Editing Software	No	0.72 %	8	1
Nodes\\Free Nodes\\Education friendliness	No	0.64 %	11	1
Nodes\\Free Nodes\\Flexibility	No	0.04 %	2	1
Nodes\\Free Nodes\\Foldback option	No	0.19 %	2	1
Nodes\\Free Nodes\\hearing impaired friendly	No	0.49 %	4	1
Nodes\\Free Nodes\\Intention to use	No	1.11 %	16	1
Nodes\\Free Nodes\\Intimacy toward traditional	No	1.79 %	21	1
Nodes\\Free Nodes\\Level and frequency of usage	No	0.35 %	4	1
Nodes\\Free Nodes\\Noise	No	4.47 %	79	1
Nodes\\Free Nodes\\Noise filtering	No	0.10 %	3	1
Nodes\\Free Nodes\\Position Locator	No	0.22 %	1	1
Nodes\\Free Nodes\\Recording facility	No	0.95 %	12	1
Nodes\\Free Nodes\\Reliability	No	0.10 %	2	1
Nodes\\Free Nodes\\Response time	No	0.19 %	3	1

Nodes\\Free Nodes\\shock proof	No	0.37 %	3	1
Nodes\\Free Nodes\\Skilled-Level of user	No	1.04 %	8	1

Hierarchical Name	Aggregate	Coverage	Number Of Coding References	Number Of Users Coding
Nodes\\Free Nodes\\Sound Audibility	No	1.53 %	30	1
Nodes\\Free Nodes\\Sound Quality	No	1.89 %	42	1
Nodes\\Free Nodes\\Telehealth compatibility	No	0.57 %	7	1
Nodes\\Free Nodes\\Timeliness for diagnosis	No	0.82 %	12	1
Nodes\\Free Nodes\\training	No	0.41 %	5	1
Nodes\\Free Nodes\\usefulness	No	2.00 %	17	1
Nodes\\Free Nodes\\User friendliness	No	0.02 %	1	1
Nodes\\Free Nodes\\Visual display quality	No	0.30 %	1	1
Nodes\\Free Nodes\\Volume control	No	0.82 %	18	1
Nodes\\Free Nodes\\Warranty	No	0.18 %	2	1
Nodes\\Free Nodes\\Wireless DS	No	0.08 %	2	1
Nodes\\Tree Nodes\\Information Quality\Input\Noise	No	4.47 %	79	1
Nodes\\Tree Nodes\\Information Quality\Input\Skilled-Level of user	No	1.04 %	8	1
Nodes\\Tree Nodes\\Information Quality\Output\Sound Audibility	No	1.53 %	30	1
Nodes\\Tree Nodes\\Information Quality\Output\Sound Quality	No	1.89 %	42	1
Nodes\\Tree Nodes\\Service Quality\Warranty	No	0.18 %	2	1
Nodes\\Tree Nodes\\System Quality\DS Quality\Amplification	No	0.99 %	17	1
Nodes\\Tree Nodes\\System Quality\DS Quality\Battery Life	No	0.26 %	6	1
Nodes\\Tree Nodes\\System Quality\DS Quality\Chest piece design	No	0.50 %	4	1
Nodes\\Tree Nodes\\System Quality\DS Quality\connectivity	No	0.27 %	5	1
Nodes\\Tree Nodes\\System Quality\DS Quality\Diaphragm Design	No	0.68 %	9	1
Nodes\\Tree Nodes\\System Quality\DS Quality\DS life	No	0.26 %	2	1
Nodes\\Tree Nodes\\System Quality\DS Quality\DS material	No	0.24 %	4	1
Nodes\\Tree Nodes\\System Quality\DS Quality\DS shape	No	0.78 %	14	1
Nodes\\Tree Nodes\\System Quality\DS Quality\DS size	No	0.54 %	11	1
Nodes\\Tree Nodes\\System Quality\DS Quality\DS Tube Length	No	0.18 %	3	1
Nodes\\Tree Nodes\\System Quality\DS Quality\DS Weight	No	0.33 %	8	1
Nodes\\Tree Nodes\\System Quality\DS Quality\Ear & Head Pieces	No	1.62 %	25	1
Nodes\\Tree Nodes\\System Quality\DS Quality\Editing Software	No	0.72 %	8	1
Nodes\\Tree Nodes\\System Quality\DS Quality\Foldback option	No	0.19 %	2	1
Nodes\\Tree Nodes\\System Quality\DS Quality\hearing impaired friendly	No	0.49 %	4	1
Nodes\\Tree Nodes\\System Quality\DS Quality\Noise filtering	No	0.10 %	3	1
Nodes\\Tree Nodes\\System Quality\DS Quality\Position Locator	No	0.22 %	1	1
Nodes\\Tree Nodes\\System Quality\DS Quality\Recording facility	No	0.95 %	12	1
Nodes\\Tree Nodes\\System Quality\DS Quality\shock proof	No	0.37 %	3	1
Nodes\\Tree Nodes\\System Quality\DS Quality\Telehealth compatibility	No	0.57 %	7	1
Nodes\\Tree Nodes\\System Quality\DS Quality\Visual display quality	No	0.30 %	1	1
Nodes\\Tree Nodes\\System Quality\DS Quality\Volume control	No	0.82 %	18	1

Nodes\\Tree Nodes\\System Quality\DS Quality\wireless DS	No	0.08 %	2	1
Nodes\\Tree Nodes\\System Quality\ease of use	No	0.66 %	16	1
Nodes\\Tree Nodes\\System Quality\Education friendliness	No	0.64 %	11	1
Nodes\\Tree Nodes\\System Quality\Flexibility	No	0.04 %	2	1

Hierarchical Name	Aggregate	Coverage	Number Of Coding References	Number Of Users Coding
Nodes\\Tree Nodes\\System Quality\Reliability	No	0.10 %	2	1
Nodes\\Tree Nodes\\System Quality\Response time	No	0.19 %	3	1
Nodes\\Tree Nodes\\System Quality\Timeliness for diagnosis	No	0.82 %	12	1
Nodes\\Tree Nodes\\System Quality\usefulness	No	2.00 %	17	1
Nodes\\Tree Nodes\\System Quality\User friendliness	No	0.02 %	1	1
Nodes\\Tree Nodes\\Use\Cost	No	1.13 %	14	1
Nodes\\Tree Nodes\\Use\DS lifetime	No	0.26 %	2	1
Nodes\\Tree Nodes\\Use\Intention to use	No	1.11 %	16	1
Nodes\\Tree Nodes\\Use\Intimacy toward traditional	No	1.79 %	21	1
Nodes\\Tree Nodes\\Use\training	No	0.41 %	5	1

APPENDIX E: NODE SUMMARY INDIAN FOCUS GROUPS

12/08/2011 12:07 PM

Node Summary

Indian Focus Groups

12/08/2011 12:07 PM

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Node

Nickname: Nodes\\Free Nodes\\acceptability

Classification:

Aggregated: No

Document	1	10	164	10	

Nickname: Nodes\\Free Nodes\\Amplification

Classification:

Aggregated: No

Document	1	25	309	25	

Nickname: Nodes\\Free Nodes\\battery life

Classification:

Aggregated: No

Document	1	14	537	15	

Nickname: Nodes\\Free Nodes\\chest piece

Classification:

Aggregated: No

Document	1	8	111	8	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Free Nodes\\comfort

Classification:

Aggregated: No

Document	1	13	290	15	

Nickname: Nodes\\Free Nodes\\connectivity

Classification:

Aggregated: No

Document	1	21	533	22	

Nickname: Nodes\\Free Nodes\\cost

Classification:

Aggregated: No

Document	1	50	1,168	55	

Nickname: Nodes\\Free Nodes\\Diaphragm Design

Classification:

Aggregated: No

Document	1	16	372	17	

Nickname: Nodes\\Free Nodes\\DS base material

Classification:

Aggregated: No

Document	1	4	47	4	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Free Nodes\\DS life time**

Classification:

Aggregated: **No**

Document	1	5	76	5	

Nickname: **Nodes\\Free Nodes\\DS shape**

Classification:

Aggregated: **No**

Document	1	7	118	7	

Nickname: **Nodes\\Free Nodes\\DS size**

Classification:

Aggregated: **No**

Document	1	5	63	5	

Nickname: **Nodes\\Free Nodes\\DS weight**

Classification:

Aggregated: **No**

Document	1	12	159	13	

Nickname: **Nodes\\Free Nodes\\Ear--head piece -head phone**

Classification:

Aggregated: No

Document	1	24	445	25	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Free Nodes\\Ease of Use

Classification:

Aggregated: No

Document	1	18	224	18	

Nickname: Nodes\\Free Nodes\\education friendliness

Classification:

Aggregated: No

Document	1	16	333	16	

Nickname: Nodes\\Free Nodes\\Follow up Service

Classification:

Aggregated: No

Document	1	6	114	6	

Nickname: Nodes\\Free Nodes\\Frequency mode

Classification:

Aggregated: No

Document	1	9	135	9	

Nickname: Nodes\\Free Nodes\\noise

Classification:

Aggregated: No

Document	1	59	1,278	65	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Free Nodes\\recording facility

Classification:

Aggregated: No

Document	1	36	946	38	

Nickname: Nodes\\Free Nodes\\Reliability

Classification:

Aggregated: No

Document	1	8	208	8	

Nickname: Nodes\\Free Nodes\\Response time - delay

Classification:

Aggregated: No

Document	1	14	323	14	

Nickname: Nodes\\Free Nodes\\Skilled-Level of user

Classification:

Aggregated: No

Document	1	22	732	22

Nickname: Nodes\\Free Nodes\\Sound Audibility

Classification:

Aggregated: No

Document	1	67	1,495	69

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Free Nodes\\Sound clarity

Classification:

Aggregated: No

Document	1	15	192	15

Nickname: Nodes\\Free Nodes\\Sound quality

Classification:

Aggregated: No

Document	1	13	195	16

Nickname: Nodes\\Free Nodes\\Training and support

Classification:

Aggregated: No

Document	1	25	461	25

Nickname: Nodes\\Free Nodes\\Tube shape - length

Classification:

Aggregated: **No**

Document	1	4	123	4	

Nickname: **Nodes\\Free Nodes\\usefulness**

Classification:

Aggregated: **No**

Document	1	105	2,528	110	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Free Nodes\\Visual Display - Editing software**

Classification:

Aggregated: **No**

Document	1	16	525	17	

Nickname: **Nodes\\Free Nodes\\Volume control**

Classification:

Aggregated: **No**

Document	1	15	304	19	

Nickname: **Nodes\\Tree Nodes\\information quality**

Classification:

Aggregated: **No**

	0	0			

Nickname: Nodes\\Tree Nodes\\information quality\Input quality

Classification:

Aggregated: No

	0	0			

Nickname: Nodes\\Tree Nodes\\information quality\Input quality\noise

Classification:

Aggregated: No

Document	1	59	1,278	65	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Tree Nodes\\information quality\Input quality\Skilled-Level of user

Classification:

Aggregated: No

Document	1	22	732	22	

Nickname: Nodes\\Tree Nodes\\information quality\Output quality

Classification:

Aggregated: No

	0	0			

Nickname: Nodes\\Tree Nodes\\information quality\Output quality\Sound Audibility

Classification:

Aggregated: No

Document	1	67	1,495	69	

Nickname: **Nodes\\Tree Nodes\\information quality\Output quality\Sound clarity**

Classification:

Aggregated: **No**

Document	1	15	192	15	

Nickname: **Nodes\\Tree Nodes\\information quality\Output quality\Sound quality**

Classification:

Aggregated: **No**

Document	1	13	195	16	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Tree Nodes\\Service quality**

Classification:

Aggregated: **No**

	0	0			

Nickname: **Nodes\\Tree Nodes\\Service quality\Follow up Service**

Classification:

Aggregated: **No**

Document	1	6	114	6	

Nickname: **Nodes\\Tree Nodes\\System quality**

Classification:

Aggregated: **No**

	0	0				

Nickname: **Nodes\\Tree Nodes\\System quality\DS quality**

Classification:

Aggregated: **No**

	0	0				

Nickname: **Nodes\\Tree Nodes\\System quality\DS quality\Amplification**

Classification:

Aggregated: **No**

Document	1	25	309	25		

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Tree Nodes\\System quality\DS quality\battery life**

Classification:

Aggregated: **No**

Document	1	14	537	15	

Nickname: **Nodes\\Tree Nodes\\System quality\DS quality\chest piece**

Classification:

Aggregated: **No**

Document	1	8	111	8	

Nickname: Nodes\\Tree Nodes\\System quality\DS quality\comfort

Classification:

Aggregated: No

Document	1	13	290	15	

Nickname: Nodes\\Tree Nodes\\System quality\DS quality\connectivity

Classification:

Aggregated: No

Document	1	21	533	22	

Nickname: Nodes\\Tree Nodes\\System quality\DS quality\Diaphragm Design

Classification:

Aggregated: No

Document	1	16	372	17	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Tree Nodes\\System quality\DS quality\DS base material

Classification:

Aggregated: No

Document	1	4	47	4	

Nickname: Nodes\\Tree Nodes\\System quality\DS quality\DS shape

Classification:

Aggregated: No

Document	1	7	118	7

Nickname: Nodes\\Tree Nodes\\System quality\DS quality\DS size

Classification:

Aggregated: No

Document	1	5	63	5

Nickname: Nodes\\Tree Nodes\\System quality\DS quality\DS weight

Classification:

Aggregated: No

Document	1	12	159	13

Nickname: Nodes\\Tree Nodes\\System quality\DS quality\Ear--head piece -head phone

Classification:

Aggregated: No

Document	1	24	445	25

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Tree Nodes\\System quality\DS quality\Frequency mode

Classification:

Aggregated: No

Document	1	9	135	9

Nickname: Nodes\\Tree Nodes\\System quality\DS quality\recording facility

Classification:

Aggregated: **No**

Document	1	36	946	38	

Nickname: **Nodes\\Tree Nodes\\System quality\DS quality\Tube shape - length**

Classification:

Aggregated: **No**

Document	1	4	123	4	

Nickname: **Nodes\\Tree Nodes\\System quality\DS quality\Visual Display - Editing software**

Classification:

Aggregated: **No**

Document	1	16	525	17	

Nickname: **Nodes\\Tree Nodes\\System quality\DS quality\Volume control**

Classification:

Aggregated: **No**

Document	1	15	304	19	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Tree Nodes\\System quality\Ease of Use**

Classification:

Aggregated: **No**

Document	1	18	224	18	

Nickname: Nodes\\Tree Nodes\\System quality\education friendliness

Classification:

Aggregated: No

Document	1	16	333	16	

Nickname: Nodes\\Tree Nodes\\System quality\Reliability

Classification:

Aggregated: No

Document	1	8	208	8	

Nickname: Nodes\\Tree Nodes\\System quality\Response time - delay

Classification:

Aggregated: No

Document	1	14	323	14	

Nickname: Nodes\\Tree Nodes\\System quality\usefulness

Classification:

Aggregated: No

Document	1	105	2,528	110	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Tree Nodes\\Use

Classification:

Aggregated: No

	0	0			

Nickname: **Nodes\\Tree Nodes\\Use\acceptability**

Classification:

Aggregated: **No**

Document	1	10	164	10	

Nickname: **Nodes\\Tree Nodes\\Use\cost**

Classification:

Aggregated: **No**

Document	1	50	1,168	55	

Nickname: **Nodes\\Tree Nodes\\Use\DS life time**

Classification:

Aggregated: **No**

Document	1	5	76	5	

Nickname: **Nodes\\Tree Nodes\\Use\Training**

Classification:

Aggregated: **No**

Document	1	25	461	25	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Tree Nodes\\User satisfaction**

Classification:

Aggregated: **No**

	0	0

APPENDIX F: NODE SUMMARY ALL AUSTRALIAN FOCUS GROUPS

12/08/2011 12:15 PM

Node Summary

All Australian Focus Groups

12/08/2011 12:15 PM

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Node

Nickname: Nodes\\Free Nodes\\Amplification

Classification:

Aggregated: No

Document	1	17	212	17	

Nickname: Nodes\\Free Nodes\\Battery Life

Classification:

Aggregated: No

Document	1	6	57	8	

Nickname: Nodes\\Free Nodes\\Chest piece design

Classification:

Aggregated: No

Document	1	4	127	4	

Nickname: Nodes\\Free Nodes\\connectivity

Classification:

Aggregated: No

Document	1	5	62	5	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Free Nodes\\Cost**

Classification:

Aggregated: **No**

Document	1	14	268	19	

Nickname: **Nodes\\Free Nodes\\Diaphragm Design**

Classification:

Aggregated: **No**

Document	1	9	153	9	

Nickname: **Nodes\\Free Nodes\\DS lifetime**

Classification:

Aggregated: **No**

Document	1	2	61	2	

Nickname: **Nodes\\Free Nodes\\DS material**

Classification:

Aggregated: **No**

Document	1	4	57	4	

Nickname: **Nodes\\Free Nodes\\DS shape**

Classification:

Aggregated: **No**

Document	1	14	189	14	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Free Nodes\\DS size

Classification:

Aggregated: No

Document	1	11	123	14	

Nickname: Nodes\\Free Nodes\\DS tube Length

Classification:

Aggregated: No

Document	1	3	43	6	

Nickname: Nodes\\Free Nodes\\DS Weight

Classification:

Aggregated: No

Document	1	8	79	8	

Nickname: Nodes\\Free Nodes\\Ear & Head Pieces

Classification:

Aggregated: No

Document	1	25	395	28	

Nickname: Nodes\\Free Nodes\\ease of use

Classification:

Aggregated: No

Document	1	16	162	18	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Free Nodes\\Editing Software

Classification:

Aggregated: No

Document	1	8	160	12	

Nickname: Nodes\\Free Nodes\\Education friendliness

Classification:

Aggregated: No

Document	1	11	148	14	

Nickname: Nodes\\Free Nodes\\Flexibility

Classification:

Aggregated: No

Document	1	2	11	2	

Nickname: Nodes\\Free Nodes\\Foldback option

Classification:

Aggregated: No

Document	1	2	48	2	

Nickname: Nodes\\Free Nodes\\hearing impaired friendly

Classification:

Aggregated: No

Document	1	4	115	5

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Free Nodes\\Intention to use

Classification:

Aggregated: No

Document	1	16	259	23	

Nickname: Nodes\\Free Nodes\\Intimacy toward traditional

Classification:

Aggregated: No

Document	1	21	412	26	

Nickname: Nodes\\Free Nodes\\Level and frequency of usage

Classification:

Aggregated: No

Document	1	4	85	4	

Nickname: Nodes\\Free Nodes\\Noise

Classification:

Aggregated: No

Document	1	79	1,051	82

Nickname: Nodes\\Free Nodes\\Noise filtering

Classification:

Aggregated: No

Document	1	3	21	3

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Free Nodes\\Position Locator

Classification:

Aggregated: No

Document	1	1	52	1

Nickname: Nodes\\Free Nodes\\Recording facility

Classification:

Aggregated: No

Document	1	12	231	14

Nickname: Nodes\\Free Nodes\\Reliability

Classification:

Aggregated: No

Document	1	2	23	3

Nickname: Nodes\\Free Nodes\\Response time

Classification:

Aggregated: **No**

Document	1	3	46	3	

Nickname: **Nodes\\Free Nodes\\shock proof**

Classification:

Aggregated: **No**

Document	1	3	91	3	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Free Nodes\\Skilled-Level of user**

Classification:

Aggregated: **No**

Document	1	8	231	8	

Nickname: **Nodes\\Free Nodes\\Sound Audibility**

Classification:

Aggregated: **No**

Document	1	30	377	32	

Nickname: **Nodes\\Free Nodes\\Sound Quality**

Classification:

Aggregated: **No**

Document	1	42	455	45	

Nickname: Nodes\\Free Nodes\\Telehealth compatibility

Classification:

Aggregated: No

Document	1	7	135	7	

Nickname: Nodes\\Free Nodes\\Timeliness for diagnosis

Classification:

Aggregated: No

Document	1	12	192	19	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Free Nodes\\training

Classification:

Aggregated: No

Document	1	5	95	13	

Nickname: Nodes\\Free Nodes\\usefulness

Classification:

Aggregated: No

Document	1	17	465	22	

Nickname: Nodes\\Free Nodes\\User friendliness

Classification:

Aggregated: No

Document	1	1	5	2

Nickname: **Nodes\\Free Nodes\\Visual display quality**

Classification:

Aggregated: **No**

Document	1	1	66	3

Nickname: **Nodes\\Free Nodes\\Volume control**

Classification:

Aggregated: **No**

Document	1	18	205	20

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Free Nodes\\Warranty**

Classification:

Aggregated: **No**

Document	1	2	45	2

Nickname: **Nodes\\Free Nodes\\wireless DS**

Classification:

Aggregated: **No**

Document	1	2	23	2

Nickname: **Nodes\\Tree Nodes\\Information Quality**

Classification:

Aggregated: No

	0	0			

Nickname: Nodes\\Tree Nodes\\Information Quality\Input

Classification:

Aggregated: No

	0	0			

Nickname: Nodes\\Tree Nodes\\Information Quality\Input\Noise

Classification:

Aggregated: No

Document	1	79	1,051	82	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Tree Nodes\\Information Quality\Input\Skilled-Level of user

Classification:

Aggregated: No

Document	1	8	231	8	

Nickname: Nodes\\Tree Nodes\\Information Quality\Output

Classification:

Aggregated: No

	0	0			

Nickname: **Nodes\\Tree Nodes\\Information Quality\Output\Sound Audibility**

Classification:

Aggregated: **No**

Document	1	30	377	32	

Nickname: **Nodes\\Tree Nodes\\Information Quality\Output\Sound Quality**

Classification:

Aggregated: **No**

Document	1	42	455	45	

Nickname: **Nodes\\Tree Nodes\\Service Quality**

Classification:

Aggregated: **No**

	0	0			

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Tree Nodes\\Service Quality\Warranty**

Classification:

Aggregated: **No**

Document	1	2	45	2	

Nickname: **Nodes\\Tree Nodes\\System Quality**

Classification:

Aggregated: **No**

	0	0			

Nickname: **Nodes\\Tree Nodes\\System Quality\DS Quality**

Classification:

Aggregated: **No**

	0	0			

Nickname: **Nodes\\Tree Nodes\\System Quality\DS Quality\Amplification**

Classification:

Aggregated: **No**

Document	1	17	212	17	

Nickname: **Nodes\\Tree Nodes\\System Quality\DS Quality\Battery Life**

Classification:

Aggregated: **No**

Document	1	6	57	8	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Tree Nodes\\System Quality\DS Quality\Chest piece design**

Classification:

Aggregated: **No**

Document	1	4	127	4	

Nickname: **Nodes\\Tree Nodes\\System Quality\DS Quality\connectivity**

Classification:

Aggregated: **No**

Document	1	5	62	5	

Nickname: **Nodes\\Tree Nodes\\System Quality\DS Quality\Diaphragm Design**

Classification:

Aggregated: **No**

Document	1	9	153	9	

Nickname: **Nodes\\Tree Nodes\\System Quality\DS Quality\DS life**

Classification:

Aggregated: **No**

Document	1	2	61	2	

Nickname: **Nodes\\Tree Nodes\\System Quality\DS Quality\DS material**

Classification:

Aggregated: **No**

Document	1	4	57	4	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Tree Nodes\\System Quality\DS Quality\DS shape**

Classification:

Aggregated: **No**

Document	1	14	189	14	

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\DS size

Classification:

Aggregated: No

Document	1	11	123	14

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\DS Tube Length

Classification:

Aggregated: No

Document	1	3	43	6

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\DS Weight

Classification:

Aggregated: No

Document	1	8	79	8

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\Ear & Head Pieces

Classification:

Aggregated: No

Document	1	25	395	28

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\Editing Software

Classification:

Aggregated: No

Document	1	8	160	12

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\Foldback option

Classification:

Aggregated: No

Document	1	2	48	2

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\hearing impaired friendly

Classification:

Aggregated: No

Document	1	4	115	5

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\Noise filtering

Classification:

Aggregated: No

Document	1	3	21	3

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\Position Locator

Classification:

Aggregated: No

Document	1	1	52	1

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\Recording facility

Classification:

Aggregated: No

Document	1	12	231	14

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\shock proof

Classification:

Aggregated: No

Document	1	3	91	3

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\Telehealth compatibility

Classification:

Aggregated: No

Document	1	7	135	7

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\Visual display quality

Classification:

Aggregated: No

Document	1	1	66	3

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\Volume control

Classification:

Aggregated: No

Document	1	18	205	20

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Tree Nodes\\System Quality\DS Quality\Wireless DS

Classification:

Aggregated: No

Document	1	2	23	2

Nickname: Nodes\\Tree Nodes\\System Quality\ease of use

Classification:

Aggregated: No

Document	1	16	162	18

Nickname: Nodes\\Tree Nodes\\System Quality\Education friendliness

Classification:

Aggregated: No

Document	1	11	148	14

Nickname: Nodes\\Tree Nodes\\System Quality\Flexibility

Classification:

Aggregated: No

Document	1	2	11	2

Nickname: Nodes\\Tree Nodes\\System Quality\Reliability

Classification:

Aggregated: No

Document	1	2	23	3

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: Nodes\\Tree Nodes\\System Quality\Response time

Classification:

Aggregated: No

Document	1	3	46	3	

Nickname: Nodes\\Tree Nodes\\System Quality\Timeliness for diagnosis

Classification:

Aggregated: No

Document	1	12	192	19	

Nickname: Nodes\\Tree Nodes\\System Quality\usefulness

Classification:

Aggregated: No

Document	1	17	465	22	

Nickname: Nodes\\Tree Nodes\\System Quality\User friendliness

Classification:

Aggregated: No

Document	1	1	5	2	

Nickname: Nodes\\Tree Nodes\\Use

Classification:

Aggregated: No

	0	0			

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Nickname: **Nodes\\Tree Nodes\\Use\Cost**

Classification:

Aggregated: **No**

Document	1	14	268	19	

Nickname: **Nodes\\Tree Nodes\\Use\DS lifetime**

Classification:

Aggregated: **No**

Document	1	2	61	2	

Nickname: **Nodes\\Tree Nodes\\Use\Intention to use**

Classification:

Aggregated: **No**

Document	1	16	259	23	

Nickname: **Nodes\\Tree Nodes\\Use\Intimacy toward traditional**

Classification:

Aggregated: **No**

Document	1	21	412	26	

Nickname: **Nodes\\Tree Nodes\\Use\training**

Classification:

Aggregated: **No**

Document	1	5	95	13	

Source Type	Number of Sources	Number of Coding References	Number of Words Coded	Number of Paragraphs Coded	Duration Coded

Relationship

Nickname: Relationships\\Education friendliness (Impacts) usefulness

Classification:

Aggregated: No

	0	0			

Nickname: Relationships\\Intimacy toward traditional (Increase) Intention to use

Classification:

Aggregated: No

	0	0			

Nickname: Relationships\\Sound Audibility (essential) Sound Quality

Classification:

Aggregated: No

	0	0			

Nickname: Relationships\\Timeliness for diagnosis (Impacts) usefulness

Classification:

Aggregated: No

	0	0			