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## **E-learning and teledermatology: Are web-based images good enough for learning?**

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## Abstract

The purpose of this study is to review different papers that discuss about e-learning and teledermatology and how web based images are helping in diagnose and treatment of dermatological problems. This study is a qualitative chronicle literature review of teledermatology and e learning to evaluate the current situation of teledermatology to solve skin related problems and how modern technologies are assessing in this field. After searching process more than 200 papers have found relevant to the thesis topic. After inclusion and exclusion criteria, 30 papers have found appropriate for the thesis topic. Selected articles are categorized according to the different arrears of telemedicine and new invention of e learning. Also the contribution of web based images to determine dermatological problems were discussed.

Some of the articles described about the role of teledermatology in non-cancerous diseases. All these articles explained about the diagnosis of skin problems and how fast and accurately these problems can be treated with the use of teledermatology technology. In most of the articles there are some comparison between face-to-face consultation and store and forward teledermatology technology. Area of research was a big factor in all papers because some of the research was conducted in rural areas. The procedures for cancerous disease were almost same. In this case the diagnostic accuracy was more important. In case of cancerous disease teledermatology played an important role for instant treatment. Some articles described about the role of mobile telephone in teledermatology. In this cases image quality was a big challenge to identify the accurate problem. Finally some articles explained about current situation of e learning condition and different fields of images used for the diagnosis procedure of skin problems. Notwithstanding this small number of articles discussed in different field of dermatology and e learning most of the articles related to the review achieved positive outcome after implementation of the telemedicine technology. These encouraging outcomes with the continuous advancement of information technology feels us to assume rising in the number of studies that investigate incorporating teledermatology and use of images in the field of dermatology in the future and the involvement of these applications into more dermatological cases.

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# CHAPTER ONE:

## INTRODUCTION

### 1.1 Background

Telemedicine can be described as medicine at a distance implemented by way of healthcare delivery systems that rely on computers, modern communication technology, video conferencing and photographic equipment managed by healthcare personnel trained to provide healthcare to patients of remote area. There are so many definitions of telemedicine based on the interest of physicians, patients, technicians and other healthcare professionals. The field of telemedicine is very broad. Telemedicine is not a separate medical branch. Products and assistances related to telemedicine are considered as a part of a larger investment by health care institutions either in information technology or in the delivery of clinical care. In this Age of Information, health care system has been shifted, from hospital-based acute care to prevention, promotion of wellness, and also to the level of maintenance of function in community and home-based facilities. Current development of telecommunications and information technology has transfigured many aspects of daily life, and this revolution has also had an impact on the practice of medicine, and especially dermatology. Telemedicine can be performed by two ways, either between doctors and patients (telediagnosis) or between two or more medical center from a distance (teleconsulting) [1].

The principal visions of telemedicine are to increase the quality of healthcare and to reduce costs of healthcare by providing patients remote access to specialized medical resources [2]. Telemedicine can be advantageous in countries having large territorial dimensions, potential transportation difficulties, and environmental factors. Telemedicine expedites both remote access to medical care and the communication of healthcare information. In the past few years the steady growth of telemedicine practice is observed in a parallel way with advantage in information and communication technologies but the progressive decline in cost of the equipment and infrastructure is required [3]. Some evidence suggests that the forthcoming challenges for the healthcare service will be the population during the next ten years that will change with regard to the composition of age groups and this will be seen more specifically in developed countries. Older people who are the leading user of healthcare services will

increase in a momentous number. From 1970 the number of person over aged 70 have doubled in Norway. This number will increase by the year of 2020. Also people of aged 90 also will increase in a heavy number. In general, the users of the health services will increase at the same time, as there will be less number of persons in the age group, which can create health services and supply to the economic resources needed by the health services. Because of the increasing cost of running, the organizations of the health care services (hospitals, nursing homes, and old care homes), Norway or other developed countries should bring a change towards greater emphasis on primary health care services. Telemedicine can be considered as a tool of efficient utilization of available resources. Telemedicine provides an opportunity to increase the combination between various health care services and in this way contributes to better care directed towards the patients.

### **1.2 Teledermatology:**

Dermatology is one of the most visual specialties in medicine and also it is suited for modern telemedicine techniques. In teledermatology, dermatologists use telemedicine techniques to diagnose and treat patients from a distance, which involves the clinical evaluation of skin lesions and the review of laboratory findings. The primary aim is to make sure that patients from remote area are getting specialized dermatological care. The further aim is to decrease the number of hospital visit and to increase diagnostic efficiency [4].

One objective of teledermatology is to deliver high quality healthcare more efficiently, by moving the patient's information rather than moving the patients [5]. Teledermatology applications consist of two different models of operation, one is store-and-forward (i.e. pre-recorded) and other is real-time (i.e. synchronous). In store-and-forward telemedicine, photographs of patients are sent for the review of a consultant at any time. On the other hand real-time telemedicine often use videoconferencing equipment and a direct interaction between teledermatologist and patients occur. Both of these systems offer a clear method of service delivery directed towards improvement of access and decreasing cost, by eliminating travel for patients, physicians and nurses. It is seen that there is an increasing demand of dermatology and so that the demand of teledermatology has increased at the same time. In U.K in the decade between 1981 and 1991 there has been almost 50% increase in dermatology referrals. Research shows that some teledermatology trials have not shown teleconsultations to be faster or more cost efficient than traditionalist consultations, although evidence suggests that low-cost store-and-forward systems of teledermatology may reduce waiting times for



some patients [6]. Some patients themselves search in the Internet to seek further information or advice regarding their illness. Patients themselves are connecting to the databases or emailing to their physicians using Internet for more advice. However, patients getting advice using the Internet may increase their level of anxiety or reach false conclusions, which may lead to poor outcome. Furthermore, there is evidence that patients can get relevant information in a way, which they will understand for example by accessing sites such as the patient information leaflets provided by the American Academy of Dermatology (AAD) website [7].

The fundamental visual nature of dermatology makes it appropriate for telemedicine. When Internet is used for distance education that can be an effective tool to support teledermatology. By using images and information provided about patients' diagnosis can be made remotely. When the qualities of images are reliable, digital images can be a substitute for physical examinations in dermatology in 83% of dermatology cases [8]. Photographic images of patients play an important role in dermatological record keeping. Physicians usually use the patient data that are collected and transmitted by teledermatological systems, which use informatics and telecommunication technology, diagnose the disease and suggests all necessary therapeutic measures. Many studies have showed that the general doctors are not able to diagnose successfully the 20 most usual dermatological diseases [9]. If not diagnosed at their very early stages many of those diseases may prove fatal (e.g., melanoma). So, for distant rural areas, the need of teledermatological system becomes necessary where general physicians usually provide dermatological care. Teledermatology provides fast and easy access to dermatological care to many patients, reduce the cost, improves the level of providing patients care. However, digital images sometimes offer challenges to physicians who are using the technology newly. Sometimes it is not clear if images captured of a patient at a visit is a part of patients' medical record. Sometimes multi images are captured and some are deleted immediately for their poor quality. These deleted images are not a part of medical record and patients can claim that these images were representing their current skin condition. Though, it is suggested that all the images should be archived to avoid debate on the extent that which images has been altered.

### **1.3 History of Teledermatology:**

The first teledermatology project was introduced in 1960s in the context of a broader telemedicine program linking a clinic of Boston's Logan Airport and the Massachusetts General Hospital [4]. In 1970, Murphy et al [10] published the results of a study where dermatologists judged images of skin lesions on either color slides or a black and white television. Studies discovered that dermatologists were more successful in terms of both treatment and diagnosis after evaluating the images of skin problems with the help of either real life video conferencing techniques or store-and-forward system than general practitioners. The use of communication technologies was quite effective but was costly to be applied in healthcare system. In 1990s, telemedicine projects touched a pick and dermatology was often the leader in the use of technologies.

Norway was the first European country to introduce telemedicine in dermatology. In 1989, teledermatology service was founded between University Hospital Tromsø (UNN) and primary care center in Kirkenes (800 km away from Tromsø). By these two participating medical centers an initial pilot study published, which reported a 100% diagnostic agreement between teledermatology consultations and face-to-face visits. The result of this finding was very effective and teledermatology was built-in as a routine service, and necessary apparatus was acquired in kirkenes in 1993 to provide phototherapy to patients. Finland has also played an important role in the development of teledermatology [11].

Teledermatology has proven to be an effective technology for making diagnosis, achieving consistency rates between 59% and 80% in consequent studies, most of which examined real-time interactive teleconsultation. Most of the studies published since 2000 have mainly focused on store-and-forward teledermatology platforms. This system is less costly, has a high reliability rate and easily manageable. Usually rich countries with a low population (Scandinavian countries, Australia, Canada, USA) are leading in the field of telemedicine. Thus, the use of teledermatology can be vindicated by healthcare policy as well as by geographical issues, because it offers noticeable advantages in terms of both better accessibility and the removal of geographical barriers. Having limitations related to staff remuneration and time required to carry out teleconsultations, the field of teledermatology in Norway is enjoying the broadest implantation. Some limitations in Australia are restricting the routine use of teledermatology which includes, lower reliability and accuracy compared to conventional face-to-face consultation, inadequate trained healthcare personnel, lack of physician and patient interaction and lack of acceptance of teledermatology techniques among

potential users [12]. Some recent studies in United Kingdom have noticed potential obstacles in the routine use of teledermatology. However, the use of teledermatology is developing in a remarkable way, many significant questions have to be resolved.

## **1.4 Categories of Teledermatology**

### **1.4.1 Synchronous or Real-Time Teledermatology**

In real-time teledermatology, at least two parties communicate synchronously. This term is applicable for both ordinary telephone call and video conferencing. In this type of system, the patient can be alone but most of the time accompanied by a primary care physician or a supplementary technical consultant who is specialized in telemedicine. Real time teledermatology is less time consuming and cost effective for patients because they are seen at the local health center rather than at a specialized hospital. In real-time teledermatology patients do not need to take an appointment that saves time, travelled need not to travel long distances, and dermatologists can examine more quickly compared with the dermatologist at the outpatient clinic [13]. Possibility of adjusting, retouching or retaking of images is immediate in real-time teledermatology.

### **1.4.2 Asynchronous or Store-and-Forward Teledermatology**

In store-and-forward teledermatology system patient data (digital images, clinical and demographic information) is sent by general practitioners (GPs) in an electronic medium for future access by dermatologists in referral centers to deliver proper healthcare in remote geographic regions. In this type of teledermatological service there is no real-time interaction between the dermatologist and the patients. These technologies allows physicians to attach and transmit a medical history of the patient with the mandatory fields completed together with digital images of the patient's grazes, so E-mail or web interfaces may be used. Images are captured and transmitted as single file in store-and-forward teledermatology system. The clinical information of patients is standard in store-and-forward process.

The store-and-forward teledermatology technique differs in three major ways from real-time teledermatology and from hybrid system. First, it saves resources that are required mutually agreeable appointments because it is asynchronous. For this reason some teledermatologists think that store and forward teledermatology system is more professional than real time teledermatology. Secondly, the hardware require for store-and-forward teledermatology

system is less expensive and freely available than other teledermatology system. The third difference is the lack of interaction between the physician and the patients, which is considered as a disadvantage of store-and-forward teledermatology [14].

### **1.4.3 Hybrid system**

Hybrid system teledermatology is one kind of store-and-forward teledermatology that can also handle real-time teledermatology. The Swiss Dermanet project uses a hybrid system to store and forward clinical histological and dermoscopic photographs to make physicians understand and later they can discuss cases on teledermatological network via a multilateral real-time video conferencing system.

### **1.5 E- learning**

E- learning is the use of computer network technology through the Internet to deliver information to individuals in education. E- learning can include computer-based instruction, computer managed instruction, multimedia learning, Internet based training, online education. E- learning is usually associated with substances that are accessible on a computer. The substances may be on the Web or the Internet, or installed on a CD-ROM or the computer hard disk. The area of E- learning can be categorized as follow,

- E- Learning as educational methodology.
- E- Learning as technical medium
- E- Learning as educational subject
- E- Learning as organizational tool.

E- Learning can be synchronous and asynchronous E- learning. Asynchronous E-learning is the E-learning that is 'pre-recorded' or accessible to employees at any time of the day and any location [15]. Synchronous E-learning is the real time 'chat' sessions where employees can log on at the same time to discuss various topics. In dermatology education E-learning is considered as an important tool especially for medical graduates. Medical students should be able to observe the skin properly and know when have to refer patients to specialist dermatologist [16]. Medical schools should explore new educational technologies including information and communication technology. Computer assistance learning program is capable to eradicate the geographical distance and time restrictions of face-to-face teaching. E-learning education system offers numerous advantages over conventional teaching mechanisms, and they are capable to deliver high-quality images at a lower cost. The students

at anytime from anywhere access E- learning education and can get feedback. Usual e-learning events include online discussion, chat and other forms of conferencing, reading specific e-learning content, taking online tests and assessments, working through short exercises to encourage thinking, or implementation of web forms such as those used for course evaluation. Some e-learning education program includes, audio conferencing, video conferencing and web conferencing.

**1.5.1 Audio Conferencing:** There are some technologies that allow the students to access teachers online using audio conferencing, while the rise of free voice over the Internet (Voice over IP, or VOIP). Skype is one of the most common tools, which has made this audio conferencing easier. Teleconferencing via VOIP is another popular way of audio conferencing.

**1.5.2 Video conferencing:** Video conferencing is applicable within remote groups of people, especially in classes where students need to work with each other. However, Video conferencing requires significant network bandwidth, also requires dedicated and sometimes expensive hardware and space for all connecting locations. Careful planning and execution is indispensable to use video conferencing for educational purpose. The advancement of fiber optic network has improved the connectivity and picture quality of video conferencing.

**1.5.3 Web conferencing:** Desktop videoconferencing is usually named web conferencing. Web conferencing involves the connection of personal computers or laptops with webcams, microphones etc. Web conferencing is usually cheaper and requires less bandwidth. But the image resolution in web conferencing is not good. Though web conferencing is now supported in many audio conferencing tools (such as Skype, MSN Messenger, there is usually larger educational effectiveness in multiple channel collaborative media for example Adobe Connect which allow video, audio, chat are used as part of a single assimilated system.

## **CHAPTER TWO:**

### **TECHNOLOGY ACCEPTANCE MODEL**

#### **2.1 What is Technology Acceptance Model**

In healthcare research and public health services, and in many other territories, we can note the emergence of large-scale technology intended for long-term use with several users and uses. Nowadays telemedicine has been considered as one of the developing new service delivery media that run on the technology superhighway [17]. The fast growth of Internet based technology has resulted in many methods to learning development, established in different forms of e learning. E learning has been approached as a technique, which uses Internet technology to deliver to people with interactions through computer interfaces. Technology acceptance model is the adaption of Theory of Reasoned Action (TRA), which is specifically personalized for modeling user acceptance of information systems. Technology acceptance model is considered one of the popular models to explain the technology acceptance and use of technology. Technology acceptance model is build up on two ultimate features, perceived ease of use (PEOU) and perceived usefulness (PU). The main feature of perceived ease of use are system design and features, whereas the core feature underlying perceived usefulness is effort decreasing [18].

Technology acceptance model has been applied into many fields to investigate user acceptance of information technology, includes the World Wide Web, healthcare, multimedia and even mobile banking [19]. In order to achieve a more ungenerous model, the attitudinal and normative factors were declined from the technology acceptance model, leaving PEOU and PU as the predictors of purpose. However, there is good number of evidence that the constructs can significantly influence the behavioral meaning and should be engaged in the model [20]. It is proved that the technology acceptance model is suitable for both genders, most of the cultures, various age groups and for all levels of individuals. It is also predict that technology acceptance in both mandatory and chosen usage settings. Further more, the trustworthiness and the robustness of the technology acceptance model has been demonstrated.



## 2.2 Background of Technology Acceptance Model

To measure and analyze computer user satisfaction, researchers first developed the tools. Bailey and Pearson indicated that, it was natural to turn to the efforts of psychologists, who study satisfaction in a larger sense [21]. Bailey and Pearson, which is used to influence the user satisfaction, identified 39 factors. As the list of factors was long, it was tried to abbreviate it and thus make it more practical. The factors were grouped in three different groups of variables,

1. Uncontrollable (task technology and organizational time frame);
2. Partially controllable (psychological climate and systems development backlog);
3. Fully controllable (end-user computing (EUC) training, rank of EUC executive, and EUC policies).

According to Fishbein and Ajzen [22], figure 1 shows the original version of technology acceptance model.

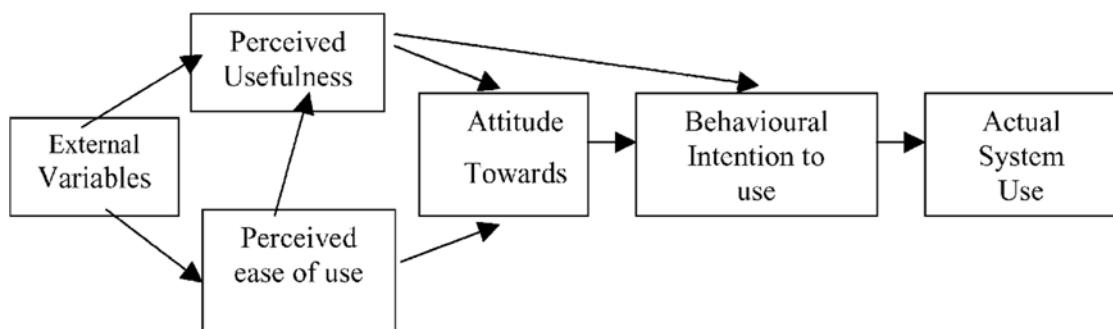


Fig. 1. Original technology acceptance model.

The key purpose of technology acceptance model is to provide a basis for outlining the influence of external variables on internal attitude and objectives. It suggests that perceived ease of use (PEOU), and perceived usefulness (PU) are the two most significant features in explaining system use.

The technology acceptance model differs from Theory of Reasoned Action (TRA) in two different ways; first, it identifies utility and ease of use as the two external variables or beliefs that it regulate attitude toward an information technology, intention to use, and actual use. Thus, in case of each behavior TAM does not need to be tailored, as long as that behavior is use of IT. Second, TAM does not involve the subjective models construct in TRA. Subjective models, account for intention to perform a behavior in TRA along with attitude.

The theory of planned behavior (TPB), which is an extension of Theory of Reasoned Action (TRA), includes behavioral control as a hypothesis to measure and account explicitly for the extent. Thus the users get complete control over their own behavior. The technology acceptance model does not include the behavioral control construct. In case of TPB intention to perform a behavior is directly affected by behavioral control. However, behavioral control is significantly depends on the particular behavior. For IT usage behavior, the importance of behavioral control is limited. If there is a comparison between TAM and TPB it can be concluded that TAM's ability to account for variance in intention to use or in case of actual use is almost the same as TPB's. Technology acceptance model represents the modifying of a well-developed social psychology theory. Technology Acceptance Model has also been verified and equaled to revisions of TRA by several authors independent of the original developers of TAM. In case of understanding IT utilization the main weakness of technology acceptance model is its lack of task focus. By using IT users accomplish organizational tasks. The lack of task mainly emphasis in evaluating IT and it also focuses in what extent it is accepted, use, and functioning provides to the mixed results in IT evaluations.

### **2.3 Theoretical Rationale for Technology Acceptance Model**

Specific attention is directed towards the relationship between technology acceptance model and Fishbein model. The technology acceptance model differs in several ways from the standard Fishbein model. The subjective model and behavioral intention variables are ignored from the present model.

Belief summation: The relationship between beliefs and attitude can be described by the following equation,

$$A_{act} = \sum_{i=1,n} b_i e_i$$

Computing the summation on the right-hand side of the above equation and computing its correlation with  $A_{act}$  generally assess the relationship between beliefs and attitudes.

### **2.4 Determinants of Perceived Usefulness**

Venkatesh and Davis [23] suggested an extension of TAM to TAM2 by identifying the general determinants of perceived usefulness, which are, subjective norm, image, job relevance, output quality, result demonstrability.

*Perceived ease of use:* This is the degree by which a user believes that using an information technology will be free of effort. This concept reflects on general beliefs associated with computers and use of computers. Computer self-efficacy suggests to individuals' control beliefs regarding his or her own capability to use a system.

*Subjective norm:* This is the degree by which the individuals identifies that most people who are important to him think he should or should not use the system. This includes two types of theoretical process, social influence and cognitive instrumental process. These are to explain the effects of the various determinants on behavioral intension.

*Images:* In this case the individuals perceive that use of an innovation will enhance his or her social status in his or her social system. This determinant represents the social influence process. There are three-influence mechanism identification, internalization and compliance. These mechanisms help to understand the social influence process. Identification refers to an individuals feeling that by performing a behavior will raise his or her social status within a referent group because important referents believe the behavior should be performed [24] Internalization is the incorporation of a referent's belief into someone's own belief structure. Compliance is the situation where an individual performs a behavior in order to avoid punishment.

*Job relevance:* In this degree the individuals' belief that the target system is applicable for hos or her own job. Job relevance point captures the inspiration of rational instrumental process observed usefulness.

*Output Quality:* This is the degree to which an individual believes that the system performs his or her job tasks in a good way. This output quality has a moderate effect on perceived usefulness. The higher will be the output quality the stronger will be the effect of job relevance on perceived usefulness.

*Result Demonstrability:* In this degree the individual believes that the results of using a system are tangible, noticeable, and transmittable.

## **2.5 Technology Acceptance Model in healthcare**

Technology acceptance model has become popular among the physicians nowadays. TAM is a good interpreter of physician behavioral intent to accept technology. In case of physician's technology acceptance, it is well defined that time practice related issues, personal issues, system practice characteristics, organizational issues can influence a physician's acceptance of a new technology. In a physician's eye speed is the main concern to process a CPOR or EMR system. For the successful CPOR or EMR implementation process, it is important to have a collaborative organizational culture in physicians' practice environment. Without such a culture, it is impossible to make such a system workable.

Health information technology often focuses on information technology design and implementation. Many recent reports of the unpremeditated consequences of health information technology show that whether an information system is 'successful' or not is decided on the work floor of health care system [25]. Most of the studies have focused on Electronic Patient Records (EPR). Comparatively small attention has been paid to the potentials of those systems and the degree to which physicians with EPRs actually use them. Electronic patient records have great potential to improve quality and safety in health care system. However, these developments will occur only if clinicians have access to key functions in EPR systems and if they are capable to use them regularly.

Technology acceptance model has had extensive applications in clarifying health care providers' reactions to health IT. Most impressive thing is the relationship between the PU and purpose to use or actual use of health IT. But in addition to the apparent strength of technology acceptance model in health care studies, there are some challenges. However, more studies should be conducted to identify salient beliefs that clinicians have about using health IT. By contextualizing technology acceptance model to health care, there is the opportunity to develop the use of information technology in healthcare system.

## **CHAPTER THREE:**

### **METHODS**

#### **3.1 Research design**

The method part plays an important role in any kind of research. Research design is a part of method in any kind of research. My study is a qualitative narrative literature review rather than a data collective qualitative research. This research mainly focused on different databases including National institute of health (Pubmed.gov), The Journal of Telemedicine and Telecare, The journal of the American Medical Association (JAMA). Some specific keywords was used to search the articles including, Telemedicine, Teledermatology, Teledermatology and skin cancer, Mobile teledermatology, E-learning, telemedicine and e-learning, telederm, digital imaging in healthcare, computer graphic imaging in teledermatology etc.

In my study research design was an important part. A good research design for a qualitative study is like a ship in an ocean. It will help to reach to the destination safely and without any trouble. On the other hand a poor research design fail to get the goal. According to Robson, research question drives the research design whether the research will be qualitative or quantitative [26]. According to him, researchers have to be concerned if they use flexible designs themselves with the reliability of their methods and research practices. It is preferable to use fix and flexible design to represent quantitative and qualitative research methods respectively. Fix design is consists of quantitative data, pre- specification; on the other hand, flexible design contains qualitative data of much less pre-specification. In flexible designs, the design develops, extends as well as discloses as the research proceeds however, in fixed design studies highlight the dimension and analysis of fundamental relationships between variables, but not processes [26].

Qualitative research method is the method of choice in evaluating information system. Qualitative system is considered as the best method of identifying and selecting research topics for exploration of matters. Qualitative research is often a requirement for quantitative research and for understanding the results from quantitative research requires qualitative methods. So in this logic, to some extent quantitative methods depend on qualitative method. Sometimes qualitative research is seen in geographical terms, for example as a movement

when a researcher, primarily as a distance, is coming closer and closer the live realities of other people. In case of qualitative research, the researchers get the permission to study selected issues in detailed and elaborate way. Alternatively, in case of quantitative study it is required to use the standardize measures so that the varying perceptions and practices of people can be shaped into a limited number of predetermined response categories where numbers are assigned [27]. Actually, qualitative methods create a variety of detailed information about a smaller number of people and cases. Perhaps by this way qualitative research can take an expected position in case of case study research.

### **3.2 Finding articles**

This step was to find the articles, which are related review. A good number of articles were found after searching in different databases. More than two hundred articles were found which are related to my topic. So there was a necessity to refine selected articles. I have tried to select some new papers where the old one was from 2007 and the latest was from 2014. Each articles was evaluated according to the inclusion criteria of my study. I have followed the following inclusion criteria,

- Articles focus completely on telemedicine applications in the field of teledermatology.
- Articles that focus on e learning and web based applications in the field of teledermatology.
- Articles that are published in English language, though I found articles in Spanish and polish language.
- Articles that focus on both technical and health issues.
- Articles that focuses on dermatological problems both cancerous and non-cancerous diseases.

I have tried to find latest articles but there were some old articles, which were much informative. For the review of literature browsing of relevant articles was performed. The following step was selecting relevant articles that match properly with my thesis topic. The next step was comprehensive reading and summarizing of the selected articles. After that the most important par was to analyze the papers.

The articles that were selected was categorize according to several issues. At first when I selected e learning or teledermatology as key ward to search papers a good number of papers were found. Some papers were old and some were totally new with good information. Articles



were published from all over the countries. Researches from different universities conducted research on both dermatological issues and technical issues in dermatology. I have mainly categorized papers based on dermatological issues and technical issues. I have tried to subdivide these issues.

Dermatological issues:

- Cancerous disease
- Non-cancerous disease
- Mobile teledermatology

And Technical issue.

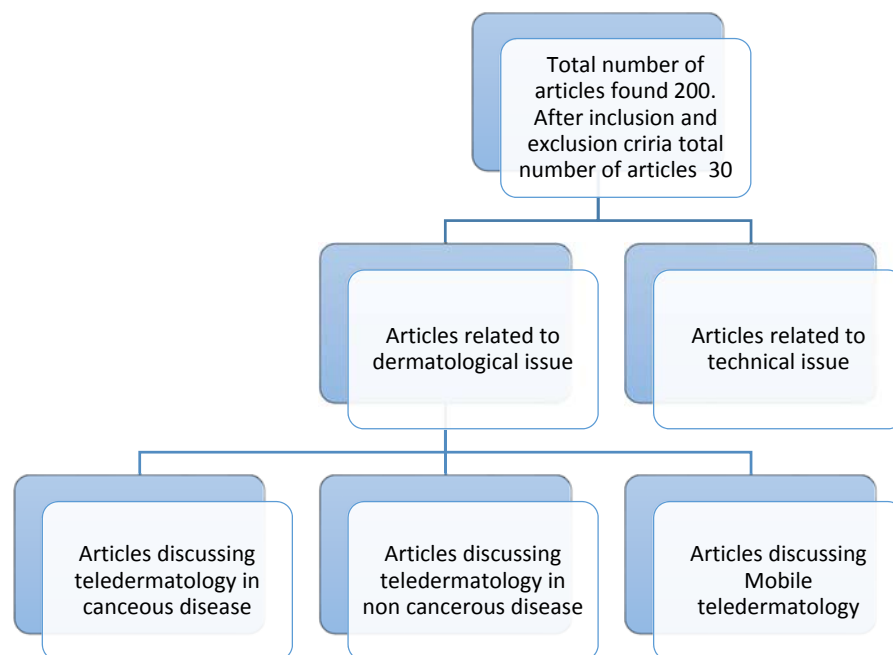


Fig 2. Categories of the articles selected for the review.

A. Articles that discuss dermatological issues

- Articles discussing cancerous dermatological problems
- Articles discussing non-cancerous dermatological problems
- Articles mobile teledermatology.

B. Articles discussing E learning and technical issues in dermatology

## CHAPTER FOUR

### RESULTS

#### 4.1 Dermatological issues

In case of discussing dermatological issues there also some other categories. Some papers discussed about the over all picture of teledermatology, some papers discussed about the different types of teledermatology, some discussed about the imaging of teledermatology and some deliberated about different types of dermatological problems. A large number of papers were found to describe dermatological issue as because this is big field of research. Some papers were really old. Two of the papers were published from Austria, one was from Australia, and four were from USA, one from Hong Kong.

On paper that was published from Austria mainly focused on the teledermatological issues. Cesare Massone, Elisabeth M.T. Wurm, Hofmann-Wellenhof and H. Peter Soyer conducted the study. In this paper they have mainly focused on the challenges of teledermatology, teledermascopy, mobile teledermatology, mobile teledermoscopy, teledermatopathology, teledermatology on the web. In the challenges part they have discussed about the present challenges of challenges of teledermatology, how much patients rely on teledermatology compared to face-to –face consultations. They have introduced SAF teledermatology as a routine triage system teleconsultations concerning skin cancer and pigmented skin lessons [28]. This SAF teledermatology is effective, more reliable and more accurate. In this system there is a chance to secondary care dermatology services for second opinion. Challenges also include the thought to introduce teledermatology services within the national health services and the service should be available without any fail. Also patients must be confident about the inviolability of the personal information.

After that they have described about what teledermascopy is. This is a practical applicability of the use of dermoscopy via Internet. In 2003, a study was performed on dermoscopic-pathologic approach using telediagnosis for melanocytic skin neoplasm. The accuracy rate of the diagnosis reached 83% [29]. Recently teledermoscopy has been evaluated as a filtering system on 219 pigmented skin lessons. In this system teleconsultations were sent from the general practitioners to the pigmented skin lesion clinic. The outcome of the teleconsultation was 49%. The researchers found a high agreement among the teleconsultants for both the

diagnosis and management actions. The authors mentioned teledermoscopy as a promising area for further research and development. The researchers have also described about some scopes of mobile teledermatology that is quite a new field in teledermatology practice.

They have defined mobile teledermatology as medicine as a distance with the participants who use mobile phones. The enactment of modern wireless telecommunication is like global positioning radio system. In many cases research in telemedicine is focusing on emerging and testing new systems to use mobile telephones for home based health data acquisition. Home-based health data acquisition is suitable for managing chronic diseases for example, diabetes, asthma, and hypertension. Photographs of skin problems can be easily taken by the use of new generation smart phones. The authors have also described another application of mobile teledermatology is the 'virtual follow up' of patients having chronic skin diseases. These diseases need systematic treatment. In this case patients themselves will take pictures of their dermatological problems with their cellular phones and will send the images by using special application of their cell phones to the dermatological services. Mobile teledermatology can be a good choice in population of the area where Internet service is not frequently available or expensive. The researchers have also described about the scope of mobile teledermoscopy. They said that according to the new concept of person centered health system this teledermoscopy approach could open a new horizon for patients having numerous mole and suspicious pigmented skin problems. Mobile teledermoscopy have the possible to become an easy appropriate tool for everyone and may open the door for a new flexible triage system to detect skin cancer in general and melanoma.

Another important theme in teledermatology that the researchers have described in the paper is the teledermatopathology. Teledermatopathology is usually performed with real time conduction of images [30]. In this system via a robotic microscope consulting pathologist provides remote consultation. By the use of SAF system each image is captured and then transmitted in a single file. Teledematopathology system is mainly used to diagnose nonmelanoma skin cancer. In this section the authors have described some statistical result of different studies regarding the outcomes of using teledermatopathology system. One study found a 100% concordance of 35 melanocytic lesions between a general pathologist and dermatopathologist. In the last few years virtual slide system (VSS) has been introduced in teledermatopathology system. By the use of VSS system a whole slide can be digitalized at a high resolution. This will allow the user to see any part of the specimen at any magnification. Recently VSS has been tested for the diagnosis of inflammatory skin diseases. Further

development of VSS system will improve the diagnosis performance of teleconsultants. Finally the authors have described about teledermatology on the web. They have mentioned this field as a new tool that has been introduced in the last few years. By the use of Internet teledermatology system offers many opportunities including databases for different problems, medical education, and online atlases. There are many online communities with open access for consultation of dermatological problems. They are free to all users and themselves can generate the contents. These communities are moderate and the role of the moderators is to check subscriptions. The authors have given some link of web sites that offer opportunities and facilities in dermatology.

#### **4.2 Articles discussing non-cancerous disease in teledermatology**

In this section some articles was totally relevant with my topic. Warshaw, E.M. et al. describes about the accuracy of teledermatology for pigmented neoplasm [31]. This study was mainly the comparison between accuracy of store and forward teledermatology for pigmented neoplasm with face to face in person clinic dermatology. The study was a cross sectional repeated measured study. The method that was used for this study was identical to a study of nonpigmented lesions. The images they have used was standard macro images (gap and close up) (digital Nikon Coolpix 4500 with a Nikon SL 1 ring flash, Nikon, Meville, NY), and PLD images (digital Nikon Coolpix 4500 with a 3Gen Dermlite lens attachment, 3Gen, San Juan Capistrano, CA), a standard CID image (35mm Minolta X 370 with a Heine dermphot lens attachment, Heine, Dover, NH). The outcome of their result was measured by accumulated diagnostic accuracy. Standard dermatology expert panel based on histopathologic diagnosis judged the appropriateness of management plan.

There were an inclusion and exclusion criteria. At the very 1<sup>st</sup> time they took 2905 approached patients. Based on some exclusion criteria they excluded 753 patients primarily. The final number of patients was 542 who meet all the criteria of the study. Major number of patients was male, elderly and Caucasian. 25% of the patients had a history of nonmelanoma skin cancer, 6% had a personal history of melanoma cancer. The common area of the cancer was head or neck. The researchers had different outcomes in different stages. In case of primary outcome, aggregated diagnostic accuracy, teledermatology and clinical dermatology result were not equivalent. The result of the clinical was higher for all image type (macro plus VID, macro only, macro plus PLD). In case of secondary diagnostic accuracy, teledermatology and clinic dermatology were almost same when macro plus CID image was observed by

teledermatologists but the result of clinic dermatology was more precise for the other two images.

In this case there were some mismanaged melanomas also. Interesting part was that the same dermatologists performed this mismanagement. This was because the dermatologist did not differ in rates of management plan appropriateness for either nonpigmented or pigmented lesions. As compared to other papers related with this paper it is showed that this paper has tried to give a clear idea about digitalized dermoscopic images of pigmented lesions. As compared with 86% for teledermatologists the accuracy of clinical dermatologist was 92%. This paper consists of some images, which gives some idea about image quality of melanoma that causes mismanagement and misdiagnosed. As I do not have the authority to use the images but I can give an idea about the images. This paper has used several images with good and low quality. The image that was taken from a distance but was clear was misdiagnosed but not mismanages. However, another picture, which had a close look but was not clear. This image was both misdiagnosed and mismanaged. In case of different images teledermatologists diagnostic accuracy was 81%, 91%, 95% as compared to diagnostics accuracy of 91%. It was mentioned that this study differences may be was because of study design. This paper has also mentioned about some limitations. The study population was mainly Caucasian elderly male. So there was a lack of diversity. Another point was that the teledermatologists was blinded to the precise purpose of the study. They may was not as careful as they may have been if it would have directly effect the patient outcome. This study didn't provide any information about patient's satisfaction, provider consummation and cost effectiveness of image-based teledermatology. However, the study mentioned that teledermatology was superior to clinic dermatology for benign lesions but inferior for malignant lesions.

In another article the same authors described about the accuracy of teledermatology in non-pigmented neoplasm [32]. The advantage of teledermatology is measured by whether it can replace standard, face-to-face patient care, which mainly provided by either dermatologists or general practitioners. For a broad range of dermatological problem the diagnostic agreement rates of teledermatologists and clinical dermatologists are almost same [33]. This agreement is acceptable in some skin conditions for example, eczematous dermatoses where clinical assessment by a dermatologist is considered as standard. However, the evaluation of skin neoplasm consists of special challenges. Because of the probable mortality and morbidity with malignant skin neoplasm, it is not easy to ensure the correct diagnosis process. Moreover, it

is standard to utilize histopathology for accurate diagnosis of skin neoplasm. Accuracy of diagnosis is measured with the ability of a test to correctly identify the disease compared with the reference standard.

The study was performed by step-by-step methods. At the very first the researchers focused on the overview of their study plan. The study consists of a cross sectional, repeated study design for the comparison of store and forward teledermatology with traditional face-to-face practice. The primary outcome was combined diagnostic accuracy. This was considered as primary outcome because most of the dermatologist has a differential diagnosis for a skin lesion and if the diagnosis is correct it should be credited. The inclusion criteria of the study were designed to assess populations of patients with low risk and high risk for developing skin neoplasm. Patients who were already joined in Minneapolis Veterans Affairs Medical Center dermatology clinic were considered as high-risk patients. Patients who were referred from general practitioners to the specialist for further diagnosis were considered as low risk patients. Exclusion criteria involves, patients requesting to remove only skin tags, patients presenting for treatment of a neoplasm, which is already biopsied, patients requiring biopsy for non neoplastic conditions, patients having inability to provide information. The research coordinator examined all dermatology consult everyday for inclusion and exclusion criteria. Included patients were mailed to participate in the study. After informed agreement, research staff obtained all digital photographs of identified lesions. After this eleven staff dermatologist performed a clinical assessment of several matters which includes a choice of 17 common diagnoses, four basic management plan, pigmentation status (yes/no). There were also an option for the dermatologists named others for diagnoses and management plan and hand write answers. Management plan of this study was based on medical opinion.

At the onset of the study macro images were used as standard method and PLD images were used for all lesions. For each lesion two macro images (distance and close-up; digital Nikon Coolpix 4500 with a Nikon SL-1 ring flash [Nikon, Melville, NY]) were taken. Also, images having more than 2 mm in height from 90-degree angle were taken. To review the electronically transmitted clinical digital photographs for each participant, one of three board certified dermatologists with clinical expertise in dermoscopy were randomly assigned. All the information was stored in a customized web site ensuring a high level of security. The diagnostic and management process used by clinical dermatologist, the teledermatologists documented one primary diagnoses, up to two different diagnosis and a management plan for



every lesion. The website used were programmed to check error which was capable to minimize missing data. For single participants the dermatologist in a single lesion evaluated all images of all lesions.

The next part of the paper was the statistical analysis. The main purpose of the study was to assess whether the diagnostic accuracy of teledermatology for the diagnosis of non-pigmented skin lesions is equivalent to face-to-face consultancy. The analysis tested the null hypothesis. So the absolute difference in accuracy rate should be at least 10% against the alternative hypothesis. The test was performed using a significance level of 0.025, resembles to assessing whether the 95% confidence interval for the difference lies within  $\pm 10\%$ . Given the serious significances of a missed malignant neoplasm the researchers used an equivalent boundary of 10%. Secondary outcomes were also measured by using the same technique to assess the equivalence of the accuracy of the primary outcome. If a participant participated in more than one lesion at a single visit, only one lesion was selected as the index lesion for primary analysis. A total number of 728 indexes were included in the main study. Analysis of all non-pigmented lesions (N=1034) was more difficult than only analysis of only non-pigmented skin lesions. The total number of neoplasm in the study was based on statistical power for the two sided equivalence tests for the primary analysis. The researchers used 520 biopsied non-pigmented lesions to assess the equivalency of clinical based evaluation and teledermatology based evaluation. The sample size covered almost 80% to measure the equivalence.

In the statistical analysis the researchers draw some tables describing various characteristics of study population. Majority of the participants were elderly male with fair skin. Location of the lesion was from face to ear. 32% of the lesions had been present for 3-2 months. 28% of the lesions had no symptoms and 32% (one third) has changed in their size. Histopathologic diagnostic categories for biopsied non-pigmented lesions were reviewed in different way. 33% were basal cell carcinomas, 20% were squamous cell carcinoma, 11% were actinic keratosis, 7% were cysts and 7% were benign keratosis. By the use of macro images only 728 teledermatologists and clinical dermatologists were not equivalent. However, in case of management plan accuracy both were equivalent. The diagnostic accuracy rate was considerably better in case of clinical dermatologists than teledermatologists. Nevertheless, the diagnostic accuracy of teledermatology was better for macro images with PLD images rather than for macro images alone.

There were some significant outcomes in this study. The first outcome was the management plan aptness for teledermatology and in person dermatology was equal. Second outcome was the PLD images meaningfully enhanced the diagnostic accuracy of teledermatology over macro images alone. The third one was the rates of management plan correctness were comparable for almost all study group apart from the benign lesions with macro images. If this study is compared with other studies the result should be limited because only a few studies have used the method of evaluating teledermatology accuracy for non-pigmented skin neoplasms using histopathology.

Another article from Warshaw, E.M.et. Al. described about Teledermatology for diagnosis and management of skin conditions [34]. In this paper the researchers performed a systematic review of teledermatology, diagnostic accuracy, clinical outcomes and cost. Telemedicine is considered as a valuable diagnostic tool and management of dermatological problems, especially in remote areas where specialist services possibly not available. There are two types of telemedicine services are available; store and forward and live interaction. In this article the authors have tried to do a systematic review to summarize the scientific literature addressing some key questions including the accuracy of telemedicine compared to face-to-face consultation, for the diagnosis of a skin condition how does the concordance of teledermatology compare with clinical dermatology? Also how do clinical outcomes of teledermatology is compared with clinical dermatology?

The title of the paper was acknowledged from the searching process was reviewed by two research associates and two physicians who were trained in the clinical analysis of literature. Addition criteria include, mobile telephone in teledermatology, non-teledermatology setting, historical reviews of teledermatology, dermatopathology lessons, some survey studies, teledermatology as an educational tool for general practitioners, remote monitoring of known problems, non English language, study involving less number of diagnosis, replica publications. The research associates extracted data based on study design, patients characteristics, skin conditions, comparison and outcome. For the study quality, quality assessment of diagnostic accuracy study instrument was used. Items were recorded as “yes” or “no” or “uncertain”. The authors testified results from each study distinctly for each outcome. Results were stratified according to the intervention whether it was store and forward (SAF) or LI (Live Interaction).

Forty-two SAF studies (reported in 43 publications) registering between 12 and 882 subjects (6634 subjects total) match the inclusion criteria for accuracy of telemedicine and concordance of teledermatology [31] [35]. With an exception of randomized control trial all studies used a repeated measures study design [36]. Most of the study was performed in United States (n=14), followed by United Kingdom (n=9), Italy (n=6), Spain (n=4), Australia/New Zealand (n=3), Turkey (n=2) and one study each from Brazil, Pakistan, Netherlands, Switzerland and Germany. Approximately 47.6% of the study patients were with an average age of 51 years (Range from 5-71 years). Most of the study reported that subjects were 57% male. Only 6 studies reported racial characteristics. Majority of those were Caucasian. In 15 studies patients were with a variety of skin conditions (eg, papulosquamous, eczematous) and circumscribed lesions (isolated skin growths). In twenty-two studies only patients with circumscribed lesions were evaluated; among these, 12 studies completely assessed subjects with pigmented skin and 2 studies registered subjects with non-pigmented skin lesions. Rest of the 8 studies involved subjects with circumscribed lesions but pigmentation status was not mentioned.

In case of Diagnosis accuracy twenty studies (19 SAF, 1 LI) defined as matching of teledermatology diagnosis with histopathology diagnosis or other laboratory test. Results were stated as percent match between the primary diagnosis and/or joint diagnoses (primary plus differential) and histopathology, kappa statistic, and/or sensitivity and specificity. Another fifteen studies also stated diagnostic accuracy of clinic dermatology (in-person dermatology diagnoses), which allowed the direct comparisons of accuracy rates between these two methods of care. It was proved that the diagnostic accuracy of clinic dermatology is enhanced than teledermatology. However, when there should be trained dermatologists, teledermatology may be advantageous. In case of diagnostic concordance Thirty-eight (28 SAF; 9 LI; 1 SAF+LI) studies were reported as diagnostic concordance (simple agreement without verification by histopathology or laboratory test) between teledermatology and clinic teledermatology. Thirty-six studies (26 SAF, 9 LI, 1 SAF+LI) stated concordance as percent agreement for precise diagnosis, combined, and/or not specified, malignant/benign status or diagnostic category. Eight studies in 7 publications stated kappa statistics and 3 studies stated sensitivity and specificity. By this studies this was proved that the weighted mean aggregated diagnosis concordance rates for SAF were almost similar with general studies as well as lesion studies. In case of management accuracy the over all rate of accuracy were almost equivalent ( $\pm 10\%$ ). However, for malignant and premalignant lesions, teledermatology rates were better

than the clinic dermatology. The concordance rates for management were moderate to very good for both LI and SAF. No significant difference in clinical course rating (improved, no change, or worse) between the two groups was found. It was assessed outcomes at 6 months using a questionnaire (response rate was 60%). A considerably higher percentage of teledermatology patients stated that their illness had determined (63% vs 23%,  $P = .03$ ). The number of cost studies was limited by variations in factors included and perspectives chosen for the study. The majority of studies (including both SAF and LI technologies) found teledermatology to be cost-effective in certain cases; the most important included patient travel distance, teledermatology volume, and costs of face-to-face consultation.

It was determined that both SAF and LI teledermatology technology had satisfactory diagnostic accuracy and concordance as compared to clinic dermatology. In case of teledermatology patients satisfaction rate was high although some patients believe that for face-to-face consultation.

Tan, E et al. described about a successful triage if patients referred to a skin lesion clinic using teledermatology [37]. In this article the authors have tried to assess teledermatology as triage tool for a hospital lesion clinic. In Australia and New Zealand the number of melanoma and non-melanoma skin cancer patients are highest [38]. In Australia, the percentage of detecting melanoma by dermatologists was 89.1% and the numbers needed to treat (NNT) by histological confirmation of melanoma are 4 [39]. In New Zealand there is a lack of dermatologists and 15% of the people are living more than 80 kilometers from a dermatologist [40]. As already mentioned before teledermatology is performed in two different ways, store and forward method and real time video conferencing. In this study the authors investigated the store and forward form of teledermatology. It was assumed to evaluate the correctness and reproducibility of teledermatology including dermoscopic images (teledermoscopy) compared with face-to-face evaluation. Two dermatologists were involved in the study and the aim was assess the technology could be used as triage to reduce the problem related to dermatology.

Their general practitioners referred patients who take part in this study. Consenting patients were judged by a “melanographer” having special training and the melanographer obtained demographic data, history and risk factors of melanoma. Then the melanographer took images for the teledermoscopic consultation. To obtain macro or micro images a Nikon D50 digital

SLR camera was used for the panoramic images and a Hewlett Packard Photosmart 912 or Canon Photoshot G6 1/1.8 inch 7 megapixel CCD digital camera was used. The stored resolution of the images was 1600x1200 resolution having 24-bit color depth. Dermatologists examine the patients without obtaining any further history. The lesions were examined then clinically. By the use of MoleMap consult software each dermatologist chronicled his or her preferred diagnoses. After a minimum time period of four weeks dermatologists separately reviewed the teledermoscopy data on a 20 inch Panasonic monitor with a resolution of 1024X 768. In the study all information gained from all patients were approved by the regional ethics committee. By the use of Cohen's kappa ( $\kappa$ ) statistic (SAS Institute Inc., Cary, NC, U.S.A.) all the interobserver and intraobserver agreement and concordance of diagnosis and management recommendations between face-to-face and teledermatology assessments were calculated. If the kappa ( $\kappa$ ) value is between 1.00 and 0.81, it indicates almost perfect agreement value.

Between the period of March and September 2008, the total numbers of participants were 207. 6 patients were excluded because didn't match with the criteria and one patients refused to participate in the study. With 491 lesions there were 126 females and 74 males. The age ranges of the patients were between 11 to 94 years. Dermatologists were divided into Dermatologist A, Dermatologist B and Dermatologist C. In face-to-face valuation Dermatologist an observed 158 patients (385 lesions), Dermatologist B observed 135 patients (298 lesions) and Dermatologist C observed 125 patients (300 lesions). In case of teledermoscopy valuation, both Dermatologists A and B observed 200 patients. Lesions were categorized as melanocytic or nonmelanocytic. In both teledermoscopy and face-to-face consultation seborrheic keratosis and solar keratosis were the most common nonmelanocytic diagnoses. In case of benign category Dermatologist A had the diagnosis percentage of 12.7, whereas Dermatologist B had 15.5%. In case of basal cell carcinoma Dermatologist A had 13.8% and Dermatologist B had 10.5%. All these types of difference were examined to determine the malignant lesions "missed" on teledermoscopy. Among all the lesions 12 lesions were initially diagnosed as malignant when was observed face to face but was benign when observed by teledermoscopy. The understanding between dermatologists on each teledermoscopy and face-to-face diagnosis was evaluated to determine the reproducibility of all data obtained. Teledermoscopy had a 72.3% concordance in diagnosis between all dermatologists, whereas in case of face-to-face consultation the exact concordance ranged

from 75.5% to 82.2%. Kappa values were 0.95 for concordance between face-to-face and teledermoscopic consultation.

With outstanding concordance in 87.7% of lesions teledermoscopy was as good as face-to-face consultation. To run a successful skin lesion triage there should be target specialist dermatological recourses to the target population and to save waiting time for first assessment. In this study it was shown that 136 of 200 patients (constituting 74% of lesions) could be spared a face-to-face consultation through using teledermoscopy as the initial valuation. As compared to other trials the concordance rate of this study was much higher. It was reflected that dermoscopy has over simple macro photography in the triage of studies [41]. The reproducibility of these data was also very good within and between dermatologists and clinical concordance and the rate was > 83% with a  $\kappa$  values > 0.90.

Two types of melanoma were diagnosed in the study by one dermatologist on teledermoscopy. However, no negative impact on patient's health as management remained suitable. The main strength of the study was the inclusion of large number of patients and the use of dermoscopic images. The use of polarized dermoscopy ensured steadiness of analysis. It was proven that use of polarized dermoscopy is more identical than the nonpolarized dermoscopy [42]. One limitation of this study was that same dermatologists worked in face-to-face diagnosis and teledermoscopic diagnosis. The generalizability and reproducibility of this study was greatly dependent on the experience and exercise of the dermatologists. The technology used in this study exposed highly concordance with face-to-face consultation. Also the study has highly sensitivity and specificity to detect malignant lesions.

Ezzedine, K et al. described about black skin dermatology online [43]. The aim of this paper was to invent and improve a teledermatology service for the improvement of communication, information, teliagnosis and teaching services in health care management. Teledermatology can important and helpful technology for the improvement of skin care in Southern region where people suffer from a lack of both medical services and transportation [44]. For this reason a North and South partnership of numerous hospital-based Dermatology Departments situated either in Belgium (four) and Africa (one) was founded. The main aim of this study, Black Skin Dermatology Online (BSDO), was to create an investigational web based platform of teledermatology for pigmented skin. The study was an open access, image based teledermatology resource. The idea was to develop both a diagram of dermatology based on

an observed image database and to provide a complete range of communication, information, teaching services and telediagnosis.

There were seven partners involved in the study, under the Department of the 'Université Libre de Bruxelles' (ULB). To coordinate the project, two partners were involved. Belgian partners were the Prince Leopold Tropical Medicine Institute of Antwerp, the Dermatology Departments of the Universities of Gent and Antwerp and finally the Work and Economic Psychology Laboratory of the ULB (LAPTÉ– U-Lab). The Dermatology department of Kaolack Hospital in Senegal was another partner in Africa. To provide the data base content and essential medical expertise and to assure the scientific value and reliability of the database was the main role of the partners. There were also two coordinators as scientific and technical specialists to support and guide the partners. The project was divided into two phases. The first phase consisted of developing a prototype interface. This phase began on September 2002 and lasted for 2 years. The second phase consisted of developing the data communication service that is linked to the image database and assessing the performance of the prototype. This phase started at January 2006 and ended at July 2008.

Two sources were used to collect case images. One from current collection existing at the universities of Brussels, Antwerp or Gent and new images obtained by the local partner in Senegal according to the needs of the project. During the consultation period by Dermatologists, information about the project was provided to the patients and personal data of patients were recorded. To avoid the flash effect, one or several images were taken under proper light exposure after having a skin examination. The sizes of the images were 800X600 pixels. If there were any doubt about the examination, a further examination was conducted. Once the diagnosis was confirmed, according to the ICD- 10 codification, the diseases were categorized. Senior dermatologist finally re-examined the all cases. Final images were then inserted into the database by the use of a store and forward computer technology. To teach undergraduate medical students a critical mass of quizzes and clinical cases were created. For the ethical approval of the project from the University or Hospital all patients had to give their written informed agreement to take part in the project. In this study a particular attention was paid to the method of evaluation of usability of the easiness of the technology used and to the usefulness of the technology. There were two steps to test the usability. In the first step, 50 undergraduate medical students were recognized through answers to an Internet advertisement. In the second step, these same 50 medical students were invited to complete a

questionnaire that was designed for the perception of the usability of the study and to observe the familiarity with the use of Internet. Observed usefulness was designed within the framework of the technology acceptance model (TAM) [22]. This study allowed the authors to assess the perceived usefulness and perceived easiness of the technology. In each case, patients were informed to use a 5-point Likert scale, varying from 'strongly disagree' to 'strongly agree'. With the use of Cronbach's  $\alpha$  -test Internet consistency was confirmed. Some other variables of the questionnaire were (i) 'Please specify how much you are familiar with using a computer' (5-point)

(ii) 'Please specify how much your are familiar with using the Internet' (5-point)

(iii) 'I intend to use Black Skin in my professional capacity to help me diagnose black skin pathologies' (5-point).

In this study SPSS® software 15 (SPSS Inc) was used for statistical analysis. Quantitative variables were measured as mean values  $\pm$  SD. Correlation relation terms was also evaluated. To evaluation the factors related to the 'intention to use the platform in the future' item, a stepwise logistic regression analysis was performed. The study model was composed of 26% men and 37% women. The average age was 23.4 years. Women were usually less acquainted with the use of computer ( $P=0.015$ ) or of the Internet ( $P = 0.042$ ). The internal consistency of the questionnaire was 0.80 for perceived usefulness. The study has established and developed an investigational multilingual, collaborative and open access web based platform of teledermatology for dark skin people. It is possible to increase the intercontinental migration if every community physician is likely to be confronted with dermatological issues in pigmented skin patients. Another outcome of the study was to development of educational tools for the medical students in dermatology. Another intension of the study was to establish a maintainable partnership with Southern low-income countries. The study was not just an atlas of dermatology; it was considered as a resource base for medical training.

Tsang et al. described about the role of dermatopathology in conjunction with teledermatology in resource-limited settings [45]. The study was conducted in Africa where having poor resources with as few as 10 physicians per 100,000, and no dermatologists in many areas [46]. Only 14% of Sub Saharan countries have the presence of a dermatopathologist in their country. The study was conducted in 2007 by a joint project of the Departments of Dermatology at the University of Pennsylvania, USA, and the Medical University of Graz, Austria, with further association from Mbarara University of Science and Technology and



Makerere University in Uganda, the Botswana-UPenn Partnership, the Baylor International Pediatric AIDS Initiative (BIPAI), the American Academy of Dermatology, and the University of Queensland in Brisbane, Australia. Approximately 700 clinical cases were selected for review and the photographs of patients were posted in a secure web based application for review by teledermatologist for feedback. The main aim of this project was to establish the importance of teledermatology technology to improve the delivery of care for skin disease in resource-limited areas. This project has helped to fill up the gaps between access to dermatological specialty care in Africa through store and forward teledermatology consultation services. By this project it was also possible to perform and send biopsy specimen to USA for processing. This project allowed characterizing the conditions that were diagnosed through clinicopathological association in combination with photos and tissue submitted to the African Teledermatology Project. In this paper the researchers have tried to classify the diagnoses rendered; to establish the timeliness of specimen collection and diagnosis; assess the concordance of the clinical diagnosis and finally to regulate the feasible clinical influence all information on the fundamental course of patient care and treatment.

The study was a retrospective case review where biopsies were sent to USA for analysis and diagnosis. This process included all tissue specimens sent for processing and subsequent pathological consultation for three years period of time (2007 to 2009). All information from patients was recorded including age, sex and country. Researchers reviewed the history outlined in the teledermatology consultation and the corresponding pathology report including the histological diagnoses rendered. For review in total 59 cases were identified. Among them 55 cases met both inclusion and exclusion criteria. These 55 cases were divided into seven different categories; malignancy (19 cases), suspected infection (8 cases), normal infection (4 cases), dermatitis (8 cases), Lichenoid tissue reaction (3 cases), non-diagnostic biopsies (3 cases) and others (10 cases). In 32 cases (58%) both clinician and the pathological diagnoses were reliable, in 21 cases (38%) diagnosis was conflicted and in 2 cases (4%) insufficient data was provided.

In countries where pathology services are not available, transfer of fixed tissue for biopsy to an experienced pathology laboratory may be considered as a possible option for histological analysis of skin lesions. In this teledermatology project histological examination confirmed the clinical diagnosis in 58% of cases and useful information was provided in the management of patients with both malignant and benign conditions. Half of the cases conformed

malignancies and half of the cases conformed benign skin lesions. In malignant cases 81% represent HIV-related Kaposi sarcoma (KS) in patients with very low CD4 counts. The study mainly highlighted on the significant contribution of teledermatology technologies that can provide diagnosis and treatment of skin diseases in rural areas. Store and forward teledermatology application can be used for dermatological care and education in settings where lack of specialist dermatologist exists. By the use of store and forward technology digital images of scanned slides could be reviewed over the existing web-based African Teledermatology Project in such a way that is similar to that currently used for clinical images.

#### **4.3 Articles discussing cancerous disease**

Haiso, J.L. et al. describes about the impact of store-and-forward teledermatology on skin cancer diagnosis and treatment [47]. Usually teledermatology is an effective service to the patients of remote areas who do not have the access of direct contact with dermatologists. The accuracy of store and forward teledermatology is compared to the conventional clinical based dermatology examined. This includes patients' satisfaction, time to initial intervention. A recent study showed that store and forward teledermatology and usual clinical consultation ensued almost same clinical outcomes [48]. Recently store and forward teledermatology is considered as a preoperative planning tool that can make the waiting interval short to surgical treatment and patients can also avoid pointless clinical visit [49]. Now a day the time interval for a consultation for surgery for a skin cancer is an objective of skin cancer management. The earlier treatment of skin cancer can minimize the morbidity rate if the time interval of surgery can be reduced. Though, the process of identifying and treating skin cancer is complex in clinical practice and the impact of teledermatology in this process is not clear. The study was conducted at Veterans Affairs (VA) Medical center at San Francisco. In this study the researchers retrospectively examined remotely located patients who are treated in the VA dermatologic surgery clinics to decide the differences present in between conventional consultation and teledermatology. The researchers also observed that store and forward teledermatology recommendations were related with both earlier diagnosis and surgical treatment of skin cancer as compared with conventional clinical recommendations for distantly located patients.

All the subject patients were classified between January 1, 2003 and July 31, 2007 in the San Francisco VA Medical Center dermatology surgery clinics. Apart from some patients referred for biopsies for suspected malignances most of the patients were treated for known skin

cancers by excision, Mohs micrographic surgery, curettage and electro desiccation or other surgical modalities. The authors used the following selection criteria (Fig. 3):

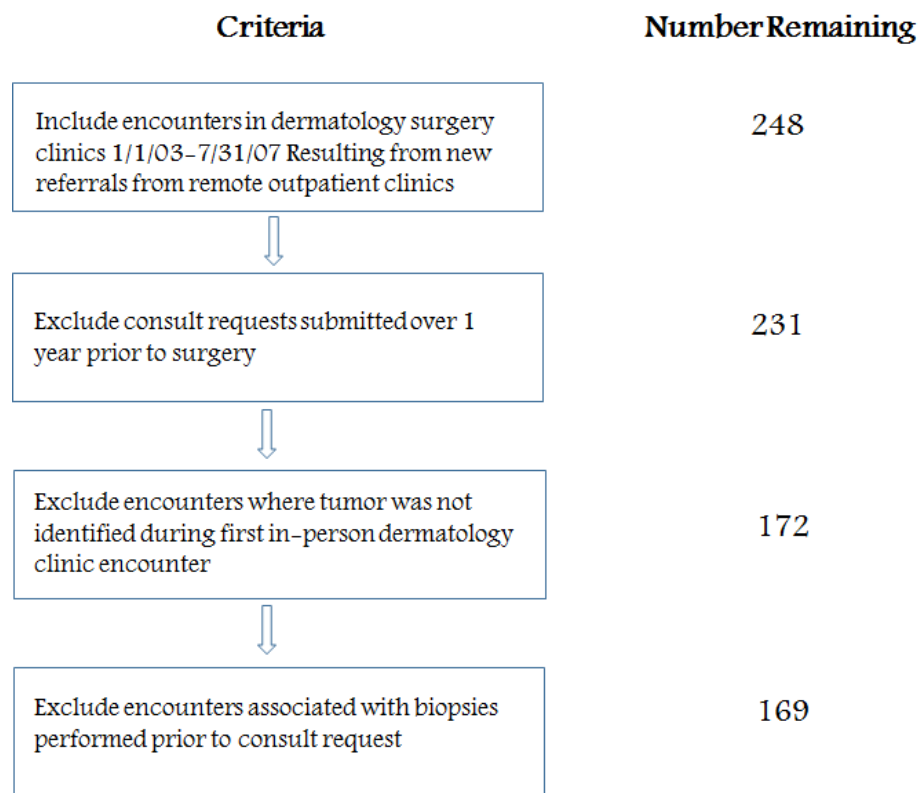


Fig 3: Inclusion and exclusion criteria.

Patients' information was collected from electronic medical record of all patients. Data includes patient's age at the time of surgery, gender, primary care location, skin type of patient, date and modality of the initial dermatology consultation, date of primary diagnosis, date and location of biopsy, date of surgical treatment, dermatologist's diagnosis, final histopathologic diagnosis, number of clinical visit and tumor size. STATA 10.0 software (StataCorp LP, College Station, Tex) was used for statistical analysis. Researchers first using the *t* test compared the baseline characteristics of the patients and encounters in the two study arms. After that a multiple linear regression model was applied to determine the relationship between the type of consult referral and the time intervals from the date of the initial consult request by the PCP to initial evaluation, to biopsy, or to surgery. *P* value less than .05 was considered statistically significant.

The total number of surgical encounters was 2281 and the study period was 4.5 years. In study included 248 encounters (10.9%) in dermatology surgery clinics resulting from new referrals

from remotely located clinics. After exclusion of surgical encounters that happened 1 year or more after an initial consult request, out of 169 encounters 149 met the inclusion criteria. Among 169 encounters, 77 (45.6%) were from conventional consultation and 92 (54.4%) were from teledermatology consultation. From the patients' data most patients were white skinned and male which is typical for skin cancer. However, some patients were diagnosed clinically suspecting of being malignant but after diagnosis the result showed that the tumor was benign. Patients referred by teledermatology and conventional consultation didn't have much difference in age, skin type and gender. However, there were also some differences between teledermatology and conventional consultation. A significantly higher proportion of priority referrals (41.6%) were observed in case of conventional consultation where the result for teledermatology consultation was 9.8%. Conventional consultation categorized a malignant neoplasm as the most likely diagnosis than did teledermatology (93.6% vs 81.3%). In case of preoperative tumor size teledermatology referrals were larger than then conventional consultation. The interval from primary assessment to biopsy was longer for the patients referred via teledermatology than via conventional dermatology (34 days compared to 9 days;  $p < .00001$ ), and no significant difference was found in the time interval from biopsy to surgery between teledermatology and conventional referral patient groups (66 compared to 68 days;  $p = .678$ ). In the study the number of in person dermatology visits before the dermatologic surgery was also evaluated to observe that if this is related with the time interval to the primary clinical end points.

Teledermatology usually facilitates the triage of skin cancer patients [25]. The study results that patients living in remote area with skin cancer primarily more quickly evaluated via teledermatology. Also it showed that diagnosis by biopsy and instant treatment also happened with teledermatology as compared with conventional consultation. The study was a retrospective study and was conducted in a Veterans Affairs healthcare system and a specific skin cancer patient population, so the result may not be straightforwardly comparable to other societies. However, the clinical outcomes in skin cancer management by the use of teledermatology technology may not be better but comparable with conventional consultations.

Massone, C. et al. described about Teledermatology for skin cancer prevention: an experience on 690 Austrian patients [50]. The aim of this paper is to scrutinize the value of teledermatology as an important tool for a dermatologist directed triage system. The

expansion of teledermatology is increasing and also related with the improvement of modern technology facilities including teledermoscopy, mobile teledermatology and mobile teledermoscopy [51]. The diagnostic accuracy of teledermatology is comparable with the accuracy of face-to-face consultations. The value of teledermatology is a valid way for a dermatologist directed triage system for skin cancer lesions.

The study was conducted between February 2008 to February 2010. All patients attended three preventive health care centers in Austria under a general preventive medicine-screening program arranged by a private Austrian Insurance company to their customers. Their general practitioners for second opinion teleconsulting selected customers. The health care centers were located in three different parts of Austria. The insurance company invited the patients for 2 days of holiday with free skin cancer screening. The general practitioners were trained at their institution for three days on skin tumors. Patients were screened for different diseases including diabetes, hypertension, cancers and if the GPs found anything suspected in skin lesions then they acquired dermoscopic skin lesions. With the use of Canon Powershot digital camera (Canon Inc.®, Tokyo, Japan) clinical images were taken and with the use of polarized light contact dermoscope (DermLite Photo®; 3Gen LLC, San Juan Capistrano, CA, USA) dermoscopic images were taken. After that images connected by only age, sex and location of the lesion were transmitted for teleconsultation via a virtual private network (skinclient.telederm.org, e-derm-consult GmbH, Graz, Austria) to two dermatologists (teleconsultants) for analysis. The answers were obtained from teleconsultant after 48 hours. Store and forward teledermatology system was used for diagnosis and management of confusing skin lesions. All of the images were analyzed by both of the teleconsultants. Images were examined using a 3-point scale rating from excellent to low quality.

The total numbers of patients were 690; male 642 and female 48 with an average age of 47. A total number of 962 dermoscopic and 123 clinical images from 962 lesions were sent to the teleconsultants. Concerning the image quality 88% (851/962) dermoscopic vs. 77% (95/123) clinical images of excellent quality, 10% (94/962) vs. 19% (23/123) of moderate and 1% (14/962) vs. 4% (5/123) of low image quality were arbitrated. 111 (12%) lesions were suggested for editing, 10 (1%) lesions were recommended for the face-to-face examination and 707 (74%) were suggested for follow up. No more treatment was preferred for 127 lesions (13%). Patients that were only recommended to the dermatologists under the study were possible to collect follow up data because patients were from the different part of Austria. A

strong concordance with the gold standards in differentiation between benign from malignant skin lesions was found in remote evaluations. Teleconsultants correctly classified almost all the lesions  $n = 30/32$ ) and the accuracy rate was excellent 94%.

The teledermatology study was performed with a large number of patients in Austria. In this study the researchers have reinforced the role of teledermatology in patients who really need a dermatological intervention. According to the World Health Organization (WHO), between 2 and 3-million non-melanoma skin cancers and 132000 melanomas happen every year [52]. Furthermore, due to increased number of population the risk of skin cancer will also increase. In this context teledermatology is capable to play an important role to support both GPs and dermatologists to manage skin cancer. Teledermatology also plays an important role from economic point of view. In this study the estimated cost was reduced by 18%. Image quality can be a drawback of teledermatology. In this study due to study design it was not possible to calculate sensitivity and specificity of teledermatology for all patients. It was the first study of teledermatology as a screening tool for skin cancers on a big number of patients in Austria. The researchers established the literature data about the possibility of teledermatology also in large number of patients and mainly its assessment as a screening tool for skin cancers.

Kahn et al. (2013) described about Evaluation of skin cancer in Northern California Kaiser Permanent's Store and forward Teledermatology Referral program [53]. The main objective of this paper is to determine the effectiveness of teledermatology referral to biopsy of the most common skin cancer compared to conventional dermatology referral. Some remote areas of United States are still in need of improved access of dermatological care. California's Central Valley, which is located approximately 100 miles northeast of San Francisco, is an example of a crowded community that lacks suitable access to most specialist dermatologists. To identify this problem, he Kaiser Permanente (KP) Northern California (KPNC) organized a teledermatology program in January 2009. Teledermatology has been proven as a precise and reliable diagnostic device for skin diseases [48]. Because of this reason KP has introduced a teledermatology program in Central Valley. Now a days skin cancer is one of the most common types of cancer that causes more morbidity and mortality in overall people. Therefore it is very important to diagnose suspected skin problems and biopsied when appropriate by a dermatologist and treatment has to be started on time. A delay of proper diagnosis on time can lead to higher chance of morbidity and mortality [54].

Institutional Review Board Committee, KPNC approved the study design and the KPNC Residency program and Kaiser Foundation Hospital provided funding. Patients for this study

was selected from automated health plan clinical and administrative database. Information includes, patients demography, membership, patients referrals, inpatient and outpatient visits, laboratory and pharmacy use. This program mainly focused on the patients who already gone through a diagnosis for skin cancer. If the patient's referral had been completed the use of either traditional e consult referral system or the new teledermatology system then the patients were eligible for the study. The referral system for the study was as follows,

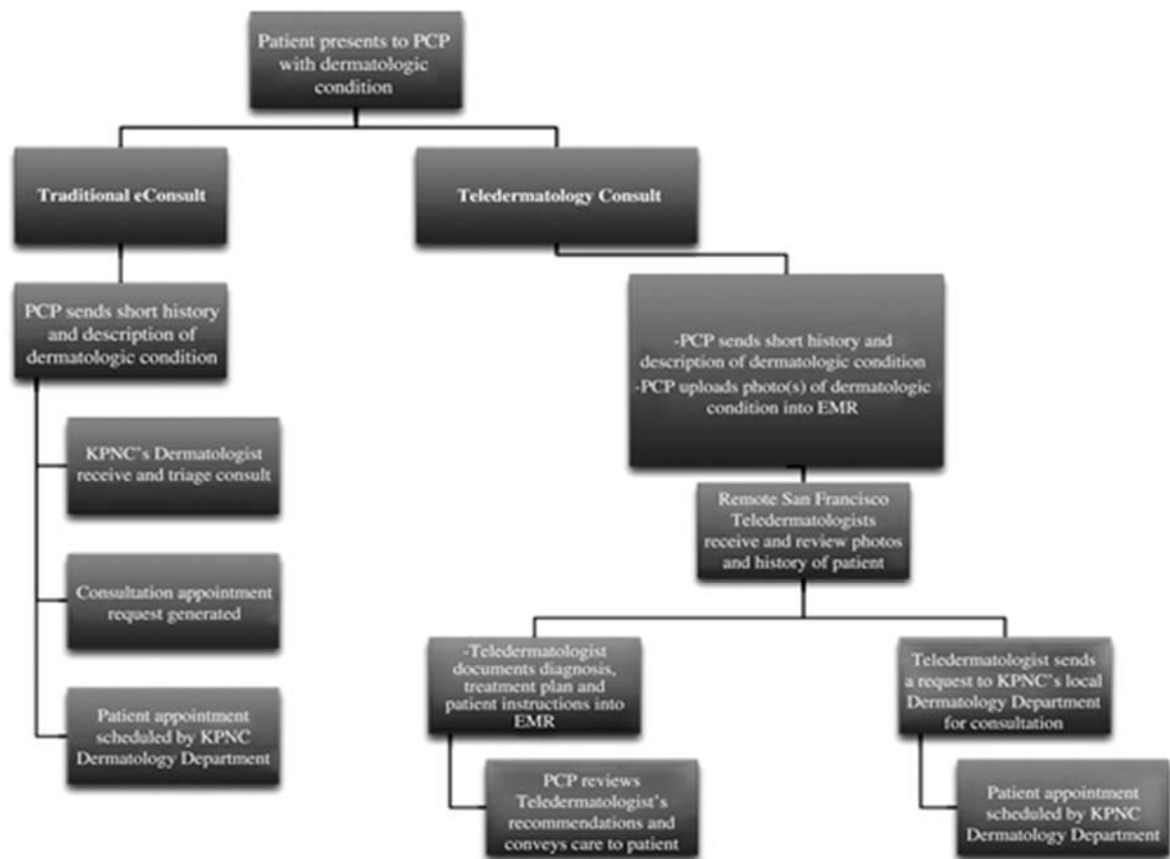


Fig: 4. Referral system for teledermatology consults Vs e- consults.

The study was a retrospective observational study where database and medical record of patients were reviewed. Patients who were referred to the dermatologist between April 1, 2009 to October 31, 2009 were selected by the use of pathology diagnosis of skin cancer from the database using Systematized Nomenclature of Medicine (SNOMED) codes. At first the time univariate analysis was performed to report the distribution of skin cancer diagnoses. After that bi-variate analysis was used to evaluate the connotation time of biopsy and type of referral. Relationship between population characteristics and type of referral was also measured. For this the Wilcoxon–Mann–Whitney nonparametric test was used. By the use of

chi-squared test the connotation between gender and referral type as well as skin type and referral type was measured. Statistical analyses were executed by the use of SAS version 9.1 software (SAS Institute Inc, Cary, NC) and a  $p$  value of 0.05 was substantial level for this study.

A total number of 382 patients were identified using SNOMED codes. 21 patients were excluded who was diagnosed as extracutaneous squamous cell carcinoma. Lastly 4 patients were excluded who were referred to non-dermatologists for biopsy of their suspected wound. In total 293 patients met the study criteria properly. Among them 170 (58%) were conventional referrals, and 123 (42%) were teledermatology referrals. There were no significant differences between the teledermatology and e consult groups for age, sex, skin type, skin cancer diagnoses. Through the teledermatology program patients who were referred to the dermatology clinic took a considerably less time for biopsy than e-consult. This time difference was statistically significant with a  $p$  value of  $<0.0001$ . Time of biopsy was measured separately for basal cell carcinoma patients and squamous cell carcinoma patients. Because of small sample size multivariable results for malignant melanoma patients were not reported. Mean time of biopsy of skin cancer of basal cell carcinoma was 13.5 days (95% confidence interval 12–15 days) for conventional referrals versus 10.0 days (95% confidence interval 8.1–11.9 days) for teledermatology referrals ( $p<0.001$ ). Mean time of biopsy of skin cancer of squamous cell carcinoma 14.1 days (95% confidence interval 11.3–16.9 days) for conventional referrals versus 8.9 days (95% confidence interval 5.6–12.2 days) for teledermatology referrals ( $p<0.001$ ).

In this study the researchers mainly compared the time interval between evaluation and biopsy of the most common skin cancers for traditional e-consultation and teledermatology. The outcome was that it requires significant less time of biopsy of the most common skin cancers for teledermatology consults as compared to e-consults. The reduced time to biopsy of a common skin cancer through a teledermatology program was because of more effective training mechanism inherent in the technology of teledermatology. The triaging of suspected skin cancer by teledermatology is more superior to traditional consultation. In the era of high cost of healthcare, teledermatology offers an advantage over traditional face-to-face consultation to avoid the unnecessary clinic visit. The store and forward teledermatology technology has a cost saving characteristic compared with conventional consultation when cost is a matter of consideration. If the large number of skin cancer diagnosed every year in



KP's Central Valley Service area and increasing healthcare cost is taken under account, then 1% pointless clinic visit can save a large amount of money. One limitation of this study was that the study was conducted in KPNC Region in the Central Valley Service Area, which might not represent the whole remote areas in the United States. Also the number of malignant melanoma patients was very few and the time interval between e consult and teledermatology referrals for these cases was not significant enough to come to a result. However, teledermatology leads to an enhanced service for healthcare system in term of faster time and cost saving.

May, C. et al. described about prospective observational comparative study assessing the role of store and forward teledermatology triage in skin cancer [55]. In this study, the research was conducted in United Kingdom (UK) where suspected skin cancer patients from General Practitioners (GP) should be referred to specialist dermatologist within 14 days and treatment should start within 62 days. This process is applicable for malignant melanoma and squamous cell carcinoma (SCC). In UK one study regarding store and forward photographic triage has already been conducted in Lanakashire with a number of 50 patients [56]. A recent teledermatology study has shown that photographic triage of skin cancer referrals and supported the clinical history and examination importance [25]. In this study the researchers tried to explore if store and forward teledermatology triage can effect the waiting time as a part of treatment.

The study was conducted in Lanakashire skin cancer clinic, which was established in May 2005 with electronic referral and dermoscopy facilities. GPs of Lanakashire community can log on to the password protected Scottish Care Initiative website and able to complete a tick box referral proforma. The direct dial telephone numbers of local medical illustration department is given to the GPs and are asked to an appointment for the patient. For each patient maximum three high quality images including dermoscopy are taken. All images were taken with a 6-megapixel single-lens reflex digital camera (Nikon, Tokyo, Japan). The dermoscopic image was taken with a Coolpix 450; Nikon digital camera. High quality images were loaded on a password protected secured server, which was possible to access via the hospital department. By reviewing the images the dermatologists could allocate priority. Patients having suspected melanoma and squamous cell carcinoma were in the priority list and got an urgent appointment. If there were any patients with doubt diagnosis were listed to be seen soon. For the study there were no ethical approval problem because it was a service

evaluation. Data was collected between May 2005 to May 2006. Through the pathology department patients with melanoma and SCC were referred conventionally identified. Specialists, consultants or senior trainees at the conventional clinics conducted selection.

451 new patients were referred with images during the study period. SCC was diagnosed in 6 cases and in 14 cases melanoma was diagnosed. Remaining 431 patients were diagnosed either having basal cell carcinoma (51cases) or nonmalignant cases. 39 patients with melanoma and 37 with SCC were managed conservatively were over the same time phase. Patients having malignant lesions were prioritized as urgent. Apart from urgent patients others were categorized as soon based on their photographs. Their appointments were given after 3 weeks. Patients having melanoma with photographs had the median waiting time of 14days and patients having SCC had a median waiting time of 13.5 days. For patients managed conservatively urgent priority situations were visited after a median of 24 days for both melanoma and SCC. 12 patients with melanoma and 22 patients with SCCs waited for 'soon' appointments. In the photograph group patients having melanoma was treated within 62 days with a median value of 21.5 days. Patients having SCC the treating median value was 56 days. 77% of patients having melanoma given urgent priority and 67% of those given a rating of 'soon' were treated within 62 days in the conventional referral group. In this study it was addressed that photographic triage can improve the prioritization of patients in cases like malignant or SCC. Usually the number of referrals to clinics from GPs for skin cancer is slow and that's why clinics are run only on weekly basis. It was because of referrals bias. Sometimes if the photograph is not clear the referral was upgraded. So the photographic diagnosis was capable to alter the management if there were any doubt. In this study the store and forward teledermatology system was helpful for running a triage system in case of malignant skin lesions.

Moreno-Ramirez, D., et al described about Economic evaluation of a store and forward teledermatology system for skin cancer patients [25]. In this study the researchers have tried to evaluate the economic analysis of a store and forward teledermatology technology for the triage of skin cancer lesions. A recent study has shown five economic studies with different results that do not showed any proper conclusion about the economic advantages of teledermatology [57]. Appropriate effectiveness measures of teledermatology, type of economic study for teledermatology; identification of all costs related to teledermatology technologies is some problems in economic evaluation of teledermatology system. The study

was conducted at the Skin Cancer Clinic of the Hospital Universitario Virgen Macarena (Seville, Spain). The study was a part of inclusive evaluation project where the clinical efficiency, precision, reliability and cogency of teledermatology were evaluated.

12 primary care centers (PCCs) was involved in to the study. At the time of study period, 2009 successive teleconsultations were performed at the clinic. Average rate of teleconsultations were 134 per month. The cost of these teleconsultations was compared with the cost of the same number of successive patients having suspected skin lesions with conventional letter referral system. Cost allocation was conducted on an activity chart where all the steps for diagnosis and treatment of skin cancer patient were described. After the first visit to general practitioners, digital images of patients with cutaneous lesions were taken and transferred to the skin cancer clinic. Patients who had malignant lesions were referred to the skin cancer clinic but general practitioners managed patients who have benign lesions. In the letter referral system were routinely referred for face to face at the skin cancer clinic. In each case specific cost was allocated. Both fixed and variable cost was considered in cost identification analysis. The cost of teleconsultation by dermatologist was measured by the time used for each consultation. However, the first visit to the general practitioners was not included to the cost identification analysis. Travel costs of the patients were also calculated depending on the distance. Private vehicle and public transport using rate by the patients were equal (50%). The average cost for round-trip was €8.47 per visit to the skin cancer clinic. On the basis of minimum wage the price of working days cost was determined and the average cost was €14.25 per visit to the skin cancer clinic. The cost of the equipment used was also considered. The total equipment cost was €9851.64 with an average cost of €4.90 per teleconsultation by dermatologist. The cost of patients with malignant lesions who were referred to the clinic had different cost than the patients with benign lesions. For the cost effectiveness analysis, waiting intervals to the in person visit from general practitioners to skin cancer clinic were considered as main outcome. For each teledermatology patient the unit cost was €79.78 and for each conventional care patient the cost was €129.37 with a  $p$  value of  $< 0.005$ . An inverse relation was found between the average cost per teleconsultation in every PCC and the number of teleconsultations transferred from these PCCs. The result was substantial using Spearman correlation ( $P < 0.001$ ). An inverse correlation ( $P < 0.001$ ) was observed between the number of teleconsultations and the impact of equipment cost. A substantial correlation ( $P < 0.001$ ) between the impact of the equipment cost and the average cost per teleconsultation was also

found. The cost effectiveness analysis established that teledermatology can save a cost ratio of €0.65 per waiting day.

The study showed that the store and forward teledermatology system is a cost effective system of managing patients in skin cancer clinic. The method was 1.6 times cheaper than the conventional letter referral system. In the economic outcome the workload of a teledermatology system has been considered as a major determining factor. An average of 28 patients have to be seen by telemedicine every week to become economically feasible [58]. Increased use of telemedicine system in skin cancer lesions can improve the cost effectiveness. In the study it was observed that the greater the number of teleconsultations transferred from a participating PCC, the inferior the unit cost of the teleconsultation in the PCC. The ability of teledermatology to avoid the face-to-face consultation also has an influence in the reduction of cost. This reduction of waiting time is considered as a clinical outcome in teledermatology effectiveness.

Viola, K.V. et al. described about Outcomes of referrals to Dermatology for suspicious lesions, Implications for Teledermatology [59]. The main aim of this paper was to determine the percentage of suspicious skin lesions referred by non-dermatologist are discovered to be malignant and the suspicious skin cancer lesions recognized by dermatologist at the same time. Researchers have also tried to figure out the role of teledermatology in this finding. The study was conducted in United States where more than one million skin cancers are diagnosed every year [60]. The use of teledermatology to link the health care personnel to non-dermatologist has obtained attention in the last few years. Teledermatology is now used for the triage of patients with suspected skin cancers. Some research has shown the roles and inventions in the relationship between the general practitioners and dermatologists. In this paper the researchers has performed a cohort study of patients with a single lesions suspected as skin cancer who were referred by non dermatologist to define the percentage of suspicious lesions found to be malignant.

For the study the researchers has used a medical record appraisal of patients referred to the dermatology service at Veterans Affairs (VA) Connecticut Healthcare System. The medical record appraisal represented a convenience sample of VA patients from January 1, 2006, through December 31, 2009. Inclusion criteria of patients from electronic patients record was based on some terms including, rule out basal cell carcinoma, possibly skin cancer; please

check, irregular border, pearly etc. Patients who were referred for total body skin examination or who were referred for follow up visit were excluded from the study. Two separate specialist dermatologist reviewed the electronic patient record that also reviewed the concluded consultations by dermatologist, consultation request from non-dermatologists and dermatophotography report after a biopsy has done. Another information that were collected were patients' age, sex, location of skin lesions on the body, general practitioner's lesions description and index and incidental lesions description. Depending on the biopsy result of both melanoma and non-melanoma skin cancer sample size for the study was calculated. The researchers have performed bivariate comparisons of the baseline characters between biopsy results of benign or malignant skin lesions using  $\chi^2$  analysis or the Fisher exact test. With the use of SAS statistical software package (version 9.1; SAS Institute, Inc, Cary, North Carolina) all statistical analysis was performed. In total number of four hundred patients were included in the study with an average age of 77.7 and 98% of them were male patients. Among all patients 74% of patients had skin cancer history. Locations for lesions were face 35%, neck/head 12%, and lower limb 12%. 22% patients (88 patients out of 400) have the index report that was positive for cancer. General practitioners referred 245 patients, midlevel practitioners referred 88 patients and other practitioners referred 37 patients. For all providers cancer diagnostic rate was 22.0% but ranged from 19.3% for midlevel practitioners to 29.6% for non-dermatology residents; almost similar diagnostic rates (22.4% and 21.6%) was found for general practitioners and other physicians. 55 (62.5%) were referred by general practitioners and 8 (9.1%) were referred by midlevel practitioners of the 88 positive biopsy result.

Health care providers did not use teledermatology directly in this study but it was believed that the role of teledermatology for the referral process was significant. Teledermatology had been used as a potential source between health care providers and physicians. Teledermatology technology had proved to be cost effective, time saving and optimum for proper referring diagnosis and prompt treatment. In this study teledermatology was proper for identifying the benign index lesions without further diagnostic studies. In this study the overall risk for skin cancer was not assessed within the cohort. However, the proportion of cancers found within referred skin lesions and further incidental lesions found at the same time of the consultations were evaluated. One of the major limitations of this study was the study population. 98% of the population was elderly white male who do not represent all people and who are already in a great risk of skin cancer. If teledermatology is applied in skin cancer lesions, non-dermatologist should have a lower threshold for using pictures of all skin lesions.

In another review article the role of tele dermatology in prevention and diagnosis of nonmelanoma and melanoma skin cancer were discussed [61]. Tele dermatology is a significant branch of telemedicine, which was developed in 1995 [62]. It is assumed that tele dermatology will be a gradually more conventional mean of emerging dermatologic health care worldwide and will play an important medical function in future. Usually tele dermatology technology used communication technologies to transfer information and images of skin lesions to the dermatologist by the use of computer, mobile telephone and Internet. A reduction of morbidity and mortality of nonmelanoma and melanoma skin cancer is one of the most important challenges for dermatology for present time and tele dermatology technology can be considered as a significant tool in preventing and diagnosis of skin cancer.

Exposure of sun is one reason of skin cancer. In order to evade the dangers of sun exposure, many educational programs have organized to notify people about preventive measure. Under the governance of World Health Organization (WHO), many scientific agencies have estimated a daily index of sun irradiance to detect the cut-off value to avoid sunburn and risks from sun. In a study by the use of mobile phone a reminder strategy was used to improve the adherence to sunshine application via SMS [63]. In total seventy people were registered in the study. Half of them received reminder about weather information and use of sunscreen via SMS on a daily basis and half of the population did not received any reminder. This practice indicated that a simple daily SMS reminder could improve the rate of adherence to sunscreen application. The use of SMS reminder can also improve outpatient clinic attendance, support to diabetes and cardiovascular patients, encourage to loss weight. Usually dermatology is a noninvasive in vivo technique which has the prospective to improve up to 49% diagnostic accuracy for both nonmelanoma and melanoma skin cancer. In dermatology, tele dermatoscopy presents a development in tele dermatology recently. It is possible to transfer dermoscopic images of skin lesions through Internet to remote teleconsultants. So many skin lesions tele dermatoscopy was used. Generally from general practitioners teleconsultations are sent to the pigmented skin lesions specialist clinic. The accuracy rates of treatment in these cases are quite high. In this regard tele dermatoscopy seems to be quite suitable for triage system. In this article the researchers have mentioned about some studies about the accuracy rate of using tele dermatology technology in skin cancer triage system, which are already mentioned in the previous articles discussed.

Finally it can be considered that teledermatology has gained good interest among scientific community. Teledermatology can assist in the preclusion and diagnosis of both nonmelanoma and melanoma skin cancer. Rural areas where lacks of specialist dermatologists are found patients seem to accept teledermatology as an excellent mean to obtain instant healthcare service.

#### **4.4 Articles discussing mobile teledermatology**

Another article which mainly focused on melanoma screening with cellular phone. This one mainly focused on mobile teledermatology [64]. In this paper they selected 18 patients having pigmentation problem. The teleconsultation was conducted by the use of a new generation cellular phone. The mobile phone was a Sony Ericson with two-megapixel camera with auto focus, macro mood and zoom. In every case they took a close up clinical image and a dermoscopic image applying the cellular phone on a pocket dermoscopic device with a 25mm 10x lens. Images had a resolution of 1632x1224 pixels. Images were stored in JPEG format. The images were transformed into computers having good quality. Teleconsultants firstly reviewed the clinical images and made their clinical diagnosis and after that reviewed the dermoscopic images. Teleconsultants diagnosed each cases for example blue nevus, recurrent nevus, angioma. After diagnosis it was found that regarding the clinical images there were a very little amount of variation in the result between mobile teledermatology and face-to-face diagnosis. In most of the cases the result was almost same. The research was conducted in 2007. However, now mobile phones are more developed and digitalized. Mobile phone having more megapixel with good quality of image is available. Currently, many medical researchers of telemedicine focusing on development of cellular phones for home based cellular data acquisition. A person who is concerned about any change in mole or a new mole can take a picture of his/her smart phone and can easily send it by suing multimedia-messaging service (MMS) to a specialized telemedicine center for diagnosis. In this case distance is not a problem. So mobile teledermatology is covering the way of early melanoma recognition by enhanced self-examination in the spirit of an e-health program.

Lamel, S.A., et al. describes about some application of mobile teledermatology for skin cancer screening [65]. This article mainly focused on the progression of mobile technology based on store and forward teledermatology, which may be applied on skin cancer screening. Only in United States more than 2 million skin cancer is diagnosed in each year with the association substantial morbidity, mortality and economic burden [66]. Skin cancer screening is related

with improved health outcomes. People who are living in remote areas or medically underserved areas have less opportunity for skin cancer observation. In this case store and forward teledermatology has been used to serve people living in remote areas. In traditional store and forward teledermatology system photos are downloaded from the camera to the computer and then the photos are transmitted to the dermatologists. This process is quite time consuming and need to use both cameras and computers. With the advancement of mobile phone technology, the use of teledermatology has been introduced in some settings [67]. The use of mobile technology to capture digital images for clinical diagnosis seemed to be practical.

The study needed an approval and the institutional review board at the University of California approved it. It was possible for the participants to designate up to 3 lesions. By the use of Google android G1 images was taken. Trained research staff and medical trainees took images. The smart cellular phone had wireless Internet connectivity with 3.2-megapixel cameras. The mobile phone had an application that was enable to facilitate remote diagnosis of skin conditions by dermatologists. All the encryption and authentication of data from the mobile telephone was secured in accordance with Health Insurance Portability and Accountability Act regulations. Two dermatologists participated in the study. One dermatologist executed in person evaluations of participants and the other evaluated digital images taken from the mobile phone. In each case both dermatologist provided 3 different diagnoses.

They measured the outcome of the study by management concordance. There was an agreement between two dermatologists for particular skin lesion. Before performing the study both dermatologists individualistically evaluated 45 skin lesions in person and 30 randomly selected store and forward images. This was done to evaluate management and diagnostic agreement. For the study a total of 86 participants presented with 137 lesions for evaluation. Among the participants majority was female and the average age was 45.24 years. Most of them were white with 1 black, 10 Asians and 2 Hawaiian. 59% of the participants were unmarried. Out of the 137 lesions 26 lesions were not transmitted immediately. 4 of the lesions were not proper for evaluation by the dermatologists. Management concordance for teledermatologist and in person dermatologist was high. The aggregated diagnostic concordance between teledermatologist and in person dermatologist was 62%. A multiple variable factor was created to determine causes that provide to disagreement in case of diagnosis of malignant and premalignant lesions. Factors that influenced were age, history of



actinic keratosis, number of prior squamous cell carcinomas. 1-year increase in age was connected with approximately 5% increase of diagnostic disagreement for premalignant and malignant lesions.

After analyzing this paper it was almost clear that mobile phone technology is a groundbreaking device that can be easily used for skin cancer screening in areas without access of ready dermatologist. This study shows that the use of mobile phone technology produced high management concordance of 81% between in teledermatology and in person valuation. The diagnostic concordance of mobile teledermatology was comparable with traditional store and forward teledermatology. There should be extra care to exercise the evaluation process of pigmented lesions through using mobile phone technology. This study was the first study where mobile phone technology was used for skin cancer screening in North America. After evaluating this paper some points was noticed in favor of mobile phone teledermatology. These include, mobile phone technology includes portability and accessibility of being able to take clinical images and the history of a single mobile device transmit the information to the dermatologists. This total process is time saving. Another point is the expanding network coverage. Mobile phone technology enables secure transmission of images clinical information to the dermatologist with high-resolution picture quality. There are also some limitations in this study. Sometimes it was not possible to transmit images instantly because of technical difficulties. Sometimes it was not possible to capture dermatoscopy images by the mobile phone, which had been found to develop diagnostic accurateness in other studies [68]. However, with the advancement of continuous technology, diminution of transmission problems and addition of dermatoscopy with mobile phone will like be up coming in near future.

Massone, C., et al. describes about the role of mobile teledermoscopy for the diagnosis of melanoma [69]. This article mainly describes about various features of mobile teledermatology, teledermatology and teledermoscopy for the diagnosis of melanoma. Nowadays mobile teledermatology is widely used in telemedicine application. Mobile phone and personal digital assistants (PDAs) are capable to replace stationary devices. Satellite communication and wireless local area network is a reality with the implementation of modern wireless telecommunication. Treatment of dermatological problem is a visual profession and it is an auspicious field for various aspects of telemedicine in general. Mobile teledermatology is considered as one of the most current expansion in this field [70]. The second and third

generation mobile phones with high number of pixels have revolutionized the transmission of data. As compared with the old devices the new generation mobile phones or PDAs do not have the limitations in image quality. In case of emergency skin disease patients, mobile teledermatology could be a filtering system. Mobile teledermatology is an excellent choice to follow up with patients who have chronic skin disease. In this case patients can take pictures of them by using their cellular phones and can send the pictures to a dermatology service by using special application. By using the satellite transmission mobile teledermatology is capable to receive data and pictures from areas where no Internet connection is available. In this perspective mobile teledermatology is an outstanding choice in the field of teledermatology.

Next stage of this article was a description about teledermoscopy. In this part the authors have explained about how clinical images of pigmented lesions is possible to transfer over telecommunication networks via email or by the use of special web applications. The consent Net meeting of dermoscopy is an evident of applied applicability of the use of dermoscopy via Internet [71]. It is possible to manage individuals with multiple pigmented skin lesions by using a two-step teledermatologic approach. In this article the writers have shortly described a pigmented skin lesions. In this lesion teledermoscopy was estimated as a streaming system. The experiment was held in a department of dermatology of a University hospital of Seville, Spain. Here teleconsultations were sent from the general practitioners to the dermatology department of the hospital. 49% of the patients among 219 were sent to the FTF clinic. There was an agreement between the teleconsultants for both diagnoses. Investigations of lesions without interaction with patients are connected with inadequate management in about 30% of equivocal melanomas. However, in this case, teledermoscopy is an auspicious area for further development and research.

The next part of this article was description about mobile teledermoscopy. To describe this part the authors have used the same study that they have used to describe about teledermoscopy. For mobile teledermoscopy images were captured with cellular phone by applying the cellular phone to a pocket dermoscope. In teledermoscopy system images are acquired with an integrated digital dermoscopy device as mentioned in the previous study. On the other hand in mobile teledermoscopy the resolution of the in build cameras in the smart cellular phones decides the issues of image quality. The routine may be responsible for the troubles of image quality. It is mentioned that mobile teledermatology is suitable technique

for both the physicians and patients. In mobile teledermatology structure it is possible to store the images in a digital archive for follow up control. It is also possible to send the images to expert colleagues for better opinion. In this whole process stuffs needs are a smart mobile phone with a built in camera, a dermatoscope apposite for image acquisition and a computer. This mobile teledermoscopy system can open a new horizon in case of newly formulated person centered health system. The intension of this concept is to allow people to adopt an active role to manage their own health and also to facilitate early diagnosis of disease. Mobile teledermatology and mobile teledermoscopy have the potential to become a realistic device for everyone. They can open the door for a new system of detecting skin cancer. A person who is worried about his/her change in an existing mole or a new mole can easily take a picture of a given lesion with their cellular phone and can send it to a specialist for triage via Internet.

Among the white people the incidence of skin cancer is like epidemic and the rate is quite high. It is important to detect it early specially if it is related to melanoma. In this aspect mobile teledermatology can be implemented as a filtering or triage system allowing a practical method for the management of patients having skin diseases. Mobile teledermoscopy may become a screening tool for malignant tumors and also it increase the reliably by the diagnosis of experts. It also reduces the expense and time. By using this system the quality of patients care system can be elevated and also the cost of the patient care health system can be reduced. A public health system where Internet facility is available, the regular us of teledermatology in skin cancer clinics can be a cost effective method [72]. For the dermatologists mobile teledermatology is a new tool to get images of suspected pigmented skin lesions. It is possible to use this system as a triage system for skin cancer. The authors hope that the mobile teledermatology system will outstrip their existing limits and will be introduce to various fields of medical system.

In another article Kroemer, S., et al. describes about mobile teledermatology for skin tumor screening and their diagnosis accuracy of clinical and dermoscopic image tele-evaluation using cellular phone [73]. In this article the authors have tried to describe the importance of patient management in case of accurately diagnosis of malignant skin tumors and distinguish them from benign tumors. Now a day the incident of melanoma skin cancer is most numerous. For better visualization of deeper structure of the skin currently epiluminescence microscopy is most frequently used [32]. This technology is useful to improve the diagnosis accuracy of

melanoma. It is ideal for telemedicine purpose as it is based on two- dimensional pictures. From a practical point of view it is sensible to use technical equipment that is generally distributed in common people and easy to get and affordable by all. This technology includes mobile camera phones and standard pocket dermoscopy devices. The popularity of using mobile teledermatology has previously been established.

In this paper the authors have conducted a study for over 3 months period to evaluate the diagnostic accuracy of clinical and dermoscopic image tele-evaluation for mobile skin tumor screening. They selected the patients from the general outpatients clinic at the Department of Dermatology, Medical University of Graz, Austria. All the patients were either self referred or selected by the general physicians. The inclusion criteria of the study were men or women with benign and / or malignant skin tumors of melanocytic or nonmelanocytic origin. For the study the dermoscopic images were taken physician himself by using Nokia mobile phone with 3.2-megapixel camera. Images were reserved in JPEG format and were saved in a computer by the use of Universal serial bus (USB) port. For online consultation other information like age, sex tumor onset, patients' history, and location were separately transmitted via a virtual private network. Every image was separately examined by a board certified dermatologist with clinical expertise in teledermatology and dermoscopy. Four different groups (benign melanocytic, benign nonmelanocytic, malignant melanocytic and malignant nonmelanocytic skin tumors) were created to diagnose the lesions. For detailed diagnosis World Health Organization recommendations were followed. According to these classifications the teleconsultant noted one primary and one differential diagnosis. By focusing on the accuracy in differentiating between benign and malignant skin tumors results were compared with the gold standard. As the gold standard histopathology was used. The accuracy of diagnosis was defined as settlement between the primary or difference diagnosis of the remote consultation and the gold standard.

Cohen's kappa statistic method was used to measure the outcome, which integrates a modification for the extent of agreement expected by chance alone. In the study,  $\kappa < 0.40$  shows a fair agreement, on the other hand values of  $0.41-0.60$  are deliberated as moderate,  $0.60-0.80$  as substantial and  $\kappa > 0.80$  specifies as a perfect agreement. The total time period of the study was three months. Throughout this three months 113 skin tumors from 88 skin patients were studied. Among them 41 were men, 47 women with an average age of 69. Among the 88 patients 20 of them were presented with two lesions. The body location for the

lesions was mainly neck/head 70% followed by trunk 16%, legs/feet 7%, arms/hands 5%, toe/nail 1% and genital area 1%. From each lesion 332 images from clinical trial and 278 images from dermoscopic trial were obtained. However, 2 clinical and 18 dermoscopic images were not clear enough for decision-making. After exclusion process of pictures majority of dermoscopic pictures (104 out of the 113) were skin tumors. After comparing with histopathology 11 of 104 lesions were misdiagnosed. Amongst these skin tumors 25 were benign nonmelanocytic, 15 were benign melanocytic and 6 were malignant melanocytic. The difference between clinical and dermoscopic tele evaluation was in the groups of malignant nonmelanocytic and malignant melanocytic skin lesions. After evaluation of diagnostic accuracy, clinical tele-evaluation was greater to teledermoscopy. A mutual result of re evaluation of both image types did not prove any diagnostic accuracy of teleconsultations.

In the discussion part of the paper the authors have mentioned that primary care doctors have reported doubtfully concerning management of more than one in three patients with dermatological conditions and it is notable that only one-tenth of these patients were sent for recommendation [74]. Fact for this reason may be lack of dermatologists and geographically maldistributed. Mobile teledermatology has the opportunity to fill up this gap since the rapid advancement of mobile technology has made the cost effective consultancy more available to the general practitioners. Majority of people now own a mobile phone with camera, this may create an affordable approach to the individuals to performance an important role in managing their health status, which can facilitate the early diagnosis of any skin disease [75]. It is seems that clinical image evaluation is a preferable method for tumor surveillance especially when one believes the high diagnostic reported. Previously it is proved that the addition of dermoscopic images for tele-evaluation improves the diagnostic accuracy in case of malignant nonpigmented skin lesions. In this study no advantage was seen over clinical tele-evaluation. The authors have demonstrated that for skin tumor surveillance both teledermatology methods were applicable even when cellular phones were used for data collection. Both clinical image tele-evaluation and teledermoscopy achieved high concordance rate. By analyzing the detailed diagnosis process, the difference between clinical and dermoscopic tele-evaluation were the diagnostic categories of benign and malignant nonmelanocytic skin tumors. This was because dermoscopic criteria may not always be so well defined for nonmelanocytic skin tumors [3]. Newly, it was confirmed that the addition of hand-held dermoscopy for melanoma screening was related with the decrease of number of patients referred for operation.

In this paper it was confirmed that low cost infrastructure of mobile teledermatology could deliver decent diagnostic accuracy for skin tumors. Patients of well aged who are suffering from widely spread skin problems could be monitored successfully from home by using the mobile teledermatology technology. Apart from some cases that were missed in this study because of the poor quality of images, both methods clinical image tele-evaluation and teledermoscopy performed admirable and equally high concordance rates with the gold standard to differentiate benign and malignant skin cancer. This result may improve the use of mobile consultations in future. In this context an easier and less expensive mobile teledermatology technique is necessary to development for skin cancer screening.

Berndt, R.D., et al. (2012) described about the development of a mobile teledermatology system [76]. This article is useful to understand the use of mobile teledermatology technology. The numbers of elderly and frequently ill patients are increasing currently. Therefore, traditional healthcare system is suffering from both increased cost and less number of available resources. Growing interest in the improvement of teledermatological technology has been motivated by the recent development in high quality digital imaging based mobile telephones. Today's smartphones are well equipped with high-resolution cameras and the prices of smart phones are quite sensible. Some current research are focusing on the improvement and testing new techniques to utilize mobile phones for home based healthcare related data collection and interaction with the patients. In this article the authors have confirmed the efficiency in diagnostics by dermatologists trusts, among other variables, on continuous examinations. This means that patients need to visit dermatologists repeatedly and results in a high cost healthcare system. It is possible to minimize the cost through the use of teledermatology system because it will reduce the face-to-face consultation frequently to the general practitioners [77]. In teledermatology system store and forward system is used which is based on the notion of sharing information asynchronously and place independently. This technology can transmit baseline photographs and information to a distant expert who delivers consultation. Mobile teledermatology has been proven to become effective for the care and therapy for patients with chronic skin disease [78].

In this article the authors have tried to describe briefly the development of mobile teledermatology technology with overall system engineering. In this method dermatologists, nurses, patients and developers worked together throughout the development process. In order

to fulfill all requirements for the development process regular consultations and discussion were organized. For proper outcome the researchers have followed a list of requirements,

- Proper system for essential functionalities needed for both dermatologists and patients.
- Appropriate graphical user interface for all participants.
- A protected data communication and data storage system.
- Ability to engender a report of patient's data
- Proper privacy system
- An accurate administration system for the whole process.
- Including an appropriate messaging system.

For system engineering the authors have followed is given in the following structure,

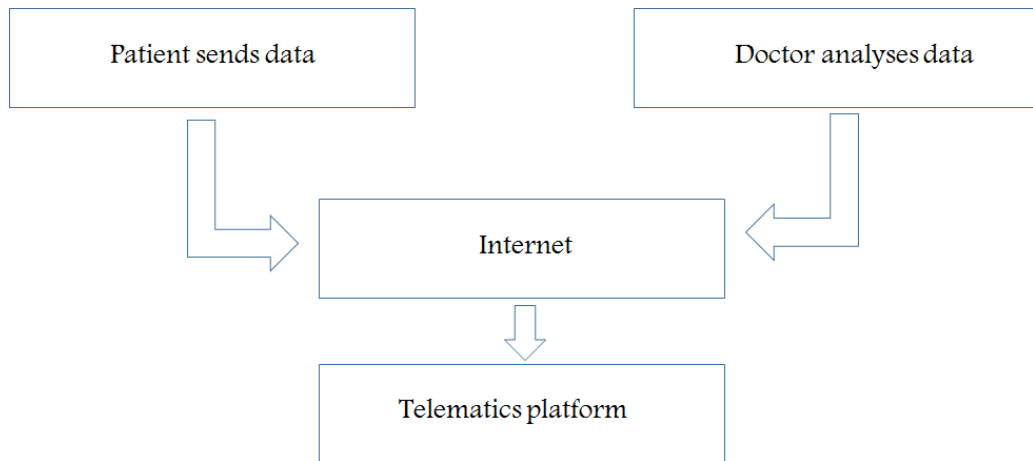


Fig 5: Structure for system engineering.

At first images of skin of subjective patients are captured and send to the telematics platform at any time and any location by the use of cellular phones. Only the authorized health personnel have the access to the data. It is only possible to see the data of patients who are assigned to the medical personnel by the administrator. A program assistant though three vital steps guide patients, image capturing, input of subjective valuation, and data transmission to the telematics platform. The telematics platform is a flexible middleware, which works for the integration of telemedical functions and assistances. Telematics platform consists of multiprocessor and multicore technology. It contains flexible interfaces to the third party applications with integrated management system. It covers multiple services including secure data transfer, secure data storage, worldwide and translucent data storage, fortifies authentication method, virus protection.

In the result section the authors have described about some mobile phone applications, which are useful for teledermatology technology. By the use of mobile phone application the patients are enable to capture and transform images at any time and from anywhere. In the study they have tried to develop two versions of application. The version is for windows operating system base mobile phone and the second one is android operating system based mobile phones. In windows system a program assistant guides the patients through three steps, 1<sup>st</sup> taking the images, 2<sup>nd</sup> input the evaluations and 3<sup>rd</sup> transforming data to the telematics platform. 1<sup>st</sup> step is the simple step, capturing the image. In the 2<sup>nd</sup> step there is an option named input evaluation where the patients are capable to enter values of different criteria describing the patient's current feelings. All these information then be connected with the image so that the doctor could get pictures with feedback from the patient. In the 3<sup>rd</sup> step communication to the telematics platform will be originated automatically by the use of communication channels like GPRS. In the Android operating system bases cellular phone there are two main views, diagram and photos. In diagram section an interactive graphic of the evaluation data is represented. It is possible to add new objects by clicking the option 'Add new' in the main menu section. In the 2<sup>nd</sup> view photos are organized in a gallery where there is a possibility to see the size of an image. In Android system it is possible to zoom out and in of an image. Android operating system is suitable to touch screen cellular phones working with the movement of fingers.

In online doctoral portal the authorized doctors have the access to all data of patients. After log in the doctors are enable to the list of their patients. There are different menus where doctors will get information about patients. In 'Evaluation' menu the doctors are capable to see the criteria of skin illness of a patients including pain, itching, weeping redness and so on. The value range from 0 to 10. 0 represent very good condition, whereas 10 represent maximum pain or very bad condition. In another menu called 'photo compare' where the doctors can open two images if same illness and can compare both condition of illness. The next menu is the 'photo data' where image gallery is open. In this option the images are chronologically listed with a possibility to see date, description of illness. In menu named 'Report' creates a PDF documents where the patients data for a chosen period is summarized. In administration section the system administrator has the authorization to register several hospitals. Therefore all the registered hospital has their administrator account. Registered hospitals then have the right tot register patients and medical personnel. This system also



allows the interaction between doctors and patients for certain period of time. This gives the doctors right to see their patients information also the patients to see their own information. In the discussion section the authors have described about the effectiveness of mobile teledermatology system for patients, doctors and nurses. The authors have divided the study into three phases. Phase 1 took one month where the application was tested by dermatologists. Dermatologists were able to test both mobile application and web-based application. After analyzing the both system dermatologists offer their suggestion for improvement of functionality of the system. Phase 2 was the testing of the system. Phase 3 was the testing of the application by patients having different kinds of skin diseases. For dermatological diseases for example eczema, pemphigus, psoriasis the use of teledermatological application was challenging. Also for the elderly patients it was necessary for them to take technical assistance from either their relatives or nurse. In the study some patients having ulcer cruris withdraw their name because of unknowingness about the new technology. At the end of all phases comments and suggestions were reviewed. Overall feedback after using new type of teledermatological technology was positive.

Fruhauf, J., et al. (2013) described about mobile teledermatology in Sub-Saharan Africa [79]. In this article the authors have described about the use mobile teledermatology system in developing countries. In African countries especially in Uganda skin disease is common problem observed in primary healthcare setting [80]. In this area most of the patients with skin diseases are treated with secondary health workers due to lack of specialist dermatologists. To cover this gap in dermatological service the authors have tried to establish a mobile teledermatology service and also have evaluated its applicability with the impact of remote diagnosis on patient outcomes.

The time period for this study was 8 months. Healthcare workers from four Ugandan health centers (Kampala, Jinjia, Mbarata and Masaka) submitted some uncertainly diagnosed problems by the use of second and third generation iphones (touch screen and 2 mega pixel camera) to dermatological specialist in three different dermatology department in Europe, USA and Australia. In every case at least there images were taken by using particular software to capture image. For each user there was special online database system to archive all pictures. African health workers could send a case to a certain specialist. In some unclear cases the health workers were requested to send skin biopsies in order to make sure about final treatment. However, for clear cases biopsies were not needed. In those types of cases, the

expert's diagnosis was considered as final diagnosis for further analysis based on substantial improvement after a certain follow up period of time. The authors have also performed a statistical analysis. For statistical analysis some diagnostic categories including infectious, inflammatory, autoimmune, neoplastic and others were created based on skin diseases. Based on aetiology diagnosis were further classified. A questionnaire was used to assess the health workers confidence level and to measure their opinion about mobile teledermatology.

For the study process a total 216 images of 72 patients (male 24, female 48, average age 29) were collected. Among the cases 35 cases (48.6%) were inflammatory skin problem, 19 cases (26.4%) were infectious, 8 cases (11.1%) were neoplastic, 3 cases (4.2%) were autoimmune skin problem. Other problems include vitiligo in 3 cases, ichthyosis vulgaris in 3 cases and pellagra in 1 case. Due to poor image quality in 6 cases no remote diagnosis was established. The rest 66 cases were well managed by the use of mobile teledermatology. However in 10 cases the skin states were unchanged until the final follow up section; 6 patients were lost for the final follow up session. Apart from all excluding cases, final diagnosis was attainable in 50 cases (69.4%) based on histopathology. When all the cases were compared with the final diagnosis, onsite diagnosis process led to 74% concordances and 26% discordances. In case of inflammatory skin problem and infectious skin diseases mismatches were mainly observed. However, skin problems like eczema, seborrhoeic dermatitis was misdiagnosed as bacterial infection and lichen planus was misdiagnosed as photodermatosis. In case of tumors warts and haemangioma were misdiagnosed as melanocytic problem and bazex syndrome were considered as photodermatosis. The local health workers were satisfied with the use of this mobile teledermatology system as it has easy portability, short request time, easy to operate. Though, in some urgent cases they faced some problem to access mobile 3G networks infrequently. The health workers felt confident in remote diagnosis, which was beneficial in 81% cases.

Through this study it was proved that it is possible to use teledermatology technology using smartphones to support dermatology auxiliary health workers in low recourse developing countries. This study had some similarities with some previous studies where dermatologists used mobile phones for dermatological purposes [81]. This study provides an additional approach to found an evidence base, in order to establish whether the presently growing enthusiasm for the use of mobile teledermatology in developing countries like Uganda. Apart from the findings there were some limitations in this study. There was a lack of true gold

standard. In this study several pitfalls existed in clinical follow up section, which was a criteria to judge the impact of teledermatological diagnosis. There was a chance to influence the final diagnosis by remote experts because no independent onsite experts were available to conform the final diagnosis. Apart from the limitations, a mobile teledermatology technology seems to be cherished for the management of skin problems in Sub Saharan Africa.

#### **4.5 Articles discussing technical issues**

Dermatology is an important branch of medicines, which represents treatment of patients suffering from diseases associated with hair, skin and nail. It is one of the challenging fields for practitioners because most of the dermatological diseases share common features with minor change in phenotypes or morphology. In addition, these diseases are mostly treated in the outpatients' section that requires rigorous and quick diagnosis. However, diagnosis is often failed because of the some of these diseases may feature slight different characteristics in different stages of same disease [82]. The diagnostic of diseases become more problematic because of reduced time dedication of medical students towards dermatology during their study. It was demonstrated that medical student curriculums only devote 0.24-0.3% of their medical study [83]. Hence, this field left with lots of opportunity to use technological advances in dermatology field, which results in development of new field called teledermatology. Rapid development of information and communication technology is providing the most needed boost to develop cost effective teledermatology field with both direct and indirect development of medical practitioners and patients. However, few major issues of e learning including technical aspects, such as use of images in diagnosis, need to be addressed to establish this field as common practice in dermatology and to avoid diagnostic errors.

E learning is a section of web-based education that involves use of Internet and different network media to provide healthcare service. Different methods are used to study the effect of e learning on patients, medical practitioners or both. However, the overall aim is to improve the healthcare service. Despite the advantages and availability of e learning, there are still some limitations due to explicitly of clinical data and time consumption. In a comparative study in medical students about e learning, Silva CS et al have shown e-learning has a positive impact on medical students [84]. This study involves two groups of medical students in which one was control group who went to discussion seminars and practical activities whereas

another group was attended online seminars in addition to the control group's activities. The groups were evaluated by a set of questions before and after the courses. Pre-test results were not significantly differing between two groups. However, post-test results were significantly different with improved score for e-learning medical students. The results were promising to conclude that e-learning have the superiority over only traditional education when it is combined with traditional education. It also provides rapid feedback and co-operation between instructor and participants. In addition, this study involved a small of group of student for limited period. Hence, the overall impact is unsure when it involves large group of participants for a longer duration. Moreover, the author has also mentioned about the challenges of engaging participants in discussion as well as more time consuming for that small group. This is type of study is not suitable to conclude and establish a method over another. However, addition of different approaches such as data based knowledge and frequent access to updated transferrable skill could make it more acceptable. In addition, the use of images is a major concern due to consent and legal rights of use it over distance location that involves e learning.

In another study, web-based educational intervention was developed to study the acceptance and impact on both medical practitioners and patients. Patient education can also have an impact to maintain the disease status as well as to make them aware of consequences with follow up their condition by themselves with direct involvement with doctors by internet based or mobile devices. In this study, the author has conducted a pilot study to in six dermatological centers included both practitioners and outpatients [85]. The patients were free to choose the intervention based on their condition in which the intervention includes all stages of specified skin disease. The feasibility and acceptance were measured by a set of scale that included point based system. The health care providers were also asked in the same way. However, the results was not promising from patients' perspective. However, the health care providers have accepted the intervention and more feasible in dermatological practice that is not the case from patients' perspectives though the patients rated the intervention as attractive and convenient. In some cases, patients did not even try the intervention or just seen it once and drop out from the intervention. It reveals that the intervention was developed from the health care providers points of view that did not quite reflect what patients were looking for. In addition, the patients needed to be more organized with self-management with disease control as well as the intervention was more time consuming for patients. Their participation became more active in the intervention that also demands their educational background

towards disease. Hence, it is important to develop e-learning system that is unbiased and fits to all that involve participation of both health care providers and patients.

Image based image analysis is most common feature in teledermatology. It encompasses few fields of teledermatology together in one frame such as teledermoscopy and dermatopathology. This is taking the advantages of image based technologies to generate an easier platform to diagnose skin lesions without being physically present to the health care providers even in some case image transfer of skin lesions over international boundary is becoming common practice to get advanced consultation from abroad. However, this field is often facing problems at different stages to generate complete scenario. Most common problem is acquisition of images, processing and dermatoscopic extraction of the image for diagnosis. There is no such standardized procedure and system in this field. Importantly, diagnosis is highly dependent on the images that are directly related to subject with less reproducibility. Hence, it is equally important to treat with great deal of experience to avoid diagnostic efficacy. Several techniques are commonly used to enhance the diagnostic capacity of the lesions. These are epiluminescence microscopy (ELM), solar scan, cross-polarization and side transillumination, confocal microscopy, ultrasound imaging and magnetic resonance imaging techniques. However, each of these techniques have pros and cons. Most commonly used method is digital dermoscopy analysis.

Dermatoscopic images of lesions are often difficult to obtain from the surrounding skin in addition to most common artifacts such as air bubbles, uneven illumination and black borders. Hence, it is important to avoid these artifacts to increase the accuracy of the system. The most common way to overcome artifacts is to use different filters such as Gaussian filters [86] mean filters [87] etc. However, these filters are mostly used for scalar images. Hence, it is important to use filters that also treat pixels as vectors if requires [88]. Another common feature is color quantization, which is equally important for segmenting images of skin lesions. In addition, presence of skin hair is another barrier that needs to take into consideration during image analysis. For this purpose, different methods such as applied curvilinear structure detection, mathematical morphology are used to avoid the problem with hair. After initial preparation and exclusion of different factors in dermoscopy, the extraction of images for specific properties towards diagnosis is crucial. It is important to differentiate one input from another. Some of the researchers are using the ABCD rule due to their ability for automatic extraction with higher reliability and less expensive in clinical diagnosis [89]. Some researchers are

using 7-point checklist, 3-point checklist and pattern analysis. Feature selection and classification are the last step for diagnosis of skin lesions. These two steps together can decide or misinterpret the diagnosis. Common methods used in feature analysis is principle component analysis, floating search methods, fisher score ranking and various filter-based methods. The main criteria of feature selection method is to have required amount of features available to classify the disease. There are two different approaches to classify dermoscopic images; one is dichotomous distinction and another model is  $P(y | x)$ . Most of the algorithmic methods use  $P(y | x)$  model for classification.

Despite of having so factors to be considered in teledermoscopy, it was found in a pilot study in 2003 that teledermoscopy has more than 80% accuracy when it was compared with gold standard also known as histopathological diagnosis [28]. The technology has advanced since then to greater level to lift this field with addition of new techniques. Three-dimensional (3D) imaging of the skin is a new challenging techniques introduced in this field. Static imaging phantom and dynamic imaging phantom were used to validate the geometric 3D measurements and different volume quantities, respectively. In that study, the author have shown that this passive stereovision camera system provides a more precise unbiased representation of the skin lesions, easy to use and sensitive to a small changes in area and volume during each step of intervention. Moreover, use of medical images is increasing with advancement in technology. The use of images is also considered as medical record that must be treated with equal care as written record. The medical image is more vulnerable to manipulate than written documents. Hence, it is important to treat medical image with confidentiality and control the access of image database. Importantly, it has also raised the question of law in frequent use of medical image.

Another study described about videoconferencing for rare disorders [90]. This article was about the participation and satisfaction of users in case of videoconferencing for rare disorders. The study was conducted in Norway where 16 state financed Centers for Rare Disorders to help people in this challenging situation of disorder [90]. One of the Centers for Rare Disorders named Frambu started using videoconferencing for some meetings in 2007. The main purpose was to lower the cost and time spend for travelling and to increase the number of professionals participated in the meeting. So it was important to evaluate the satisfaction of the participants in case of using videoconferencing as compared to face-to-face interaction. The researchers included items to measure user participation. They also

investigate which background (e.g. age, experience, role of participants) predicted users' participation and satisfaction.

During the period of January 2008 to March 2010, 115 face-to-face interactions and 19 videoconferencing were held with a number of 724 participants. Among them, 113 parents, 2 patients, 7 other relatives (50.8%), 230 (52.1%), number of local service providers 230 (52.1%) and from the Centre responded 23 (74.2%) were professionals; 13% of the clients (i.e. patients and their relatives) and 57% of the local service suppliers. The average number of professionals at the Centre was 2.92 in case of videoconferencing, while in case of face-to-face meetings the amount was 1.71 ( $t_{360} = 11.48$ ,  $p < 0.001$ ). 74% of videoconferencing meeting was able to save a distance of minimum 1600 km/professional from the center. Videoconferencing was conducted in school, hospitals or libraries. For the videoconferencing a Tandberg VC system with a 3000 MXP codex was used. The bandwidth and transmission speed was ISDN/384 kbps. Questionnaire provided to measure user participation and satisfaction consisted of 35 questions among which 12 questions were about the feeling during meeting, attendance, dialogue and cooperation, active involvement. These were for exploratory factor analysis (EFA). Some questions were about the characteristics of participants including age, previous experience previous relation with the center.

For statistical analysis SPSS 18 (SPSS Inc., Chicago, IL, USA) was used. Fundamental factors with eigenvalues  $>1$  was obtained. Factor loadings was below  $<0.30$ . The exploratory factor analysis specified two dormant components (eigenvalues of 4.60 and 1.62) with a variance of 51.8%. The general satisfaction with the Frambu meetings was quite good ( $M = 4.31$ ,  $SD = 0.62$ , range 1–5), with 95% of the sample scoring above middle score (3.0). Participation rate were also high ( $M = 4.05$ ,  $SD = 1.11$ , range 1–5), with 78.5% of the sample scoring above 3.0.

All these statistical analysis showed that the user satisfaction was high. In case of user participation the study found a high average score. Proper guidance may progress equipment-handling skills and skills in handling the particularities of cooperating by way of this videoconferencing technology. Because of the presence of increased number of professionals from the Centre at the videoconferencing meetings may indicate a broader range of expertise. Although it was not possible to validate any claim about causality, when the professionals at the Centre need not to travel and time and costs related to meetings were also low, which

could be advantageous to a higher attendance at the videoconferencing meeting. This study indicated that videoconferencing meeting is acceptable in case of sensitive topic. Not all meeting may be suitable for videoconferencing but proper training of patients and their relatives may increase the participation rate in near future.



## **CHAPTER FIVE**

### **DISCUSSION and LIMITATIONS**

#### **5.1 Discussion**

Tele dermatology has a great prospective of developing the delivery of dermatology services and serving reasonable service to isolated areas and allowing general practitioners to refer patients to dermatology center of at a distance. It is possible to use tele dermatology in two ways, either using store and forward technology or real time tele dermatology by the use of videoconferencing equipment. Telemedicine is the practice in healthcare that includes healthcare delivery, diagnoses, consultation and treatment. Now a day's telemedicine is widely involved in education and transfer of medical data. A successful tele dermatology technology depends on the effective implementation of a unified system of computerized medical records, imaging techniques, and trained persons. In my study I have tried to describe about different field of tele dermatology and e learning and how tele dermatology and e learning are associated with each other in both treatment and education purposes. Also I have tried to explain about the importance of images in the treatment of dermatological problems and the value of technology for the practice of tele dermatology.

I was encouraged to choose this topic because I had my personal experience in the field of tele dermatology practice. I had severe acne problem in my face and backrest, which was beyond description. I contacted with general practitioners. He suggested me some antibiotics that was not enough for cure. After that I meet with one dermatologist from University Hospital Northern Norway (UNN). He examined my skin but he was not sure which medicine he will apply on me because I have dark skin. He took pictures of my face by his digital camera and send it to another dermatologist in New Zealand. Dermatologist from New Zealand analyzed my face images and both dermatologist from Norway and New Zealand came to a decision about my medication. The treatment regimen was almost six months. Within this six months period of time I used to visit my dermatologist in every two months. As a follow up routine my dermatologist asked me to took picture of my face by my smart phone and send it to him to observe the improvement. I usually took two or three pictures of

close look of my face and send it to him. Below I have added some of those pictures that I send to dermatologist.

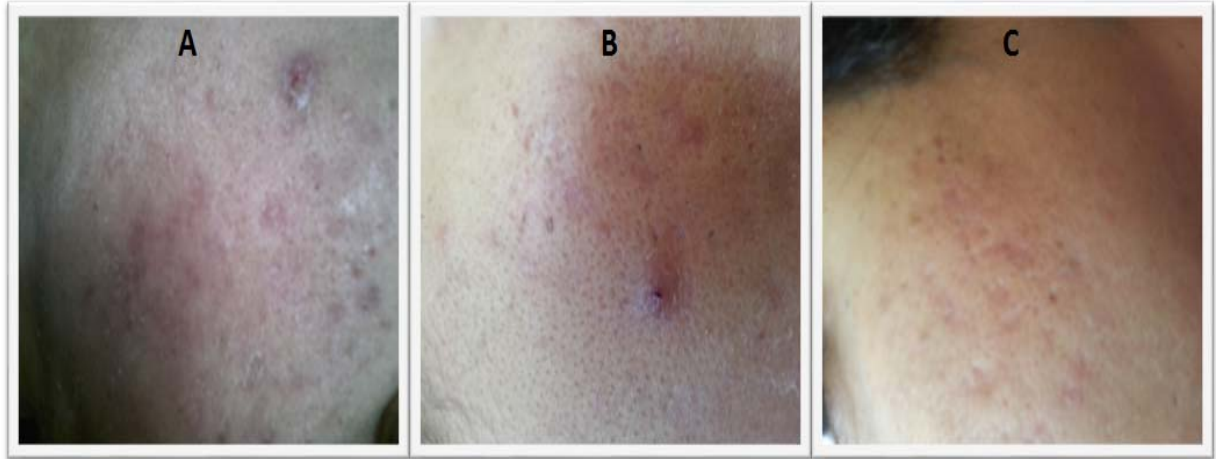


Fig 6: Different stages of follow up. A. Picture taken after one month of medication, B. Picture taken after two months of medication, C. Picture taken after four months of medication

The pictures given above describe several steps of my treatment and the improvement stages. This process was the proper use of teledermatology technique because it not only saved the time of both the dermatologist and myself but also I have got the chance of using mobile teledematology system. After my treatment procedure to me it seems like the mobile teledermatology technique will more grow in that direction in the next few years. Patient acceptance and demand will push in that direction because they want the opportuneness of taking a photo of their skin lesion, sending it promptly, and having it assessed by their dermatologist rapidly. Technology played an important role in my treatment because there was the frequent use of digital camera, Internet and smart phones.

After analyzing several literatures on teledermatology and e learning for several skin problems there are some outcomes in my study. It is possible to use teledermatology technology for the diagnosis of different skin problems, for the management of skin condition. Cost effectiveness of treatment, some important clinical outcomes in skin cancer, implementation of mobile teledermatology in modern skin problem treatment were also some important findings. Most of the study was performed in rural areas where there were lack of specialist dermatologist and hospitals. Results varied from area to area and also for different types of skin. However patient satisfaction in teledermatology practice were generally positive. Some factors

including distance to the dermatology clinic and wait times for an in-person appointment played great roles in patient satisfaction. Some studies found that tele dermatology is cost effective if some critical assumptions are fulfilled; distance of patients travel, tele dermatology volume, and costs of general treatment. To evaluate the accuracy of a new technology in treatment management it is more important to evaluate the clinical outcomes. By analyzing the process of tele dermatology and e learning it is indicated that technology acceptance model is good extrapolative model of healthcare professionals' intention to use tele dermatology systems. The perception of users is the most significant variable in the prediction of nurses' and physicians' intention to use any new technology like tele dermatology. New technologies used in tele dermatology such as videoconferencing, smart phone use, and high-resolution digital cameras are relatively high in healthcare professionals. Healthcare personnel, especially physicians and nurses also patients are considered the most important gatekeepers for tele dermatology services [91]. Technology acceptance model is a decent way to predict physicians' intention to use tele dermatology and that the variables apparent usefulness. Health-care professionals usually use the Technology Acceptance Model for the prediction of adoption behavior for various technologies that also included the adoption of tele dermatology [92]. The studies that I have analyzed in my thesis it was possible to use the Technology acceptance model by the researchers in both genders, various age groups, most cultures and for individuals of all levels of information technology experience.

To accept the new technologies of tele dermatology by the physicians, it is important to evaluate the its ability to fulfill the needs of both physicians and patients who tend to consider technologies as tool, acceptable when desire values in their practice are proven. In my thesis, some studies were conducted in rural areas where local health care professionals also took part. In those cases it was important to introduce them with the new technologies that may make their work easier. Also elderly patients who are not well introduced with new technologies, it was necessary to inform them about new technologies. In developing countries Internet is not available as like developed countries. It is also vital to make Internet available to all citizens. In many cases most patients were informed of tele dermatology programs and the use of technologies by their healthcare providers and could be more willing to receive e health services if they perceive support from nurses and physicians. I have found only one paper that discussed about the cost effectiveness of tele dermatology and face-to-face consultation, which does not give a clear picture of cost benefit of using tele dermatology

technology. Finally, the decision of whether to use this service and technology depends mainly on providers' willingness as well as on patient s' enthusiasm.

## **5.2 Limitations**

The present study has some limitations. I have chosen the papers from 2007 to 2014. I have found almost 200 papers relevant to my thesis topic. However, because of time limitation it was not possible to review all the papers. There were also some papers before 2008 that were quite informative. In addition, I did a literature review. It was about comparison of different studies conducted by different researchers. Therefore, it was not possible for me to achieve any practical knowledge from realistic field. The papers I have reviewed consisted of many images of close look of skin problems, which was quite informative and was capable to give a clear picture of problems. However, I could not use those pictures because of copyright problem. If I could have used those pictures it would have been possible to describe the skin problems more elaborately.

## CHAPTER SIX

### CONCLUSION

The rapid growth of information and technology allowed potential eradication of many of the world's illnesses including dermatological problems. Now we are living in a period of time, which may call "The Information Age". The present embellishment of telemedicine illustrates that it may act as an important media to condense some of the most important skin related problems or disorders including malignant skin cancer, atopic eczema, wound problems, psoriasis etc. Articles that have been reviewed mainly focused on the role of teledermatology technology on cancerous skin problems and non-cancerous skin problems. Also how mobile teledermatology can improve the field of dermatology in a shorter period of time. Some of the study was conducted in developed countries like United States and Austria where there were lack of specialist clinic and professional dermatologist. However, the reason behind this was not mentioned. More researches are required to focus on the economic outcomes of applying teledermatology and e learning possibilities in dermatology field to reduce cost of skin problems by sharing all kind of available resources. Some of the articles described above have discussed about the comparison of store and forward teledermatology procedure and face-to-face consultations and the result in both cases to reach the better result of diagnosis and improve the access of dermatologists to accelerate treatment. This can be credited to the existing accessibility and relatively low costs of the basic infrastructure required for such systems including high speed internet, efficient videoconference systems, high resolution digital cameras, in some cases smart phones. However, more researches are required to observe more efficient result in the field of teledermatology.

Telemedicine techniques can be considered as a well-suited technology for reducing the health problems in dermatologic diseases including cancer treatment and other skin problems. We can hope that in the next five years we will observe a dramatic changes in telemedicine and e-health services not only in developed countries but also in all the corners of the world. The cost of transmission as well as the telemedicine equipment prices will be reduced. But the functionality of this service will upsurge. It is also expected that the eagerness among healthcare professionals as well as patients of different skin problems will increase. Though the primary set up of teledermatology technique is costly in preliminary phase for a country,

but when it will be practiced on very large scale to address the skin problems, it will be very much cost-effective.

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