TESI DOCTORAL

Evaluating the impact of asynchronous telemedicine in the Catalan central region

Josep Vidal i Alaball

Thesis Directors:
Dr Josep Lluís Garcia Domingo
Dra Gemma Flores Mateo
Dr Francesc Garcia Cuyas

Doctoral Programme in Law, Economics and Business

2018

UNIVERSITAT DE VIC
UNIVERSITAT CENTRAL DE CATALUNYA
Escola de Doctorat

Dedicat a la meva família

"A man travels the world in search of what he needs and returns home to find it"

(George Edward Moore).

Acknowledgements

To my tutors, for their guidance during these long four years.

To the Manager of Gerència Territorial de la Catalunya Central (Catalan Institute of Health) for her unconditional support, believing that quality research can be done in central Catalonia.

To the personnel of the Technical and Support Area of Gerència Territorial de la Catalunya Central (Cristina, Edu, Olga, Montse), for their implication in data collection.

To the colleagues of the Research Support Unit of Gerència Territorial de la Catalunya Central (Glòria, Joan, Jacobo, Pere), for their methodological support.

To the hard-working professionals of primary care for responding yet another questionnaire!

To Jordi Franch, economics professor at Fundació Universitaria de Manresa, for his health economics advice.

To the Catalan Institute in Primary Care Research (IDIAP Jordi Gol), for granting me the intensification scholarship that allowed me to finish the thesis.

To the Catalan Institute of Health, for granting me the joint scholarship with IDIAP and the Innòbics grant to extend telemedicine in Catalonia.

To the University of Vic – Central University of Catalonia and specially the Health and Social Studies Center for facilitating me the tasks of the thesis.

And specially thanks to Dra. Dolors Vila, dermatologist, for her pioneering vision starting the teledermatology program in the county of Bages. Without her, teledermatology would not have been possible.

ABSTRACT

Introduction:

A teledermatology pilot scheme was first conducted in the city of Manresa in the summer of 2010. The clinical success of the scheme prompted its expansion to the whole county of Bages in 2011 and to the adjacent county of Berguedà in 2012. In the teledermatology service, primary care physicians take a photograph of the lesion and attach it to the electronic medical records of the patient together with a brief clinical account. In the referral hospital, the consultant dermatologists access the electronic medical records, review the images and suggest a treatment or action plan. Next, the primary care physicians review these recommendations and call the patient to explain the results. This whole process is usually completed in less than 5 working days.

Methods:

We have looked at the quantitative impact of the teledermatology service through an economic analysis comparing the teledermatology service with a conventional dermatology service. We have estimated cost savings per patient visited in the teledermatology service and extrapolated to the whole Catalan territory. To study the pattern of referrals from primary care to the teledermatology service, we have analysed the number of referrals to the conventional dermatology service after an initial referral to teledermatology and the number of visits saved. We have measured the degree of satisfaction of health professionals with the telemedicine services using a questionnaire we have validated.

Results:

The estimated added costs of the teledermatology service during 2016 amounted to 61,870 €. For the same period, the estimated costs of traditional outpatient dermatology

services were of 113,034 €. This represents savings of 51,164 € per year. After subtraction of societal costs, the savings equal 10,350 € per year.

Although in 2016 there were more teledermatology visits than in 2015 (5.71% increase), this did not correlate with an increase in the conventional dermatology referrals, as at the contrary, they decreased 8.9%. Referrals to conventional dermatology after an initial teledermatology consultation also decreased 19.71% in 2016 compared to 2015. This effect was more pronounced in rural than in urban areas.

The validated questionnaire we distributed amongst primary care professionals showed that 2/3 of respondents rated the overall quality and the technical quality of the telemedicine consultations as good. More than 2/3 of respondents considered that telemedicine services could improve the health status of patients and wanted to keep using the services in the same way as they were doing it. Nursing staff rated the overall quality of care delivered by the telemedicine services statistically significantly better that medical staff. Compared with nurses, physicians stated having more difficulties that could have affected the quality of care.

Conclusions:

Using a teledermatology service instead of a face-to-face dermatology service could save up to 51.164€ a year in the county of Bages. This is equivalent to a saving of 11,4€ per patient attended. Most of the savings come from a society point of view. Extrapolating the savings for the whole population of Catalonia would amount to a savings of 2,085,061 € a year.

Teledermatology service in operation in the Bages County increases the resolution of primary care teams as reduces referrals to the face-to-face dermatology service. This is more pronounced in rural than in urban areas.

Respondents to the questionnaire, who used more often the telemedicine services in the previous year, significantly rated the quality of care of these services worse than respondents who used them less often.

We can finally conclude that the asynchronous telemedicine services in the Catalan central region are efficient as can save economic resources and enjoy a good acceptance among health professionals.

RESUM (Catalan Version)

Introducció:

A l'estiu de 2010 es va dur a terme una prova pilot d'un servei de teledermatologia a la ciutat de Manresa. L'èxit assistencial de la prova va impulsar la seva expansió a tota la comarca del Bages el 2011 i al Berguedà el 2012. En el servei de teledermatologia, els metges d'atenció primària prenen una fotografia de la lesió i l'adjunten la història clínica electrònica del pacient juntament amb un breu comentari clínic. A l'hospital de referència, els dermatòlegs accedeixen a la historia clínica electrònica, revisen les imatges i suggereixen un pla de tractament o d'acció. A continuació, els metges d'atenció primària revisen aquestes recomanacions i realitzen una trucada telefònica al pacient per explicar els resultats. Tot aquest procés generalment es completa en menys de 5 dies hàbils.

Metodologia:

Hem analitzat l'impacte quantitatiu del servei de teledermatologia mitjançant un anàlisi econòmica que compara el servei de teledermatologia amb el servei convencional de dermatologia. S'ha estimat l'estalvi de costos per pacient visitat al servei de teledermatologia i s'ha extrapolat a tot el territori català. Per estudiar el patró de derivacions des de l'atenció primària cap al servei de teledermatologia, hem analitzat el nombre de derivacions al servei convencional de dermatologia després d'una primera derivació a teledermatologia i la quantitat de visites que es varen estalviar. Hem mesurat el grau de satisfacció dels professionals sanitaris amb els serveis de telemedicina a través d'un qüestionari que hem validat prèviament.

Resultats:

Els costos afegits estimats del servei de teledermatologia durant el 2016 varen ascendir a 61.870 €. Durant el mateix període, els costos estimats dels serveis de dermatologia ambulatòria varen ser de 113.034 €. Això suposa un estalvi de 51.164 € a l'any. Si no es tenen en compte els costos socials, l'estalvi és de 10.350 € a l'any.

Tot i que durant el 2016 hi varen haver més visites de teledermatologia que durant el 2015 (augment d'un 5,71%), això no es va correlacionar amb un augment de derivacions al servei de dermatologia convencional, ans al contrari, aquestes varen disminuir un 8,9%. Les derivacions al servei de dermatologia convencional després d'una consulta teledermatològica inicial també varen disminuir un 19,71% el 2016 en comparació amb l'any 2015. Aquest efecte va ser més pronunciat en les zones rurals que en les zones urbanes.

El qüestionari validat prèviament que vàrem distribuir entre els professionals d'atenció primària va mostrar que 2/3 dels enquestats valoraven la qualitat general i la qualitat tècnica de les consultes de telemedicina com a bona. Més de 2/3 dels enquestats consideraven que els serveis de telemedicina podien millorar l'estat de salut dels pacients i volien seguir utilitzant aquests serveis de la mateixa manera que l'utilitzaven. El personal d'infermeria va qualificar la qualitat general de l'atenció prestada pels serveis de telemedicina estadísticament significativament millor que el personal mèdic. En comparació amb les infermeres, els metges varen declarar que havien tingut més dificultats que podrien haver afectat la qualitat de l'atenció prestada.

Conclusions:

La utilització d'un servei de teledermatologia en lloc d'un servei de dermatologia presencial podria estalviar fins a 51.164 € l'any a la comarca del Bages. Això equival a un estalvi d'11,4 € per pacient atès. La majoria d'aquest estalvi prové de l'estalvi que

suposa per a la societat. Si extrapoléssim aquest estalvi a tota la població de Catalunya suposaria un estalvi de 2.085.061 € a l'any.

El servei de teledermatologia en funcionament a la comarca del Bages augmenta la resolució dels equips d'atenció primària, ja que redueix les derivacions al servei de dermatologia presencial. Això és més pronunciat en zones rurals que en àrees urbanes.

Els enquestats, que havien utilitzat més freqüentment els serveis de telemedicina durant l'any anterior, varen considerar significativament pitjor la qualitat de l'atenció sanitària que oferien aquests serveis comparat amb els enquestats que els utilitzaven amb menys freqüència.

Finalment, podem concloure que els serveis de telemedicina asíncrona a la Catalunya central són eficients, ja que poden estalviar recursos econòmics, i gaudeixen d'una bona acceptació entre els professionals de la salut.

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

Telemedicine can be defined as "*the use of telecommunications technology to provide medical information and services*" (Perednia & Allen 1995) or as "*medicine practiced at a distance*" (Coates et al. 2015; Romero Aguilera et al. 2008; Kvedar et al. 2014; Wootton 1996).

In 1997, the World Health Organization defined telemedicine as: *"The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities"* (World Health Organization 1998).

1. Types of telemedicine

Three main types of telemedicine can be distinguished according to the timing of the information transmitted: real-time, not real-time telemedicine and remote patient monitoring (Eedy & Wootton 2001; Hersh et al. 2006; Nepal et al. 2014; Levin & Warshaw 2009).

- **Asynchronous**, not real-time or store-and-forward telemedicine. It is a type of telemedicine where clinical data is collected, stored, and then forwarded to be interpreted later. It has the advantage that there is no need for the patient and the clinician to be available at the same time or place (American Telemedicine Association 2013). However, asynchronous telemedicine has the disadvantage that there is not the immediacy of direct patient contact, some images can have poor quality and it may require repeat consultations if clinical details are not complete

enough (Kanthraj & Srinivas 2007; Coates et al. 2015).

- **Real-time time telemedicine** or videoconference. In this type of telemedicine, patient and clinicians are available at the same time or place. It has the advantage of saving time by the opportunity to provide direct interaction between health care professionals that allow clarifying clinical details. However has disadvantages such as the higher costs of the technology, the need for significant bandwidth and the fact that video images may have lower resolution compared to photographs (Coates et al. 2015).
- **Remote patient monitoring.** It can be also considered a type of telemedicine as patient's health information is gathered with technological devices and send and stored in the patient's electronic medical records for future evaluation and use (Daniel & Sulmasy 2015).

2. History and evolution of telemedicine

It is difficult to determine when telemedicine was used for the first time. Zundel theorised that telemedicine in the form of bonfires may have been used as early as in the ancient Greece to transmit information relating to war or later on across Europe to transmit information about bubonic plagues (Zundel 1996). Some authors have suggested telemedicine started in late 18th century with the invention of the telegraph. It is recorded that the telegraph was used in Australia to unite a dying man with his wife and in America during the American Civil War to pass information about wounded soldiers (Eikelboom 2012). Other authors consider that the invention of the telephone by Graham Bell in 1875 constituted the origin of telemedicine, as it is probable that the telephone was used to discuss medical matters between physicians (Garcia Vega 2003). It has been published that in 1879 the telephone was used by an anonymous doctor to listen to a cough and reassure a mother convinced that their child had croup. In that

time, some experiments were also done to transmit amplified heartbeats though the telephone (Aronson 1977).

Bashshur and Shannon, in their comprehensive book about the History of Telemedicine, explained that "from a technological perspective, modern telemedicine emerged from a continuous series of technological advancements in electronic communication and computer processing". This advances started with the telegraph, continued with television and is now an ongoing process in the internet and digital age (Bashshur & Shannon 2009).

Figure 1: Approximate time line for major technological developments (Bashshur & Shannon 2009).

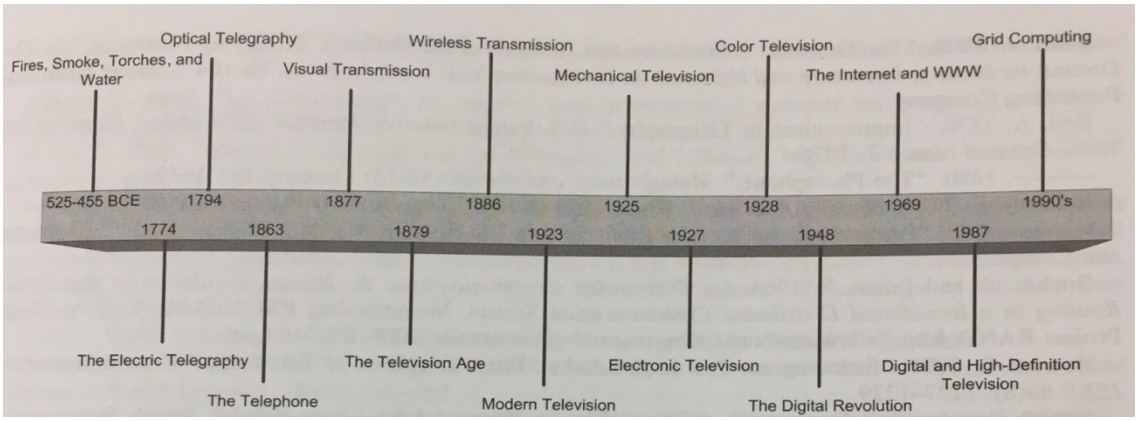
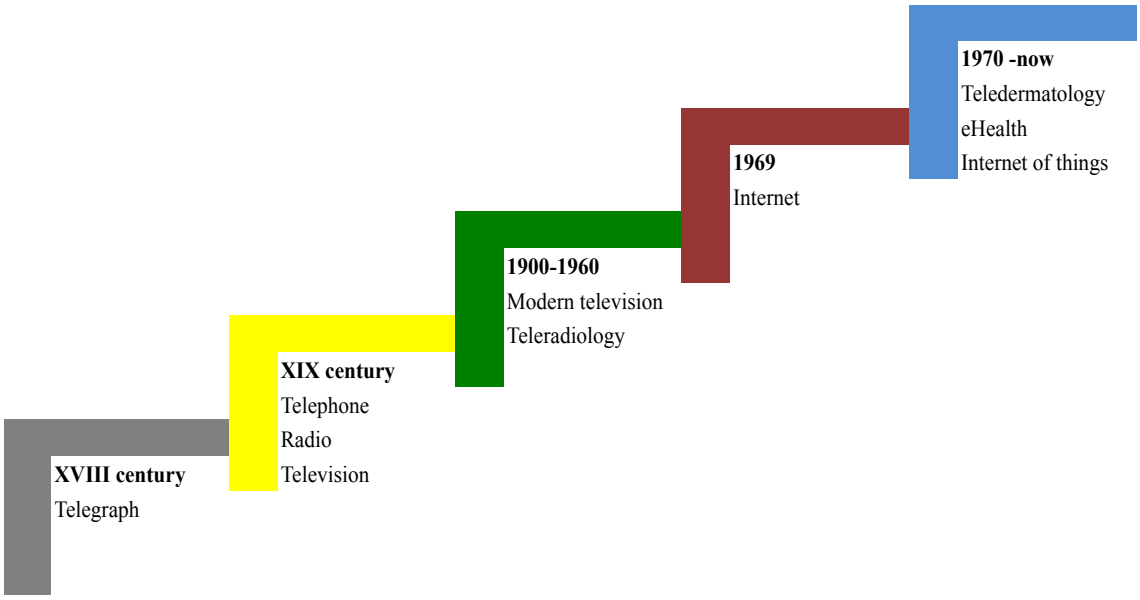
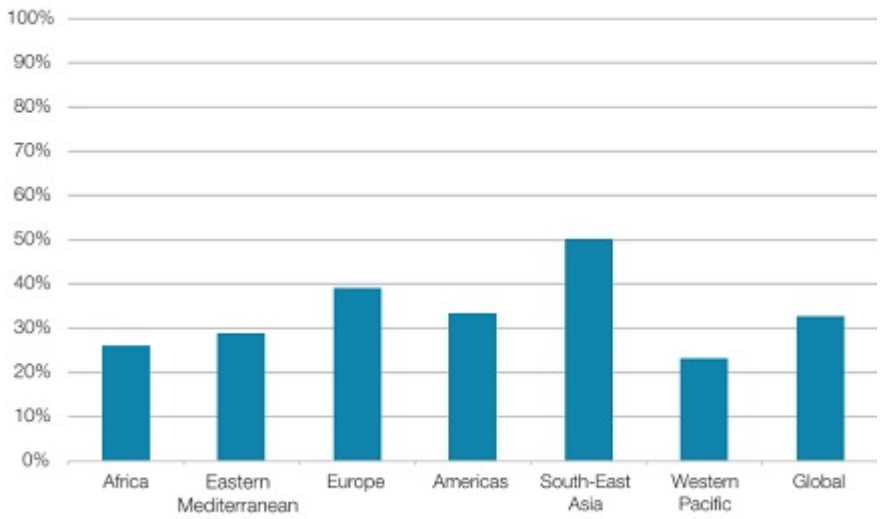


Figure 2: Ladder of developments in telemedicine



In the last 25 years, telemedicine has been implemented in many countries. In 2010 a World Health Organization survey found that 38% of the countries surveyed had some kind of telemedicine programmes and 30% of the countries had agencies that managed telemedicine services (World Health Organization 2010).

Figure 3: National Telemedicine agencies by WHO region (World Health Organization 2010):



Of all telemedicine services available globally, teleradiology is the most common telemedicine service used, followed by telepathology and teledermatology (World Health Organization 2010; World Health Organization 2016).

Table 1: Global implementation rates of telemedicine services (World Health Organization 2010):

	Established	Pilot	Informal	No Stage Provided	Total
Teleradiology	33%	20%	7%	2%	62%
Telepathology	17%	11%	9%	4%	41%
Teledermatology	16%	12%	7%	3%	38%
Telepsychiatry	13%	5%	5%	1%	24%

3. Efficacy, efficiency and effectiveness of telemedicine

Efficacy has been defined as the *"capacity for producing a desired result or effect"* (Dictionary.com 2017), whereas e**fficiency** is *"the ability to accomplish a job with the least waste of time and effort"* (Dictionary.com 2018). **Clinical effectiveness** is the application of the efficacy in clinical real settings. It has been defined as *"doing the right thing, in the right way, for the right patient, at the right time"* (Cullum 1998).

Since the beginning of the XXI century, many studies have looked and the efficacy and effectiveness of this technology and have gradually established that it is both effective and can provide efficient care at lower costs (Lee & English 2018; Van Der Heijden et al. 2011):

- In 2002, Hailey *et al.* published a large systematic review of 66 studies looking at the evidence of benefits of telemedicine and found little good quality studies looking at the effectiveness and efficacy of telemedicine. However, they found convincing evidence of the efficacy and effectiveness of teleradiology, telemental health (telepsychiatry), teleechocardiography, teledermatology and home telecare. The savings and clinical benefits identified mainly derived from the avoidance of travel and associated delays (Hailey et al. 2002).
- Hersh *et al.* in 2002 conducted another systematic review of 59 studies looking at the efficacy of telemedicine. Again the best evidence on the efficacy of telemedicine come from teledermatology and telepsychiatry. Some evidence was also found for telecardiology and teleophthalmology. In dermatology, they found two high quality studies looking at the concordance of store-and-forward teledermaology compared with in person consultations and they found that both services were comparable in outcomes (Hersh et al. 2002).
- In 2004, McKoy et al. evaluated asynchronous teledermatology looking at accuracy,

access time, cost and acceptance by patients and primary care physicians. They concluded that the accuracy of the teledermatology diagnosis was adequate and that teledermatology could serve as a valuable tool for triaging dermatology referals (McKoy et al. 2004).

- In 2007, Pak *et al.*conducted a systematic review involving 698 patients. They followed these patients and studied clinical improvement based on serial cutaneous examination. They concluded that there is no difference in clinical outcomes between store-and-forward teledermatology and normal dermatology visits (Pak et al. 2007).
- Ekeland *et al.* in 2010 published a comprehensive systematic review of reviews including 80 studies. They found 31 reviews affirming that telemedicine was effective and 18 reviews with promising but incomplete evidence. They concluded that the evidence base of the effectiveness of telemedicine was accumulating (Ekeland et al. 2010).
- In 2013 Whited *et al.* conducted a randomized controlled trial that included 392 patients and concluded that there was no difference in clinical outcomes between face-to-face visits and store-and-forward teledermatology (Whited, Warshaw, Kapur, et al. 2013).
- In 2013 Edison *et al.* conducted a very interesting study comparing the content and the style used by dermatologists in teledermatology consultations and normal face-to-face visits. They audio-recorded 101 in-person and teledermatology visits and concluded that they used similar style and content in both scenarios (Edison et al. 2013).
- In 2015, Livingstone and Salomon studied 248 referrals from primary care to teledermatology during a 3 year period. They performed a cost-effectiveness analysis taking into account the savings made by reducing referrals to secondary care from

primary care and found teledermatology to be effective and to generate a savings of £12.460 (13.545€) in a 3-year period (Livingstone & Solomon 2015).

Of all studies looking at the efficacy, efficiency and effectiveness of the different telemedicine services, the largest number of studies came from teledermatology. The most assessed aspect of teledermatology is its **accuracy**, **reliability** and particularly interobserver concordance.

- Whited *et al.* in 1999 used a sample of 129 patients to study the reliability and accuracy of a dermatology clinic compared with digital image consultations and concluded that consultations using digital images were reliable and accurate compared to conventional visits (Whited et al. 1999).
- Krupinski *et al.* reported 83% concordance rates between face-to-face versus digital photo diagnoses. They also reported concordance rates with biopsy results of 76% (Krupinski et al. 1999).
- Romero *et al.* in 2006 performed a systematic review looking at diagnostic concordance between conventional visits, synchronous teledermatology and asynchronous teledermatology. They concluded that the reliability of teledermatology was very high and the errors detected between the 3 different groups studied where not statistically significant (Romero Aguilera et al. 2006).
- Lane and Chance found that although dermatologist reported that they were more confident with in-person examinations, they had comparable diagnostic and managing agreement rates between conventional dermatology and teledermatology (Lane & Chance 2008).
- Taberner Ferrer *et al.* in 2009 revised 158 patients and calculated Cohen's kappa coefficient between diagnosis in primary care, a teledermatology service and usual dermatology visits. They found high concordance rates (92%) between the diagnosis

made in teledermatology and the real diagnosis made in dermatology. They also remarked that one of the main advantages of asynchronous teledermatology was that could improve the screening for malignant or suspicious lesions (Taberner Ferrer et al. 2009). Other studies have also pointed towards the fact that teledermatology could be a good triage tool for detecting skin cancers (Massone et al. 2014; Barbieri et al. 2014).

- In 2013, in a trend of 15 years in India, Kanthraj reported diagnostic accuracies of 73.35% for store-and-forward teledermatology compared to face-to-face visits (Kanthraj 2013).
- Nami *et al.* also reported very high concordance rates in 2015. In a study including 391 patients, they obtained a concordance rate between face-to-face and store-and-forward teledermatology of 91.05% (Nami et al. 2015).
- In 2015, Bashshur *et al.* conducted a literature analysis of teledermatology that included 71 articles. They reported high concordance rates in diagnostic and treatment planning between teledermatology and face-to-face dermatology (Bashshur et al. 2015).

4. Dermatoscopy

It has been reported that diagnostic accuracy of teledermatology increases significantly with the use of dermatoscopy (examination of skin lesions with a dermatoscope, a magnifier with a light source), particularly with pigmented lesions (Braun et al. 2000; Kittler et al. 2002).

- Some authors have reported sensibilities of 1with no false negative results (Moreno-Ramirez et al. 2006). Moreno-Ramirez *et al.* also reported that although primary care physicians spent 1.5 times longer on dermatoscopic teleconsultations, the teledermatoscopy service increased the economic investment of the teledermatology

facility by 2.4 times.

- Piccoli *et al.* conducted an observational cross-sectional study using data from 333 examination requests. They concluded that using a protocol for photographic lesion standardization consisting of panoramic photo, close-up with ruler and dermatoscopy, statistically increased the rate of diagnostic compatibility of skin cancer (Piccoli et al. 2015).

5. Telemedicine and wound care

Chronic wounds are an important health problem with an estimated prevalence between 0,44% and 0,54% amongst people of 65 years of age or more in Spain (Pancorbo-Hidalgo et al. 2014; Soldevilla Agreda et al. 2006). It has been reported that pressure ulcers increase the risk of death among elderly patients by as much as 400%, also decreasing quality of life and increasing the frequency and duration of hospitalisation (Stern et al. 2014). It is estimated that 5.46% of patients in Spanish hospitals have pressure ulcers (Sociedad Española de Medicina Preventiva. Salud Publica e Higiene 2016).

In 2003 an observational, cross sectional study, conducted in the counties of Bages and Berguedà that included 810 patients concluded that the prevalence of patients with pressure ulcers was 0.11% among the adult population (more than 14 years old) and 0.42% in individuals above 64 years of age. The prevalence of pressure ulcers was 7.3% in patients receiving home care and 4.8% amongst nursing home residents (Heras-Fortuny et al. 2006).

Wound imaging has been also used to support wound care, mainly for measurement accuracy, remote assessment and telemedicine (Bowling et al. 2013).

- One of the first published studies on the use of telemedicine in wound care is the study performed by Salmhofer *et al.* in 2005. They studied the concordance between

face to face consultations and teleconsultations in 110 chronic leg ulcers and found high concordance rates relating to slough, necrosis and granulation (Salmhofer et al. 2005).

- In 2007 Binder *et al.* followed 16 patients that generated 707 images in a case series of telemonitored patients with leg ulcers in nursing homes. They reported that telemonitoring of leg ulcers was well accepted by patients, home care nurses and patients. They described reduction in costs by the reduction of the number of visits to specialist care (Binder et al. 2007).
- In 2008, Chanussot-Deprez and Contreras Ruiz published a description of three clinical cases. They described the successful assessment and treatment of these patients suing telemedicine and concluded that this method could be cost-effective, saving mainly on transportation (Chanussot-Deprez & Contreras-Ruiz 2008).
- Vowden and Vowden in 2013 published a randomised controlled pilot study using telemedicine to support wound care in nursing homes. They concluded that telemedicine improved patient's outcomes and could save costs by improving the selection of dressing products. The technology was also well received by the nursing home staff involved with the care (Vowden & Vowden 2013).
- Quinn *et al.* in 2013 evaluated the use of smart phones by primary care professionals to manage chronic leg ulcers with the support a tertiary centre. The study just included eight patients but reported Concordances of 100% for wound bed assessment, 80% for skin integrity/colour and 60% for exudate assessment. They also conducted focus groups to explore nurse's perceptions of the service and reported an overwhelmingly positive feedback (Quinn et al. 2013). In 2005, Rasmussen *et al.* also conducted focus groups and individual semi-structured interviews to eight health professionals and also reported a good response to a new telemedicine service aimed

to follow diabetic food ulcer patients (Rasmussen et al. 2015).

- Chen *et al.* published in 2014 a study including 53 patients that compared wound images with face to face consultations and reported again high concordance and agreement rates between remote and on site plastic surgeons (Chen et al. 2014).
- A study also conducted in nursing homes including 90 patients with chronic wounds, reported that telemedicine was associated with significantly increased healing compared with conventional practice (Zarchi et al. 2015).
- Another study conducted by Rasmussen *et al.* on 401 randomised screened individuals with diabetic foot ulcers comparing telemedicine monitoring and standard care found no significant differences between both models of care regarding amputation and healing. However, they found a higher mortality rate in telemedicine monitored patients (Rasmussen et al. 2015).
- A recent non-inferiority trial published by Smith-Strøm *et al.* showed that the telemedicine used to follow up patients with diabetic related food ulcers in primary care was not significantly inferior compared to standard outpatient care in relation to healing time, death, number of consultations, or patient satisfaction. Moreover, the telemedicine group had a significantly lower proportion of amputations (Smith-Strøm et al. 2018).

6. Access

Access is one of the best studied aspects relating to telemedicine. It has been known for the last 2 decades that telemedicine provides better access to users in addition to reducing the waiting time between diagnosis in primary care and hospital.

- Jennett *et al.* in 2003 performed a literature review on the socio-economic impact of telemedicine and found that telemedicine enhanced access to health for patients living in rural or remote areas (Jennett et al. 2003). Other studies have also reported

the benefits of telemedicine in rural and remote locations (Mars & Maurice 2013; Bradford et al. 2016; Saleh et al. 2016). Telemedicine benefit patients as they improve access, but also professionals, as they increase contact with specialists and have better opportunities for professional development (Moffatt & Eley 2010).

- Van Der Heijden *et al.* in 2011 looked at 37.207 telemedicine consultations and concluded that 68% of referrals to the usual dermatology service were prevented. Primary Care physicians also stated that the programme had benefits on their continuous education. The reduction of costs of the programem was stimated to be of 18% (Van Der Heijden et al. 2011).
- According to Landow *et al.*, there were 4 factors that determined the capacity of a teledermatology service to improve access by reducing face-to-face consultations: an effective preselection of patients for teledermatology consultations, a high-quality photographic images, the use of dermatoscopy for pigmented lesions and to have in place an effective infrastructure and culture to implement teleconsultations (Landow et al. 2014).
- In 2014 Vidal-Alaball *et al.* demostrated that waiting times for the usual dermatology services could be reduced with teledermatology from a mean of 30 days before the implementation of teledermatology to a mean of 16 days after its implementation (Vidal-Alaball et al. 2014).
- In 2015, a two-phase pilot study comparing the time required to complete consultations with and without teledermatology suggested that teledermatology could improve access by reducing the time required by dermatologists to complete inpatient consultations (Sharma et al. 2015).
- A recently published pragmatic cluster-randomized controlled trial by Piette *et al.* compared the delay before care between primary care physicians using store-and-

forward teledermatology and primary care physicians addressing their patients with a standard referral letter. They showed that the teledermatology intervention significantly reduced the delay in obtaining a dermatologist's opinion and therefore allowed primary care physicians the beginning care much earlier (Piette et al. 2016).

7. User and professional acceptance of telemedicine

It has been published that telemedicine services enjoy a high acceptance among users (Whited et al. 2004).

- In the Eddy *et al.* review from 2001; authors reported high patient satisfaction with teledermatology. They also reported good satisfaction amongst physicians, although this satisfaction was higher in primary care doctors compared with dermatologists. 75% of primary care doctors also reported that teledermatology visits had an educational benefit (Eedy & Wootton 2001).
- In 2002, Weinstock *et al.* conducted a telephone survey on 100 patients who reported excellent/good satisfaction with a teledermatology program. They also surveyed providers of the service who even reported higher rates of satisfaction with the service (Weinstock et al. 2002)
- In 2004, McKoy *et al.* used questionnaires to asses acceptance to a teledermatology service and reported that 82% of users considered that it was a valid alternative to face to face appointments (McKoy et al. 2004).
- Klaz *et al*. in 2005 performed a multi-center prospective uncontrolled cohort study and reported that although patients and physicians using teledermatology had overall satisfaction with the service, this satisfaction was higher in rural settings than in urban settings (Klaz et al. 2005).
- Akesson *et al*. looked in a literature review at the health care consumers' experiences using Information Communication Technologies, including telemedicine, and

reported that consumers found these technologies acceptable and felt more empowered when using them (Åkesson et al. 2007).

- In 2009 Devine assessed user satisfaction of diabetic patients with the telemedicine services in a rural area of Australia using semi-structured face to face interviews. The results showed that patients and careers had a good acceptance and experience of the programme (Devine 2009).
- In 2013, McFarland *et al.* conducted a survey amongst imaging technicians and primary care providers including 55 participants. They reported 71% of primary care providers and 94% of imaging technicians being satisfied or extremely satisfied with a rural teledermatology project (McFarland et al. 2013).
- Also in 2013, Whited *et al.* conducted a randomized controlled trial that included 392 patients to compare quality of life of patients using teledermatology and using conventional dermatology clinics. They did not report any statistically significant difference between both groups (Whited, Warshaw, Edison, et al. 2013). Two years later, Whited conducted a review and also concluded that teledermatology interventions did result in improved quality of life, and more importantly, he stated that the changes correlated with improvements in disease severity and clinical course. However, he recommended more studies looking specifically at the effects of the telemedicine programmes on quality of life (Whited 2015).
- Another qualitative study using semi-structured interviews with 32 health professionals using telemedicine conducted in UK in 2014 by MacNeill *et al.* showed mixed views; while it was broadly welcomed by nursing staff, some primary care physicians were worried that telemedicine could increase their workload and potentially could undermine their professional autonomy (MacNeill et al. 2014). As stated by Blum and Gottlieb, clinician acceptance is the key factor for sustainable

telehealth services (Blum & Gottlieb 2014).

- In 2015, Livingstone and Solomon assessed satisfaction of 129 patients with a teledermatology service and concluded that the rate of satisfaction was high; 93% of patients found the teledermatology procedure to be comfortable or very comfortable Patients also stated that they would recommend the service to other patients (Livingstone & Solomon 2015).
- A recently published cross-sectional patient satisfaction survey that included 1.734 patients reported high satisfaction rates with their telehealth experience. 95% of patients were very satisfied with the quality of the health care they received (Polinski et al. 2016).
- Also in 2016, Dario *et al.* assessed patients's perceptions of a telemedicine service using the Service User Technology Acceptability Questionnaire. They enrolled a total of 2.118 patients with diabetes, chronic obstructive pulmonary disease, congestive heart failure and Cardiac Implantable Electronic Devices. They concluded that telemedicine showed a high level of acceptability amongs patients and was perceived as a viable addition to their usual care. This positive perception for telemedicine services extended over 12 months (Dario et al. 2016).
- Good professional acceptance has also been reported with teleulcer programmes. Kolltveit *et al*. in 2016 used focus groups to assess health professionals' experience with a telemedicine programme relating to diabetic foot ulcers. The programme improved wound assessment knowledge and skills and was well received by the professionals that felt that enabled them to approach their patients with diabetic foot ulcer with more knowledge (Kolltveit et al. 2016).
- It has also been reported that patients prefer to use telemedicine with their own doctor and felt it was important to have an established relationship with a provider

they were having a telemedicine visit with (Welch et al. 2017).

- Rajda *et al*. have recently reported patient satisfaction as high as 4.38/5, with high scores for confidence in care, ease of use and likelihood of future use (Rajda et al. 2017).
- A recent comprehensive systematic review published by Mounessa *et al.* reported that patients and providers were highly satisfied with the 2 types of telemedicine: store-and-forward and real time telemedicine (Mounessa et al. 2017).

8. Costs of telemedicine

Initially studies evaluating telemedicine studied efficacy, effectiveness and acceptance; however, in the last decade several studies have centred their efforts in studding the costs of telemedicine using different methods of health economics.

- In an exhaustive systematic review looking at several aspects of teledermatology, Warshaw *et al.* concluded that teledermatology was cost-effective if certain critical assumptions were met; the most important of which was patient travel distance (Warshaw et al. 2011).
- In 2015, Datta *et al.* conducted a study with 199 randomised participants referred to a store-and-forward teledermatology service. They compared the cost and utility of a referral to this service compared with a referral to a conventional service. They took into account society costs and concluded that compared with conventional referrals, store-and-forward teledermatology referrals were performed at comparable or even at lower costs if they took into account the societal perspective. (Datta et al. 2015).
- Also in 2015, Iannitti *et al.* conducted a literature review looking at telemedicine use in different medical specialities. They reported that telemedicine was an important cost-effective tool providing at least the same quality of medical care as face-to-face consultations in numerous medical fields (Iannitti et al. 2015).

- In 2016, Bashshur *et al.* published a literature review reporting the results of seven studies comparing costs of teledermatology in primary care with face-to-face consultations in dermatology clinics. The methods used in these articles included cost-effectiveness analysis, cost-benefit analysis, or some variant of cost-benefit analysis. They concluded that teledermatology in primary care is increasingly demonstrating to be cost-effective (Bashshur et al. 2016).

9. Limitations of telemedicine

In the last few years, some authors have questioned different aspects of telemedicine (Bergmo 2009; Bahaadinbeigy et al. 2010; Kahn 2015).

- Armfield and colleagues have argued that despite the fact that we have a large literature base on telemedicine, the evidence base for it is limited as very few of the thousands of articles relating to medicine, telehealth or telecare found on MEDLINE are incorporated into critically appraised summaries. However, they recognised that due to costs and practical issues, it is difficult to use randomised controlled trials for determining the effectiveness of telemedicine. They have also stated that clinicians are adopting telemedicine in a slowly and patchy manner. They recommend that studies looking at telemedicine programs should look at efficacy, effectiveness, economic aspects and health worker's preferences and that these aspects should be introduced when designing telemedicine programs (Armfield et al. 2014). The need to focus on patients' perspectives has also been stated (Ekeland et al. 2010).
- Furthermore, Mistry *et al.* published a systematic review of studies of the cost-effectiveness of telemedicine in 2012 and concluded that there was not conclusive evidence that telemedicine interventions were cost-effective compared to the usual care. However the authors also stated that this lack of evidence was result of investigators not using appropriate methods or not reporting them accurately (Mistry

2012). They repeated the study 2 years later concluding that reporting of cost-effectiveness had generally improved although there was still room for improvement (Mistry et al. 2014).

- In 2015, de la Torre-Díez *et al.* conducted a systematic review of cost-utility and cost-effectiveness research studies of telemedicine, electronic health and mobile health systems. They found few studies looking at cost-effectiveness and cost-utility in the literature. Some cost-effectiveness studies demonstrate that telemedicine could reduce costs, but not all of them (de la Torre-Díez et al. 2015).
- In 2015, Taylor et al. examined the use of telemedicine in community nursing. They stated that frontline staff acceptance of telemedicine in United Kingdom had been slow, fragile and fragmented. The reasons behind this were multiple including organisational, professional and technological difficulties (Taylor et al. 2015).
- In a study from 2005, Tandjung *et al.* raised concerns relating the avoidance of specialist care with teledermatology programs and the possible increase in missed skin cancers, specially melanomas (Tandjung et al. 2015).

10. Telemedicine in the Catalan central region

In the Catalan central region, three counties, Anoia, Bages and Berguedà, have developed several distinct telemedicine programs, which have had considerable success in reducing waiting lists while having wide acceptance among users. Among the different programs of telemedicine, the most successful has been teledermatology and the most innovative teleulcers and teleaudiometries. Teledermatology is a service that has been able to attend thousands of users swiftly and avoiding unnecessary trips to the hospital (Vidal-Alaball et al. 2014). Teleulcers, however, has not sought to attend a high number of patients but has strived for increasing the quality of care of people with chronic ulcers (Navarro et al. 2014).

Teledermatology was first introduced in the Catalan central region in the county of Anoia in 2007. Since them, this programme has evolved and has consolidated.

In summer 2010, a separate and distinct teledermatology pilot project was initiated in the city of Manresa (province of Barcelona). The waiting list in dermatology had been soaring in primary care due to the economic context of generalized cuts in healthcare spending and a quick and low cost solution was needed. Due to the immediate impact of the pilot project, teledermatology was expanded to all county of Bages in 2011 and to the county of Berguedà in 2012. In 2014 we published a study evaluating the impact of teledermatology in decreasing the waiting list in the Bages region during the period 2009-2012 and we found that due to teledermatology, the waiting times in the dermatology services decreased from a mean of 30 days (95% CI: 29-32) before the implementation of teledermatology to a mean of 16 days (95% CI: 15-17) after its implementation (Vidal-Alaball et al. 2014). Other studies have also reported that telemedicine services are useful in reducing waiting list (Caffery et al. 2016).

Inspired by the good results of the teledermatology programme, in November 2012 the Teleulcers programme was introduced in the counties of Bages and Berguedà. The project was aiming to improve the care of patient with chronic wounds or ulcers. With this programme, expert vascular advice is available for primary care nurses. Three main features define this service: its transversality, a virtual teleconsultation system and the nursing leadership in the care of patients with chronic wounds (Navarro et al. 2014).

All telemedicine programs work in the same way; the primary care physician or nurse take a photograph of the lesion or the injury and attaches it to the electronic medical records of the patient along with a clinical explanation of the injury. Using the electronic medical records guaranties the security of the images, as there is no need to send the images though e-mail or to store them using an electronic medium. The

specialists of the hospital access the electronic medical records, review the images and propose a treatment or action plan. The primary care physician or nurse review these instructions and makes a telephone call to the patient to explain the results of the consultation. All of this can usually be done in less than 5-7 working days. If the specialist of the hospital has any doubts, she or he can ask the primary care professional to refer the patient for a face-to-face visit.

The latest telemedicine service being introduced in 2013 in the counties of Bages and Berguedà was Teleaudiometries. This programme had some similarities with teledermatology and Teleulcers but no photographs are taken. In the programme the patients are referred to a Primary Care Centre when an audiometry is performed. This audiometry, together with some clinical information is scanned and inserted in the electronic medical records. The Otorhinolaryngology physician access the electronic medical records, review the audiometry and propose an action plan. The primary care physician reviews these instructions and makes a telephone call to the patient to explain the results of the consultation. This service is also used to periodically follow patients with hearing loss.

It has to be noticed that the teledermatology services in place in Anoia and Bages-Berguedà use a very different model of care. In Bages-Berguedà all the patients are referred first to the teledermatology service as this service is used as a triage tool to decide whether the patients can be treated in primary care or need to be referred to the face-to-face dermatology clinic. On the contrary, the model used in Anoia is the so-called "full dermatology model" where just the patients that have determinate characteristics that made them candidates to the teledermatology service use this service (British Association of Dermatology 2011). In the county of Anoia, patients are accurately selected before sending them to teledermatology as the main aim of the

service is to avoid the referral to the face-to-face dermatology clinic.

11. Sociodemographic context

In April 2015, the new county of **Moianés** was created (Generalitat de Catalunya 2015a). The new county included some of the municipalities of Bages (Calders, l'Estany, Moià, Monistrol de Calders and Santa Maria d'Oló), but also municipalities from other 2 counties; Osona and Vallès Oriental, the latest not being managed by the same regional health authority (Idescat. Statistical Institute of Catalonia 2017c).

For this research, we have used the municipalities of the county of Bages as it was in 2014.

The county of the **Bages** is located in the center of Catalonia, with a Population of 184,403 inhabitants (91,260 men and 93,143 women) and a surface area of 1,299.1 km^2. It has a low density of population with 141.9 inh./Km^2 compared to Catalonia (234,2 inh./Km^2) (Idescat. Statistical Institute of Catalonia 2014).

Figure 4: Location of county of Bages in Catalonia

The county of Bages has an age group population structure quite similar to the one in Catalonia (Idescat. Statistical Institute of Catalonia 2014). It has 16% of population from 0 to 14 years (15,6% in Catalonia), 64,9% from 15 to 14 years (65,9% in Catalonia), 15,9% of population from 65 to 84 years (15,5% in Catalonia) and 3,2% of the population from 85 years and over (3% in Catalonia).

Table 2: Population by age groups 2014:

From 0 to 14 years	29.556
From 15 to 64 years	119.611
From 65 to 84 years	29.279
From 85 years and over	5.957

The county of Bages has 72,8% of its population born in Catalonia, whereas this is just 64,8% for the rest of Catalonia. In this county, 15% of the population is born in the rest of Spain and 12,1% abroad. For Catalonia, this figures are quite different with 17,5% of the population born in Spain and 17,6% abroad.

Table 3: Population. By place of birth 2014:

Catalonia	134.265
Rest of Spain	27.752
Abroad	22.386

The county of Bages has less population with University education, with 15,4% of the population, compared with 20,3% in the rest of Catalonia.

Table 4: Population of 16 years and over. By level of education 2011:

No qualifications	16.011
Primary level	23.419
Secondary level	90.161
University education	23.642

The Bages has a clear tendency to population decline with a negative growth rate.

Table 5: Population growth. Crude rate per 1,000 inhabitants:

Crude Birth Rate. 2013	9,59
Crude Death Rate. 2011	8,83
Crude Rate of Natural Increase. 2013	0,46
Net Migration Rate. 2013	-8,02
Total Growth Rate. 2013	-7,56

The county of **Berguedà** has a Population of 39,178 inhabitants (19,460 men and 19,718 women) and a surface area of 1,185.2 km^2. It has an even lower density of population, with 33inh./Km^2 compared with Catalonia (234,2 inh./Km^2) (Idescat. Statistical Institute of Catalonia 2017b).

Figure 5: Location of county of Berguedà in Catalonia

The county of Berguedà has an age group population structure very different from the one in Catalonia, with a clear tendency to ageing (Idescat. Statistical Institute of Catalonia 2017b). It has 12,9% of population from 0 to 14 years (15,6% in Catalonia), 62,9% from 15 to 14 years (65,9% in Catalonia), 19,2% of population from 65 to 84 years (15,5% in Catalonia) and 5% of the population from 85 years and over (3% in Catalonia).

Table 6: Population by age groups 2016

From 0 to 14 years	5.068
From 15 to 64 years	24.661
From 65 to 84 years	7.509
From 85 years and over	1.940

The county of Berguedà has 80,3% of its population born in Catalonia, whereas this is much lower in Catalonia with just 64,8% of population born in Catalonia. In this county, 10,5% of the population is born in the rest of Spain and just 9,1% abroad. For

the rest of Catalonia, this figures are quite different with 17,5% of the population born in Spain and 17,6% abroad.

Table 7: Population. By place of birth 2016:

Catalonia	31.475
Rest of Spain	4.124
Abroad	3.579

The county of Berguedà has much less population with University education, with just 13,5% of the population, compared with 20,3% in the rest of Catalonia. Moreover, 11,3% of the population of 16 years and over has no qualifications, compared with just 10% in the rest of Catalonia.

Table 8: Population of 16 years and over. By level of education 2011:

No qualifications	3.939
Primary level	4.811
Secondary level	21.428
University education	4.693

With data from 2015, the county of Berguedà had an even more clear tendency to population decline than Bages with a negative growth rate of -8,23 (Idescat. Statistical Institute of Catalonia 2017b).

Table 9: Population growth. Crude rate per 1,000 inhabitants 2015:

Crude Birth Rate	7,49
Crude Death Rate	12,57
Crude Rate of Natural Increase	-5,08
Net Migration Rate	-3,14
Total Growth Rate	-8,23

CHAPTER 2

HYPOTHESIS AND OBJECTIVES

1. Hypothesis

The hypothesis of the study is that asynchronous telemedicine services in the Catalan central region is efficient from the economic point of view and enjoy acceptance among health professionals.

2. Main objectives

- To assess the economic impact of the telemedicine services in the Catalan central region comparing the cost of teledermatology with the costs of usual dermatology care.
- To assess the acceptance of the telemedicine services among health professionals of the Catalan central region using a validated questionnaire.

3. Secondary objectives

- To demonstrate that switching patients from the normal dermatology care to the telemedicine programmes in primary care in Catalonia on a generalized level could save Health Service resources.
- To study the pattern of referrals from primary care to the teledermatology service.
- To explore the utility of using social media (twitter polls) to assess acceptance of telemedicine.

METHODOLOGY

1. Theoretical frameworks

Several theoretical frameworks have been applied to telemedicine research. Wade and colleagues have described them recently, linking each theory with typical examples of associated research questions (Wade et al. 2017).

To answer the main objectives, we have formulated in our research we have used 2 different theoretical frameworks:

- Health economics to compare the cost of telemedicine with the costs of usual practice.
- A Technology acceptance model to assess the acceptance of the telemedicine programmes implemented in the Catalan Central region (Chau & Hu 2002; Davis 1989).

2. Design

In consonance with the two theoretical frameworks, the thesis has followed different methodological approaches:

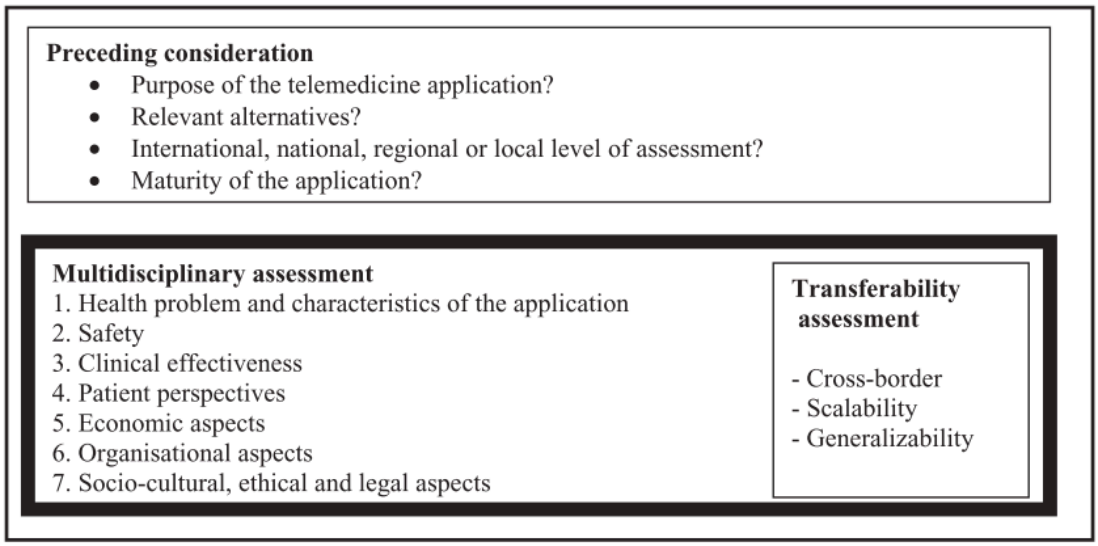
- Firstly, we have looked at the quantitative impact of the teledermatology service through an economic analysis comparing the teledermatology service with a conventional face-to-face dermatology service. We have estimated cost savings per patient visited in the teledermatology service and extrapolated to the whole Catalan territory
- To study the pattern of referrals from primary care to the teledermatology service, we have analysed the number of referrals to the conventional dermatology service after an initial referral to teledermatology and the number of visits saved due to the teledermatology program.

- We have measured the degree of satisfaction of health professionals with the telemedicine services using a questionnaire we have previously translated and validated.
- To assess acceptance of Telemedicine using social media, we have used twitter polls with previously used questionnaires.

3. Models of assessment of telemedicine

We could have applied some models for assessment of telemedicine already in use, the main one of which is MAST (Model for ASsessment of Telemedicine applications). MAST is a model developed in Europe through workshops with users and stakeholders of telemedicine that takes into consideration 3 elements: preceding considerations, a multidisciplinary assessment and a transferability assessment. The multidisciplinary assessment involves assessment of the outcomes divided into seven domains (Kidholm et al. 2010; Kidholm et al. 2012).

Figure 6: Elements in MAST



We have not strictly followed the MAST model but we have used some aspects of the multidisciplinary assessment: description of the health problem, clinical safety and effectiveness, socio-cultural aspects and a societal economic evaluation comparing

teledermatology with the alternatives in terms of costs. We have taken into consideration professional satisfaction and acceptance of the telemedicine programs in place in the Catalan central region but not the patient's perspectives. We have used some aspects of the transferability assessment to discuss the generalisability of the results.

4. Population

For the economic analysis, the population of reference has been all the population included in the 14 Primary Health Care Teams in the county of Bages. Of those 14 teams, 12 of them are managed by the Institut Català de la Salut and the other two by another health care provider: ALTHAIA Xarxa Assistencial Universitària de Manresa.

To assess the acceptance of the telemedicine services, the population of reference has been all professionals that potentially can use these services in the 17 Primary Health Care Teams in the counties of Bages and Berguedà.

5. Inclusion and exclusion criteria

There have not been any exclusion criteria. All population of the 14 Primary Health Care Teams of Bages that have had a teledermatology consultation had been included in the quantitative study.

All professionals that potentially can use telemedicine services in the 17 Primary Health Care Teams in the two counties of Bages and Berguedà, willing to participate have been included in the questionnaire.

6. Sample size

There has not been any sample calculation for the economic study, as we have taken into consideration all teledermatology consultations performed during 2016.

For the acceptance study, there was no need for sample calculation either as the questionnaire was send to all health care professionals of the 17 Primary Care Health Teams that potentially could use the telemedicine services.

7. Collection of data and sources of information

We just needed to collect quantitative data for the economic analysis and to calculate the pattern of referrals.

All quantitative data relating to patients has been obtained anonymized from the Institut Català de la Salut, the health provider of 12 of the Primary Health Care Teams of Bages included in the study. Data from the other two teams was obtained from the same source as they share the same electronic medical records and therefore the same database.

8. Literature Review

For the literature review, we used several sources of information:

- **Electronic databases**. For the electronic search, we used the following key words to identify relevant trials, studies and reviews relating to the topic: telemedicine, telehealth, teledermatology, teleconsultation, asynchronous, synchronous, teleulcers, e-Health, e-medicine, cost, cost effectiveness, cost-utilisation, and cost-minimisation, questionnaire. We scanned the following databases: Wiley Online Library, Scopus, MEDLINE/PubMed, EMBASE, Web of Science and BMJ Clinical Evidence.
- **Mendeley Library**. We used the weekly personalised suggestions for articles based on the PhD student's Mendeley library.
- **Handsearching**. We searched the bibliographies of all relevant papers selected with this strategy.
- **Websites**. we searched www.scholar.google.com

9. Limitations of the study

Any economic analysis requires assumptions about the cost of the resources used. These assumptions lead to a degree of uncertainty. However, when as in this case, the economic evaluation is not parallel to a clinical trial, statistical methods may be difficult to use and when used, may not be able to totally remove uncertainty. In these cases, it is advised to perform a sensitivity analysis to see how much the results of the economic analysis could change if we modify the assumptions we have made.

10. Ethical approval

This study protocol has been already approved by the Catalan Institute in Primary Care Research (IDIAP Jordi Gol) Health Care Ethics Committee on the 10/06/2016. Code P16/046 (see attached letter).

To ensure confidentiality, all data has been collected and processed anonymized at all times. Data extraction has been conducted from databases available to the Technical and Support Area of Gerència Territorial de la Catalunya Central (Institut Català de la Salut) and never by directly accessing the medical records of patients. We have signed a declaration of good practices in using health information data and a document agreeing to guarantee the confidentiality of the data provided for this thesis.

The ethical principles of the Helsinki Declaration of 1964 as revised by the World Health Organization in 2000 in Edinburgh have always been followed. The standards of the Spanish Organic Law 15/1999 of data protection have been met.

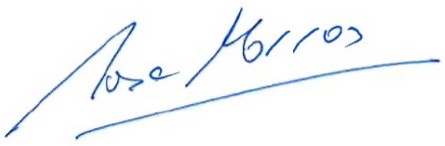
INFORME DEL COMITÈ ÈTIC D'INVESTIGACIÓ CLÍNICA

Rosa Morros Pedrós, Presidenta del Comitè Ètic d'Investigació Clínica de l'IDIAP Jordi Gol.

CERTIFICA:

Que aquest Comitè en la reunió del dia 25/05/2016, ha avaluat el projecte ***Evaluating the impact of telemedicine in the catalonian central region*** amb el codi **P16/046** presentat per l'investigador/a **Josep Vidal Alaball.**

Considera que respecta els requisits ètics de confidencialitat i de bona pràctica clínica vigents.



Barcelona, a 10/06/2016

CHAPTER 3

ECONOMIC IMPACT OF THE ASYNCHRONOUS TELEDERMATOLOGY SERVICE IN THE CATALAN CENTRAL REGION

1. Objectives

The primary objective of this study is to look at the quantitative impact of the asynchronous (not real-time) teledermatology service through an economic analysis comparing the teledermatology service with a conventional dermatology service in the county of Bages. The economic analysis has been performed by measuring the direct and indirect cost of both strategies.

We used a combination of one-way sensitivity analysis and the extreme scenario analysis to test the robustness of the results. We analysed the variable we thought had the biggest impact in the study generating the best and worst scenario.

Another objective of the study was to estimate the cost savings per patient visited with the teledermatology service and to extrapolate these savings to the whole Catalan territory.

Finally, we studied the pattern of referrals from primary care teams to the teledermatology service, comparing rural and urban primary care teams.

2. Methods

We used methods of health economic analysis to identify measure and value the resources used with the usual dermatology services and we looked at how those resources vary when the asynchronous teledermatology was used instead.

Because we have robust evidence that the effectiveness of both usual dermatology and asynchronous teledermatology services is the same and they provide equivalent care, we performed a **cost minimisation analysis** (CMA). A CMA (or cost saving analysis) is a type of economic evaluation that compares the cost of alternative interventions that have equal effects. This type of study is useful when you want to establish the least costly way to deliver a determinate health care service (Bergmo 2015). We have estimated cost savings per patient visited at the teledermatology service and have extrapolated them to the whole Catalan territory.

Several studies have demonstrated that asynchronous teledermatology is as effective as conventional dermatology. Of all studies looking at the efficacy and effectiveness of the different telemedicine services, the largest number of studies came from teledermatology (Whited, Warshaw, Kapur, et al. 2013; Livingstone & Solomon 2015; Snoswell et al. 2016). The most assessed aspect of teledermatology was the interobserver concordance (Lane & Chance 2008; Taberner Ferrer et al. 2009).

To study the pattern of referrals from primary care to the teledermatology service, we have analysed the number of referrals to the conventional dermatology service after an initial referral to teledermatology and have established the number of visits saved.

2.1 Number of visits

We obtained data relating to the number of visits to the dermatology and teledermatology services from 01/01/2015 until different dates in 2017. As we just had data from the full year 2015 and 2016, we just analysed these two years. For the

economic analysis, we decided to use data from year 2016 as economic analyses usually study one natural year.

For this study, we had data relating to number of conventional dermatology visits, teledermatology visits and the number of conventional visits after an initial teledermatology consultation. We had data from the different primary care centres of the 14 primary care teams in the county of Bages.

2.1.1 Number of visits saved

To calculate the number of conventional dermatology visits saved by the teledermatology service, we subtracted the number of conventional visits to the dermatology service within the following 3 months of an initial teledermatology consultation from the total number of teledermatology consultations.

We considered that any referral to the dermatology service within the following 3 months after an initial referral to teledermatology had relation with the initial referral and therefore those teledermatology referrals required a posterior face-to-face visit.

2.2 Identification of costs of resources

There are costs directly attributable to the teledermatology service and costs attributable to the conventional dermatology service. They include equipment and technology costs, such as the costs of the cameras and hardware, and staff costs. There are also costs not directly determinable to the teledermatology and conventional dermatology services. They include the costs of building maintenance, IT services, gas-electricity, telephone-internet connexions and medical insurance. Those costs also take into consideration the patients' experience. Other costs are more difficult to evaluate, such the costs of the productivity lost incurred by the patient and the society; this includes time lost from work and lost salaries, loss of leisure time and time lost in travelling to the visits.

Direct costs:

- Cameras
- Hardware, software
- Staff: primary care physicians, dermatologists

Indirect costs:

- Building maintenance
- IT services
- Gas-electricity
- Internet connexions
- Medical insurance
- Lost productive time
- Loss of leisure time
- Time lost in travelling
- Petrol costs

2.2.1 Equipment costs

When the program was started, the practices used the digital cameras they already had as part of the equipment of the centre. Now, some practices have acquired iPads, which give a better quality of image with increased resolution. For this study, we assumed that the 14 practices in Bages have an iPad. We used the cost of iPads in 2007, which for an iPad Air Wi-Fi + Cellular 32GB was at that moment 559€ (Apple Inc. 2017).

2.2.2 Technical costs

There is no significant added cost for technical support such as computer maintenance, hardware, software, and communication networks (including internet) as these services are already provided in the primary care practices and in the hospital.

2.2.3 Staff costs

To calculate the costs of an hour's work of a primary care physician, we used the basic salary paid by the Institut Català de la Salut, the main provider of primary care services in Catalonia. The gross basic salary varies according to some variables such as number of patients, seniority assigned or rurality. We have taken the mean of the higher and lower salaries which gave us an annual salary of 37.982€ a year in 2015. According to this salary, and taking into consideration that a primary care physician works 1.642 hours a year, the estimated cost of an hours of this professional was established at 23,1€ (Institut Català de la Salut 2015).

To calculate the costs of an hour's work of a dermatologist, we used the basic salary agreed in the Collective Work Agreement used by the majority of hospitals in Catalonia. The gross basic salary varies according to some variables such as seniority, so we have taken the mean of the higher and lower salaries which has given us an annual salary of 34.574,38€ a year in 2015. According to this salary and taking into consideration that a dermatologist works 1.688 hours a year, the estimated cost of an hours of this professional was established at 20,5€ (Generalitat de Catalunya 2015b).

It has to be noted that the primary care physician cost of an hour of work is slightly higher than the cost of an hour of a dermatologist (23,1€ compared to 20,5€), this is due to the fact that primary care physicians in the area are employed by the Institut Català de la Salut, which is a public company and therefore they are civil servants. On the other hand, the dermatologists of the area are employed by ALTHAIA Xarxa Assistencial Universitària de Manresa, which is a private foundation that has slightly lower salaries for their employees.

2.2.4 Structural costs

There is no significant added cost for structural support such as building maintenance and gas-electricity, as they are already included in the primary care practices and in the hospital for their normal day-to-day use.

2.2.5 Medical insurance

There is no significant added cost for medical insurance as doctors working in primary care and dermatologists in the hospital are already insured and covered by their usual day-to-day medical indemnity insurance.

2.2.6 Society costs

The costs for the society are always difficult to evaluate in economic analysis; they include time lost from work, cost of lost leisure time and time lost in travelling to the visits. They also include time lost by people accompanying patients to the visits.

2.2.6.1 Productivity costs

To calculate the costs of an hour of work we have used the labour cost by effective hour by activity sectors. The average total cost by hour, that includes salary costs and taxes-insurance, in the industry sector was 24,6€, in the constructions sector 19,8€ and in the services sector 20,5€. We have used the overall total cost of an hour of work in all services which was established at 21,2€ in the last quarter on 2015 (Idescat. Statistical Institute of Catalonia 2015).

2.2.6.2 Costs of travelling

2.2.6.2.1 Productivity loss

To calculate the time lost in travelling to the hospital located in Manresa, we used Google maps to calculate the travelling time by car from the village or town where the patient lives to the Hospital located in Manresa, using the shortest time possible. For Manresa, as it is a big city, we used as address for the patients, the address of their

Primary Care Centre. The name of the hospital in Manresa is Hospital Sant Joan de Déu (ALTHAIA Xarxa Assistencial Universitària de Manresa) and we used the following address: C/ Dr. Joan Soler, s/n, 08243 Manresa, Barcelona.

We used the time lost in travelling to the hospital and the costs of an hour of work to calculate the costs in terms of loss of work. We added an average of 25 minutes to take into account the time spent in the consultation with the dermatologists, which, according to Dr Dolors Vila, consultant dermatologists, is on average 15 minutes for first visits in the local hospital (Vila 2017), and also to take into account the waiting time before entering into this consultation.

To calculate the time lost in travelling to the primary care centre to take a photograph to send to the hospital, we considered that the majority of patients live in the same town or city where the consultation is done and therefore we did not add any travelling time.

We added an average of 20 minutes to take into account the time of the consultations with the general practitioner, which although some studies have reported is on average 7,8 minutes (Deveugele et al. 2002), according to our own experience, in the area is on average 10 minutes. We also took into account the waiting time before entering into this consultation. We assumed that the time of consultation is shorter in primary care compared with hospitals as this is what is happening at this moment in the area.

As the consultations in hospital and in primary care are mostly done during working hours, we considered that the time lost occur mainly during working hours.

2.2.6.2.2 Travel costs

To calculate the costs of the petrol needed to travel to the hospital, we have used the average of the price of mileage paid by companies to their workers in Spain in 2015. This price ranges from a minimum of 0,07€ to a maximum of 0,75€, the average was established on 0,25€ (Captio 2015).

We have used Google maps to calculate the mileage by car from where the patient lives to the Hospital in Manresa.

As in the county of Bages, some towns and villages do not have a regular public transport service, we assumed that all journeys that patients did from their home to the hospital were done by private car.

2.2.7 Carbon emission costs

It is known that healthcare systems have been contributing to global warming by consuming energy and generating waste. Another of the advantages of the telemedicine services is that as it saves travel to hospital, it also saves emissions from the combustion of fossil fuels and therefore carbon emissions (Ellis et al. 2013). We have excluded these environmental costs from our calculations, as these costs are complex to quantify as they depend on several factors such as the type of transport or type of vehicle used.

2.3 Resources excluded

Although friends and relatives of the patient that uses the service are often affected by the patient's disease, there are few guidelines for how to include relatives' effects (Davidson 2009). We have excluded the cost of friends and relatives, as with the data we obtained it was impossible to know whether the patients went to the consultations by their own or accompanied. We could have assumed that patients of a certain age, for example above 70 years or below 18 years, would go to visit the dermatologist accompanied, but as we had anonymized data, we did not know the age of the patients using the teledermatology service.

We have excluded the costs of leisure time lost as it impossible to differentiate whether the time lost occurs during working hours or leisure hours and we considered that consultations in hospital and in primary care are mostly done during working hours.

We have also excluded structural costs, technical costs and medical insurance costs as they are already included in the practices and in the hospital for their normal day-to-day use. We have calculated that Teledermatology services in the hospital represents just 1,4% of the total activity of the hospital (ALTHAIA Xarxa Assistencial Universitària de Manresa 2016).

Training costs were excluded as no extra training was provided to family care physicians and dermatologist taking part in the programme. It has to be mentioned that some telemedicine programs include specific training in clinical photography and the use of the specific telemedicine system (Van Der Heijden et al. 2011; Zarchi et al. 2015) as these costs can be important and adequate training can improve the overall quality of referrals (McKoy et al. 2004; Mahendran et al. 2005; McFarland et al. 2013).

Table 10. Costs excluded and reason for exclusion

Costs	**Reason for exclusion**
Technical costs	No significant added costs [(a)]. Part of overall costs
Building maintenance	No significant added costs [(a)]. Part of overall costs of building
Electricity, heating	No significant added costs [(a)]. Part of overall costs of building
Medical insurance	No significant added costs [(a)]. Doctors already insured
Telephone calls	No significant added costs
Training costs	No significant added costs
Relatives time	Very difficult to quantify though secondary data
Leisure time	Very difficult to quantify though secondary data
Carbon emission	Very difficult to quantify though secondary data

[(a)] Teledermatology represents just 1,4% of the total activity of the hospital.

2.4 Sensitivity analysis

When, as it happens in this study, the economic evaluation is not parallel to a clinical trial, statistical methods may be difficult to use and when used, may not be able to totally remove uncertainty. In these cases, it is advised to use sensitivity analysis to see

how much the results of the economic analysis could change if we modify the assumptions we have made in the study.

2.4.1 Types of sensitivity analysis

Some authors have distinguish three types of sensitivity analysis (Briggs & Gray 1999; Briggs 1999).

- **Univariate/One-way analysis**. This technique consists in analysing the impact that each variable has in the study by holding one variable constant and varying the other variables.
- **Extreme scenario analysis**. This technique consists in generating a best or worst case scenario taking the most optimistic or pessimistic values of the different variables being analysed.
- **Probabilistic sensitivity analysis**. Briggs says that this approach may produce a more realistic approach to uncertainty (Briggs & Gray 1999; Briggs 1999). The technique consists in allowing each different variable to vary simultaneously and analysing the effects that this has on the results of the economic evaluation.

For this study, as the PhD student did in a previous economic analysis performed in 2006 (Vidal-Alaball et al. 2006), we have used a combination of one-way sensitivity analysis and the extreme scenario analysis to test the robustness of the results. We analysed the variable we thought had the biggest impact in the study generating the best and worst scenario. We decided not to use probabilistic sensitivity analysis because it was too complex given the context of this study.

2.5 Discounting costs

Discount rates are used when you want to reflect the fact that costs and benefits are valued more now than if they incurred in the future. Discounting allows us to convert costs and benefits in future time periods into present values (Harrison 2010).

In this study, we have excluded the discounting costs, as they do not change the outcome of our analysis. The only items that could incur in discounting costs were the iPads and we took into account an amortisation time over 5 years, as we considered that after a 5 year period the iPads would need to be replaced.

3. Results

3.1 General data description

3.1.1 Dermatology referrals

During 2015 and 2016, 45 different health centres belonging to the 14 different Primary Health Care Teams in the county of Bages made referrals to the conventional dermatology service.

In 2015, a total of 2.380 patients were referred to conventional dermatology visits. During 2016, these referrals decreased to 2.168, this was a decrease of 212 referrals (8,9%).

Table 11: Referrals to Dermatology from primary care centres

Primary Care Centre	2015	2016
CAP BALSARENY	9	12
CAP BARRI ANTIC	160	109
CAP CALLÚS	26	10
CAP CARDONA	39	26
CAP CASTELLBELL I EL VILAR	30	22
CAP CASTELLGALÍ	33	25
CAP CASTELLTERÇOL	18	15
CAP GORETTI BADIA	70	53
CAP II BAGES	3	0
CAP LES BASES	602	582
CAP MANRESA 2	273	288
CAP MOIA	36	30
CAP MONISTROL DE MONTSERRAT	22	7
CAP NAVARCLES	35	45
CAP NAVAS	61	53
CAP PONT DE VILOMARA	36	26
CAP SAGRADA FAMILIA	282	248

CAP SALLENT	59	66
CAP SANT FRUITÓS	65	65
CAP SANT JOAN DE VILATORRADA	118	132
CAP SANT VICENÇ DE CASTELLET	100	109
CAP SANTPEDOR	88	81
CAP VACARISSES	21	25
CAP VALLS-PALÀ	7	3
CONSULTORI AGUILAR DE SEGARRA	5	2
CONSULTORI ARTES	51	38
CONSULTORI AVINYÓ	23	20
CONSULTORI CALDERS	13	8
CONSULTORI DE CANET DE FALS	3	2
CONSULTORI DE CASTELLCIR	4	3
CONSULTORI DE LA COROMINA	2	2
CONSULTORI DE L'ESTANY	2	1
CONSULTORI FALS	4	2
CONSULTORI FONOLLOSA	8	7
CONSULTORI MONISTROL DE CALDERS	3	3
CONSULTORI MONTMAJOR	2	1
CONSULTORI MURA	1	1
CONSULTORI RAJADELL	1	1
CONSULTORI RELLINARS	3	0
CONSULTORI SANT FELIU SASSERRA	4	0
CONSULTORI SANTA MARIA D'OLÓ	8	5
CONSULTORI ST. SALVADOR DE GUARDIOLA	40	28
PAD BAGES	6	8
PAD NAVÀS	2	0
RAE CAP II BAGES	2	4
Total general	**2380**	**2168**

Additional information relating to patients referred to the teleulcers and teleaudiometries services can be found at Appendix I, II and III.

3.1.2 Teledermatology referrals

During 2015 and 2016, 42 different health centres belonging to the 14 different Primary Health Care Teams in the county of Bages made referrals to the teledermatology service.

In 2015, a total of 5.303 patients were referred to the teledermatology service. During 2016, these referrals increased to 5.606, this was an increase of 303 referrals (5,71%).

Table 12: Referrals to Teledermatology from primary care centres

Primary Care Centre	2015	2016
CAP BALSARENY	32	41
CAP BARRI ANTIC	4	6
CAP CALLÚS	54	57
CAP CARDONA	113	133
CAP CASTELLBELL I EL VILAR	119	122
CAP CASTELLGALÍ	124	132
CAP CASTELLTERÇOL	103	99
CAP GORETTI BADIA	227	205
CAP LES BASES	3	2
CAP MANRESA 2	899	1067
CAP MOIA	128	132
CAP MONISTROL DE MONTSERRAT	66	59
CAP NAVARCLES	171	140
CAP NAVAS	181	212
CAP PONT DE VILOMARA	106	86
CAP SAGRADA FAMILIA	827	828
CAP SALLENT	329	376
CAP SANT FRUITÓS	333	294
CAP SANT JOAN DE VILATORRADA	390	494

CAP SANT VICENÇ DE CASTELLET	281	345
CAP SANTPEDOR	297	286
CAP VACARISSES	92	140
CAP VALLS-PALÀ	17	18
CONSULTORI AGUILAR DE SEGARRA	3	1
CONSULTORI ARTES	155	175
CONSULTORI AVINYÓ	55	77
CONSULTORI CALDERS	44	4
CONSULTORI DE CANET DE FALS	17	12
CONSULTORI DE CASTELLCIR	6	2
CONSULTORI DE LA COROMINA	10	9
CONSULTORI DE L'ESTANY	4	2
CONSULTORI FALS	12	3
CONSULTORI FONOLLOSA	9	7
CONSULTORI MONISTROL DE CALDERS	26	4
CONSULTORI MONTMAJOR	2	2
CONSULTORI RAJADELL	9	1
CONSULTORI RELLINARS	8	7
CONSULTORI SANT FELIU SASSERRA	15	11
CONSULTORI SANTA MARIA D'OLÓ	11	13
CONSULTORI ST. SALVADOR DE GUARDIOLA	19	1
CONSULTORI ST.QUIRZE SAFAJA	1	
RAE CAP II BAGES	1	1
Total general	**5303**	**5606**

3.1.3 Teledermatology referrals per 1.000 habitants

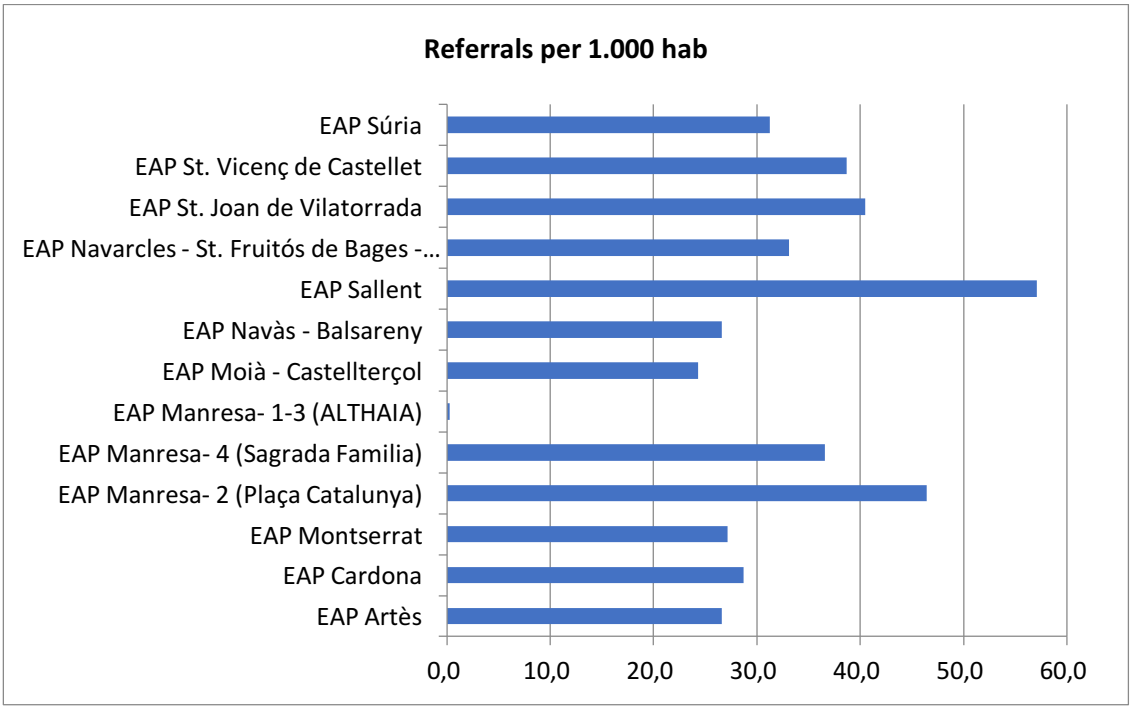
To know the teams that referred the most to teledermatology we analysed referrals to the service per 1.000 habitants. We used the assigned total population (population covered by a primary care team) to the 14 different primary care teams in Bages during

2016. Data from the two primary care teams managed by ALTHAIA, Xarxa Assistencial Universitària de Manresa, were analysed together.

The average referrals per 1.000 habitants for the 14 primary care teams was 28,9. The primary care team that had more referrals to teledermatology during 2016 was Sallent with 57,1 referrals per 1.000 habitants. The primary care teams that referred less were the ones managed by ALTHAIA. We think this could be due to the fact that the teledermatology program has not been fully deployed in these centres. The following team with less referrals to teledermatology is Moià-Castellterçol with 24,3 referrals per 1.000 habitants.

Table 13: Teledermatology referrals per 1.000 habitants by primary care centres

Primary Care Team	Assigned population	Teledermatology referrals	Referrals/1000 Hab.
EAP Artès	10.682	284	26,6
EAP Cardona	5.019	144	28,7
EAP Montserrat	12.066	328	27,2
EAP Manresa- 2 (Plaça Catalunya)	22.992	1.068	46,5
EAP Manresa- 4 (Sagrada Familia)	22.622	828	36,6
EAP Manresa- 1-3 (ALTHAIA)	36.768	9	0,2
EAP Moià - Castellterçol	9.670	235	24,3
EAP Navàs - Balsareny	9.508	253	26,6
EAP Sallent	6.589	376	57,1
EAP Navarcles - St. Fruitós de Bages - Santpedor	21.760	720	33,1
EAP St. Joan de Vilatorrada	12.720	515	40,5
EAP St. Vicenç de Castellet	14.545	563	38,7
EAP Súria	8.956	280	31,3
TOTAL Bages	**193.897**	**5.603**	**28,9**



3.1.4 Dermatology referrals after teledermatology

We have analysed the number of referrals to the conventional dermatology service after an initial referral to teledermatology (within the following 3 months). During 2015, 1.375 referrals were made after initial teledermatology consultation, in 2016; this number was reduced to 1.104 referrals. This was a reduction of 271 referrals (19,71%).

Table 14: Referrals to Dermatology after teledermatology by primary care centre

Primary Care Centre	2015	2016
CAP BALSARENY	6	8
CAP BARRI ANTIC	2	
CAP CALLÚS	21	8
CAP CARDONA	34	21
CAP CASTELLBELL I EL VILAR	22	20
CAP CASTELLGALÍ	35	21
CAP CASTELLTERÇOL	19	17
CAP GORETTI BADIA	65	46
CAP LES BASES	3	
CAP MANRESA 2	216	227

CAP MOIA	40	24
CAP MONISTROL DE MONTSERRAT	16	1
CAP NAVARCLES	42	38
CAP NAVAS	48	39
CAP PONT DE VILOMARA	30	13
CAP SAGRADA FAMILIA	214	178
CAP SALLENT	54	53
CAP SANT FRUITÓS	99	64
CAP SANT JOAN DE VILATORRADA	96	105
CAP SANT VICENÇ DE CASTELLET	81	69
CAP SANTPEDOR	69	59
CAP VACARISSES	20	24
CAP VALLS-PALÀ	9	3
CONSULTORI AGUILAR DE SEGARRA	1	
CONSULTORI ARTES	48	39
CONSULTORI AVINYÓ	15	19
CONSULTORI CALDERS	12	
CONSULTORI DE CANET DE FALS	13	1
CONSULTORI DE CASTELLCIR	3	
CONSULTORI DE LA COROMINA	1	1
CONSULTORI DE L'ESTANY	1	
CONSULTORI FALS	3	1
CONSULTORI FONOLLOSA	5	
CONSULTORI MONISTROL DE CALDERS	6	
CONSULTORI MONTMAJOR	2	
CONSULTORI RAJADELL	4	1
CONSULTORI RELLINARS	3	2
CONSULTORI SANT FELIU SASSERRA	4	
CONSULTORI SANTA MARIA D'OLÓ	5	2
CONSULTORI ST. SALVADOR DE GUARDIOLA	8	
Total general	**1375**	**1104**

3.1.5 Number of conventional visits saved

During 2016, 5.606 patients were referred to the teledermatology service, of those referrals; just 1.104 patients were referred to the conventional dermatology service within the following 3 months. Therefore, 4.502 visits were potentially saved by the teledermatology service, as they did not need referral to conventional services thereafter. This is an overall referral rate of 19,69%.

Some centres had very low or very high referral rates to dermatology after an initial teledermatology consultation. However, these were usually small centres with very few referrals per year. Excluding these small centres, the centre with the lowest referral rate was Monistrol de Montserrat with 1,69% and the centre with the highest referral rate was Navarcles with 27,14% of referrals to dermatology after an initial teledermatology consultation.

Table 15: Dermatology visits saved by primary care centre

Primary Care Centre	TeleDM	Referrals	Saved visits	%referral
CAP BALSARENY	41	8	33	19,51
CAP BARRI ANTIC	6	0	6	0,00
CAP CALLÚS	57	8	49	14,04
CAP CARDONA	133	21	112	15,79
CAP CASTELLBELL I EL VILAR	122	20	102	16,39
CAP CASTELLGALÍ	132	21	111	15,91
CAP CASTELLTERÇOL	99	17	82	17,17
CAP GORETTI BADIA	205	46	159	22,44
CAP LES BASES	2	0	2	0,00
CAP MANRESA 2	1067	227	840	21,27
CAP MOIA	132	24	108	18,18
CAP MONISTROL DE MONTSERRAT	59	1	58	1,69
CAP NAVARCLES	140	38	102	27,14

CAP NAVAS	212	39	173	18,40
CAP PONT DE VILOMARA	86	13	73	15,12
CAP SAGRADA FAMILIA	828	178	650	21,50
CAP SALLENT	376	53	323	14,10
CAP SANT FRUITÓS	294	64	230	21,77
CAP SANT JOAN DE VILATORRADA	494	105	389	21,26
CAP SANT VICENÇ DE CASTELLET	345	69	276	20,00
CAP SANTPEDOR	286	59	227	20,63
CAP VACARISSES	140	24	116	17,14
CAP VALLS-PALÀ	18	3	15	16,67
CONSULTORI AGUILAR DE SEGARRA	1	0	1	0,00
CONSULTORI ARTES	175	39	136	22,29
CONSULTORI AVINYÓ	77	19	58	24,68
CONSULTORI CALDERS	4	0	4	0,00
CONSULTORI DE CANET DE FALS	12	1	11	8,33
CONSULTORI DE CASTELLCIR	2	0	2	0,00
CONSULTORI DE LA COROMINA	9	1	8	11,11
CONSULTORI DE L'ESTANY	2	0	2	0,00
CONSULTORI FALS	3	1	2	33,33
CONSULTORI FONOLLOSA	7	0	7	0,00
CONSULTORI MONISTROL DE CALDERS	4	0	4	0,00
CONSULTORI MONTMAJOR	2	0	2	0,00
CONSULTORI RAJADELL	1	1	0	100,00
CONSULTORI RELLINARS	7	2	5	28,57
CONSULTORI SANT FELIU SASSERRA	11	0	11	0,00
CONSULTORI SANTA MARIA D'OLÓ	13	2	11	15,38
CONSULTORI ST. SALVADOR DE GUARDIOLA	1	0	1	0,00
RAE CAP II BAGES	1	0	1	0,00
Total general	**5606**	**1104**	**4502**	**19,69**

A more detailed analysis of the referrals with a comparison between urban and rural primary care teams is attached in next section.

3.2 Equipment costs

Assuming that each of the 14 practices in the county of Bages had an iPad Air Wi-Fi + Cellular 32GB at a cost of 559€, the costs of this equipment would be 7.826€ (559€ x 14 = 7.826€). This was an initial cost as this equipment is expected to last for about 5 years. Taking into account this obsolescence, the annual costs of this equipment would be **1.565€**.

3.3 Personnel costs

3.3.1 Primary care physicians

During 2016 a total of 4.502 visits were potentially saved by the teledermatology service. Assuming than a teledermatology primary care appointment needs an initial 10 minute consultation by a primary care physician, this means than a total of 45.020 minutes (750,3 hours) were spent in teledermatology related appointments. As the estimated cost of an hour of this professional was 23,1€, this means that the costs of this time spent in primary care was **17.332€** a year.

Table 16: Primary care physicians cost

N. Visits	Consultations		Cost
	mins	hours	€
4502	45020	750,3	17332

After the initial consultation and the dermatologist reply, the primary care physician contacts the patient by phone to explain which the following course of action is. This telephone contact we have estimated would last an average of 2 minutes. This means than during 2016, a total of 9.004 minutes (150,1 hours) were spent in teledermatology

related telephone calls. As the estimated cost of an hour of this professional was 23,1€, this means that the costs of this time spent was **3.467€** a year.

Table 17: Primary care physicians cost (2)

N. Visits	Consultations		Cost
	mins	hours	€
4502	9004	150,1	3467

Therefore, the total costs of the time spend by primary care physicians was 17.332 + 3.467 = **20.799€** a year.

It has to be noted that with conventional dermatology, an initial visit with the primary care physician is also needed, therefore with teledermatology, the only extra time spent by primary care physicians is the time needed to make the telephone call to explain the results to the patient.

3.3.2 Dermatologists

During 2016, 4.502 visits were potentially saved by the teledermatology service. Assuming than a conventional dermatology appointment needs a 15 minute consultation by a dermatologist, this means than a total of 67.530 minutes (1.125.5 hours) would have been spent in conventional dermatology appointments during 2016 if the teledermatology service would have not been in place. As the estimated cost of an hours of this professional was 20,5€, this means that the costs of this time spent would have been **23.073€** a year.

Table 18: Dermatologist cost with conventional visits

N. Visits	Consultations		Cost
	mins	hours	€
4502	67530	1125,5	23073

As a teledermatology appointment needs a 5 minutes consultation by a dermatologist, this means than a total of 22.510 minutes (375,2 hours) were spent in teledermatology related appointments. As the estimated cost of an hours of this professional was 20,5€, this means that the costs of this time spent was **7.691€** a year.

Table 19: Dermatologist cost with teledermatology

N. Visits	Consultations		Cost
	mins	hours	€
4502	22510	375,2	7691

3.4 Society costs

3.4.1 Cost of time lost from work

We calculated the time patients would have lost in travelling to the hospital to visit the dermatologist from each of the primary care centres if the teledermatology service would have not been in place, adding 25 minutes to allow for the time needed for the visit and the waiting time associated with any visit. During 2016, a total of 2.840 hours would have been spent on this concept if the patients had attended a visit at the local hospital instead of using the teledermatology service. As we have calculated that the average total cost of an hour of work in all services was 21,2€, this gave a total cost of the time lost from work of **60.208€** during 2016.

We have calculated the time lost in travelling to the primary care centre to take a photograph to send to the hospital, adding 20 minutes to allow for the time needed for the visit and the waiting time. During 2016, a total of 1.500,7 hours were spent on this concept. As the average total cost of an hour of work in all services is 21,2€ this gave a total cost of the time lost from work of **31.814€** during 2016.

Table 20: Cost of time lost by primary care centre

Primary Care Centre	Time adding consultation in hospital (25 mins)	Total time with consultation to hospital		Time spent in Primary care	
		Minutes	Hours	(20 mins)	hours
CAP BALSARENY	41	1353	22,6	660	11,0
CAP BARRI ANTIC	30	180	3,0	120	2,0
CAP CALLÚS	38	1862	31,0	980	16,3
CAP CARDONA	55	6160	102,7	2240	37,3
CAP CASTELLBELL I EL VILAR	46	4692	78,2	2040	34,0
CAP CASTELLGALÍ	35	3885	64,8	2220	37,0
CAP CASTELLTERÇOL	64	5248	87,5	1640	27,3
CAP GORETTI BADIA	44	6996	116,6	3180	53,0
CAP LES BASES	31	62	1,0	40	0,7
CAP MANRESA 2	34	28560	476,0	16800	280,0
CAP MOIA	56	6048	100,8	2160	36,0
CAP MONISTROL DE MONTSERRAT	44	2552	42,5	1160	19,3
CAP NAVARCLES	38	3876	64,6	2040	34,0
CAP NAVAS	45	7785	129,8	3460	57,7
CAP PONT DE VILOMARA	34	2482	41,4	1460	24,3
CAP SAGRADA FAMILIA	28	18200	303,3	13000	216,7
CAP SALLENT	40	12920	215,3	6460	107,7
CAP SANT FRUITÓS	32	7360	122,7	4600	76,7
CAP SANT JOAN DE VILATORRADA	36	14004	233,4	7780	129,7
CAP SANT VICENÇ DE CASTELLET	37	10212	170,2	5520	92,0
CAP SANTPEDOR	36	8172	136,2	4540	75,7
CAP VACARISSES	45	5220	87,0	2320	38,7
CAP VALLS-PALÀ	46	690	11,5	300	5,0
CONSULTORI AGUILAR DE SEGARRA	46	46	0,8	20	0,3

CONSULTORI ARTES	42	5712	95,2	2720	45,3
CONSULTORI AVINYÓ	44	2552	42,5	1160	19,3
CONSULTORI CALDERS	46	184	3,1	80	1,3
CONSULTORI DE CANET DE FALS	42	462	7,7	220	3,7
CONSULTORI DE CASTELLCIR	66	132	2,2	40	0,7
CONSULTORI DE LA COROMINA	53	424	7,1	160	2,7
CONSULTORI DE L'ESTANY	57	114	1,9	40	0,7
CONSULTORI FALS	39	78	1,3	40	0,7
CONSULTORI FONOLLOSA	49	343	5,7	140	2,3
CONSULTORI MONISTROL DE CALDERS	53	212	3,5	80	1,3
CONSULTORI MONTMAJOR	69	138	2,3	40	0,7
CONSULTORI RAJADELL	44	0	0,0	0	0,0
CONSULTORI RELLINARS	51	255	4,3	100	1,7
CONSULTORI SANT FELIU SASSERRA	58	638	10,6	220	3,7
CONSULTORI SANTA MARIA D'OLÓ	47	517	8,6	220	3,7
CONSULTORI ST. SALVADOR DE GUARDIOLA	41	41	0,7	20	0,3
RAE CAP II BAGES	34	34	0,6	20	0,3
Total general	Total	Time	2840		1500,7
	Total	€	60208		31814

3.4.2 Costs of petrol

We have calculated that a total of 49.684km would have been made by patients if they had attended a visit at the hospital instead of using the teledermatology service. This amounts of a total of **12.421,05€** spent in petrol.

Table 21: Cost of petrol by primary care centre

Primary Care centre	Saved visits	Km to Hospital	Saved Km	Cost Km saved
CAP BALSARENY	33	19,6	646,8	161,7
CAP BARRI ANTIC	6	1,8	10,8	2,7
CAP CALLÚS	49	13,1	641,9	160,475
CAP CARDONA	112	35,1	3931,2	982,8
CAP CASTELLBELL I EL VILAR	102	16,6	1693,2	423,3
CAP CASTELLGALÍ	111	8,4	932,4	233,1
CAP CASTELLTERÇOL	82	34,9	2861,8	715,45
CAP GORETTI BADIA	159	20,1	3195,9	798,975
CAP LES BASES	2	4,5	9	2,25
CAP MANRESA 2	840	2,8	2352	588
CAP MOIA	108	27,9	3013,2	753,3
CAP MONISTROL DE MONTSERRAT	58	17,3	1003,4	250,85
CAP NAVARCLES	102	10,1	1030,2	257,55
CAP NAVAS	173	24,9	4307,7	1076,925
CAP PONT DE VILOMARA	73	10,5	766,5	191,625
CAP SAGRADA FAMILIA	650	1,2	780	195
CAP SALLENT	323	15	4845	1211,25
CAP SANT FRUITÓS	230	6	1380	345
CAP SANT JOAN DE VILATORRADA	389	9	3501	875,25
CAP SANT VICENÇ DE CASTELLET	276	9,2	2539,2	634,8
CAP SANTPEDOR	227	9,2	2088,4	522,1
CAP VACARISSES	116	22,4	2598,4	649,6
CAP VALLS-PALÀ	15	23,9	358,5	89,625
CONSULTORI AGUILAR DE SEGARRA	1	27,3	27,3	6,825
CONSULTORI ARTES	136	14,8	2012,8	503,2
CONSULTORI AVINYÓ	58	22,8	1322,4	330,6
CONSULTORI CALDERS	4	18,5	74	18,5

CONSULTORI DE CANET DE FALS	**11**	**15,2**	167,2	41,8
CONSULTORI DE CASTELLCIR	**2**	**39,1**	78,2	19,55
CONSULTORI DE LA COROMINA	**8**	**32,6**	260,8	65,2
CONSULTORI DE L'ESTANY	**2**	**35,8**	71,6	17,9
CONSULTORI FALS	**2**	**17,6**	35,2	8,8
CONSULTORI FONOLLOSA	**7**	**22,6**	158,2	39,55
CONSULTORI MONISTROL DE CALDERS	**4**	**23,9**	95,6	23,9
CONSULTORI MONTMAJOR	**2**	**44,5**	89	22,25
CONSULTORI RAJADELL	**0**	**19,9**	0	0
CONSULTORI RELLINARS	**5**	**20,9**	104,5	26,125
CONSULTORI SANT FELIU SASSERRA	**11**	**33,9**	372,9	93,225
CONSULTORI SANTA MARIA D'OLÓ	**11**	**28,6**	314,6	78,65
CONSULTORI ST. SALVADOR DE GUARDIOLA	**1**	**10,6**	10,6	2,65
RAE CAP II BAGES	**1**	**2,8**	2,8	0,7
Total	**4502**		**49684,2**	**12421,05**

3.5 Total costs

The estimated added costs of the teledermatology service during 2016 were **61,870€.** For the same period, the estimated costs of the conventional dermatology services if the teledermatology service would have not been in place and all teledermatology visits would have been referred to face-to-face visits would have been **113.034€.** This is a saving of **51.164€** during 2016. As during 2016 a total of 4.502 patients were attended, this is a saving of **11,4€** per patient attended.

Table 22. Costs of teledermatology compared with conventional dermatology

Cost per year in €	Teledermatology	Dermatology
Equipment	1.565	0
Personnel primary care	20.799	17.332
Personnel hospital	7.691	23.073
Society		
Time	31.815	60.208
Petrol		12.421
TOTAL	**61.870**	**113.034**
	savings	-51.164

3.6 Sensitivity Analysis

3.6.1 One-way and extreme scenario analysis.

Analysing the numbers, it is clear that the **society costs** is the variable that has a bigger impact on our calculations.

The main savings of the teledermatology service came from the time patients saved from going to the hospital. If data is analysed removing the costs for the society, the savings are more modest: **10.350€** a year. As during 2016 a total of 4.502 patients were attended, this is a saving of **2,3€** per patient attended.

Table 23. Costs of teledermatology compared with conventional dermatology, removing society costs

Cost per year in €	Teledermatology	Dermatology
Equipment	1.565	0
Personnel primary care	20.799	17.332
Personnel hospital	7.691	23.073
TOTAL	**30.055**	**40.405**
Without society costs	savings	-10.350

The society costs savings due to the teledermatology service amounted for **40.814€** a year.

Table 24. Society costs of teledermatology compared with conventional dermatology

Society Cost per year	**Teledermatology**	**Dermatology**
Time	31.814	60.208
Petrol		12.421
TOTAL	**31.815**	**72.629**
	savings	**-40.814**

Another variable that also had an impact on the calculations is the **personnel costs**. The biggest impact of this variable is on the hospital. Personnel costs were significantly lower in hospital when using teledermatology as the time saved by the hospital professionals is considerable. With usual face-to-face dermatology visits, personnel costs in hospital amounted for 23.073€ a year, whereas with teledermatology, this amount is reduced to 7.691€ a year. This was a saving of 15.382€ a year.

In primary care, personnel costs increased slightly with teledermatology, as primary care physicians needed to do an extra telephone call to patients to explain the results of the teledermatology referral. With conventional dermatology, the personnel costs in primary care were 17.332€ a year, whereas with teledermatology the costs increased to 20.799€ a year. This was an increase of 3.467€ a year.

4. Discussion

This cost minimisation study examined the total cost of the resources associated with the use of a teledermatology programme in the Catalan central region and compared them with the cost of using a conventional face-to-face dermatology service. The study tried to establish whether savings could be made by using the teledermatology programme.

For our calculations, we used the county of Bages as a geographical boundary. However, there is no reason to think that the results are not easy to extrapolate to other areas in Catalonia.

4.1 Summary of results

4.1.1 Referrals

This study shows that compared to 2015, in 2016 there was an increase in teledermatology referrals. However, at the same time there was a reduction in dermatology referrals from the primary care centres. This means that although there were more teledermatology consultations, this did not correlate with an increase in the conventional dermatology referrals.

Referrals to conventional dermatology after an initial teledermatology consultation (within the following 3 months) decreased in 19.71% in 2016 compared to 2015. In 2011, Van Der Heijden *et al.* reported a significant 74% decrease in face-to-face visits after the introduction of a teledermatology programme (Van Der Heijden et al. 2011).

The decrease in referrals could be due to the educational benefits that this teledermatology programme could have. Other studies have also identified the educational profits of the teledermatology programmes (van den Akker et al. 2001; Landow et al. 2014). In 2002, Aas reported that 80% of professionals interviewed in their study stated that they had learnt something new by using telemedicine (Aas 2002).

Van Der Heijden *et al.* also reported that 85% of primary care physicians interviewed responded that they learned from the dermatologists' response to their teledermatology referral (Van Der Heijden et al. 2011).

It has to be considered that probably not all the referrals to the teledermatology service would have been referred to conventional dermatology if there were not this service in place because some physicians may have tended to refer more cases to teledermatology due to the quick reply time that the service offer.

4.1.2 Significant savings

This cost minimisation analysis suggests that the teledermatology programme implemented in the Catalan central region generates important savings compared with the usual model of face-to-face dermatology visits. This saving could amount to 51.164€ a year.

The results of the study show that the economic benefits of the teledermatology programme favour the patient more than favour the health-care system.

These results are consistent with other studies published. Armstrong *et al.* conducted a cost minimisation analysis in 2007 comparing the hourly costs of a teledermatology service with a face-to-face dermatology clinic. They concluded the hourly cost of operating the teledermatology practice was lower than that of the conventional clinic (Armstrong et al. 2007).

4.1.3 Sensitivity analysis

Sensitivity analysis shows that the results of our analysis are robust. The variable 'society costs' has the higher impact on the calculations as the main savings come from the time patients save from avoiding travelling to the hospital. This saving amount for 40.815€ a year.

Other savings also come from personnel costs, particularly from the time saved by dermatologists. These savings amount for 15.382€ a year.

4.2 Limitations of the study

We have tried to minimise the limitations of our study by performing a sensitivity analysis. However, a number of limitations in the study need to be taken into considerations when evaluating the results:

4.2.1 Estimation of costs

An economic analysis is only as accurate as the information used to estimate their costs. We have estimated the costs of teledermatology compared with the usual face-to-face dermatology using my day-to-day experience in clinical practice, data obtained from experts and the findings of the extended literature review we conducted.

4.2.2 Costs excluded

In any economic study, one of the more controversial aspect is the decision about with costs are excluded and which costs are included in the study.

We have excluded costs that do not represent a significant added cost because they are part of the overall costs of usual practice and costs that are not different between teledermatology and usual dermatology practice. We have excluded costs that are very difficult to quantify through secondary data such as the costs of relatives and friends of the patients, costs of leisure time lost and costs of carbon emissions. We have justified our decisions in the methods section.

4.2.3 Cost-effectiveness estimation

Despite having robust evidence though several studies that the clinical effectiveness of teledermatology is comparable with face-to-face consultations, recently some authors have raised concerns stating that convincing evidence of the effectiveness of

telemedicine is limited as it is difficult to conduct good methodological studies to determine their effectiveness (Armfield et al. 2014).

4.2.4 Opportunity costs

This economic study, like many health economic evaluations, tacitly assumes that health services resources that are freed up will be redeployed efficiently to other services. In this case, we have assumed that resources liberated by reducing hospital visits to dermatology, will be efficiently used to provide other dermatology services to other patients. If the time redeemed is not used in this way, no savings would have been made.

4.3 How this fits with other work

Eminović *et al.* also conducted a cost minimisation analysis in store-and-forward teledermatology in 2010. The authors calculated that teledermatology was 32.5€ (95% CI, -29.0 to 74.7) more expensive than conventional dermatology visits. They concluded that savings delivered by teledermatology only could be achieved if the distance to a dermatologist in hospital was larger (>=75km) or when more consultations (>= 37%) could be prevented due to teledermatology. Therefore in order to achieve cost savings, teledermatology should only be applied in those cases with a reasonable probability that a face-to-face consultation could be prevented (Eminović et al. 2010)**.**

The study included similar costs as ours, however they included training for primary care physicians and dermatologists and the costs of diagnostics and treatment. They included society costs consisting on travel costs of the patient and of an accompanying person. They estimated (based on trial population) that about 20% of patients (children and elderly) visit a health professional accompanied.

This study used a different and more complex methodology as it was based on a clustered randomised trial including 631 patients (intervention: 327, control: 304) with a

decision analytical approach and using in total 282 variables. Our study is based on secondary obtained data. The authors performed a multivariate probabilistic sensitivity analysis with 31 parameters that according to one-way sensitivity analysis influenced model outcome.

Whereas Eminović *et al.* concluded that 20.7% of dermatological consultations were preventable due to teledermatology, in our study this number is much higher as the overall referral rate in 2016 was just of 19,69%. It has to be considered that in our study; probably not all referrals to teledermatology would have been made to a conventional dermatology service if the teledermatology service was not in place.

4.4 Transferability and generalisability

Our study can be easily generalised to the Catalan territory, as we did not use specific local data to calculate the costs and therefore all costs can be extrapolated at a Catalan level. Increasing the number of patients using the teledermatology service will increase the savings as we have calculated that the teledermatology service saves 11,4€ per patient attended. We have estimated that if a teledermatology program wold have been in place in Catalonia, the savings for the whole population of Catalonia (7,519,000 inhabitants) could have amounted to 2,085,061€ per year.

It has been described that a telemedicine model is enhanced and therefore easier to transfer when provides social and economic value, as it is the case in this teledermatology programme we have studied (Chen et al. 2013).

We should be more cautious extrapolating these results to other countries different from Catalonia, as different legislation, reimbursement or organisation of the health care sector can make transferring the results more problematic.

5. Conclusions

According to the results of this study, although in 2016 there were more teledermatology visits than in 2015 (5.71% increase), this did not correlate with an increase in the conventional dermatology referrals; at the contrary, they decreased 8.9%. Referrals to conventional dermatology after an initial teledermatology consultation also decreased 19.71% in 2016 compared to 2015.

From an economic point of view, the study found that using a teledermatology service instead of a face-to-face dermatology service could save up to 51.164€ a year in the county of Bages. This is a saving of 11,4€ per patient attended. Most of the savings come from a society point of view (40.815€ a year). If we remove the society costs, the savings are more modest but still amount for 10.350€ a year.

Extrapolating the savings for the whole population of Catalonia would amount to a savings of 2,085,061 € a year.

The full article covering this part of the thesis has already been published in the BMC Health Services Research journal (see Appendix VI) (Vidal-Alaball, Garcia Domingo, et al. 2018).

RURAL-URBAN DIFFERENCES IN THE PATTERN OF REFERRALS TO AN ASYNCHRONOUS TELEDERMATOLOGY SERVICE

1. Introduction

Telemedicine has been defined as the "*medicine practiced at a distance*" (Wootton 1996). Three main types of telemedicine can be distinguished according to the timing of the information transmitted: store-and-forward or asynchronous (not real-time) telemedicine, videoconference or synchronous (real-time time) telemedicine and remote patient monitoring (Dario et al. 2016; Eedy & Wootton 2001).

Telemedicine has shown in several studies its effectiveness, efficiency, safety and capacity to reduce costs (Livingstone & Solomon 2015; Ekeland et al. 2010; Whited, Warshaw, Kapur, et al. 2013). These effects are especially important in rural areas where telemedicine can enhance access to health for patients living in rural or remote areas (Jennett et al. 2003; Mars & Maurice 2013; Bradford et al. 2016). Telemedicine benefit patients as they improve access, but also professionals, as they increase contact with specialists and allow them to have better access to professional development (Moffatt & Eley 2010). Primary care physicians have reported the educational benefits of telemedicine (Eedy & Wootton 2001).

Telemedicine services are well accepted by users (Yahya & Anh 2015; Polinski et al. 2016); satisfaction has been reported to be higher in rural settings than in urban settings, since it can prevent unnecessary travel to hospitals (Klaz et al. 2005). By facilitating access to specialised care in regions far from urban hospitals, telemedicine can help reducing inequalities between rural and urban areas (Mars & Maurice 2013; Devine 2009).

In three counties of Central Catalonia; Anoia, Bages and Berguedà, telemedicine services between primary care and local hospitals have been developed. Among the programs of telemedicine, the most successful has been teledermatology and the most innovative teleulcers and teleaudiometries. In the teledermatology program set in Bages, in operation since 2010, primary care professionals take photographs of dermatological lesions and attach them into the patient's computerised medical records together with a clinical description. The use of electronic medical records guarantees the confidentiality of the images at all times, since it is not necessary to send them by e-mail or store them in an external server. The dermatologists at the hospital access the patient's medical history, review the images and propose a treatment or plan of action to follow. The primary care professionals review the proposal and make a phone call to the patient to explain the results of the consultation. The whole process usually takes less than a week. If the dermatologists consider it convenient, can ask the primary care professionals to refer the patient for a face-to-face visit.

This program has had considerable success in reducing the dermatology waiting lists, achieving an average reduction in patient wait time from 30 to 16 days (Vidal-Alaball et al. 2014). The objective of this study is to evaluate the degree of resolution (as the capacity to solve health problems within primary care) of the Bages teledermatology service and analyse whether there are differences between rural and urban primary care teams.

2. Methods

Longitudinal descriptive study of the referrals to the hospital dermatology service as a consequence of a previous referral to the teledermatology program in the Bages region during the years 2015 and 2016.

As population of reference we took the entire population included in the 14 Primary Care Teams (PCTs) of the County of Bages that used the teledermatology service at some point. The PCTs of Bages are managed by to two different health care providers: Institut Català de la Salut (12) and ALTHAIA, Xarxa Assistencial Universitària (2). These teams refer patients to a district hospital located in Manresa (Sant Joan de Déu Hospital). The PCTs include Primary Care Centres and Surgeries located in populations of less than 12,000 inhabitants, except Manresa, which is a city of almost 75,000 inhabitants. (Idescat. Statistical Institute of Catalonia 2017a).

Although there is no consensus about when a population is considered rural or urban, for this study we have used the analysis done by Dominguez Amorós *et al.* that classified all Catalan populations in rural and urban according to the number of inhabitants, density of population and sectors of economic activity. Considering this study, except Manresa (with four PCTs) and Sant Joan de Vilatorrada, which are considered urban areas, the rest of the Bages population is considered rural (Domínguez Amorós et al. 2010). For each of the PCTs, we extracted from computerized medical records data relating to the population assigned to the centres together with the origin and the total of the consultations to the teledermatology service and the referrals made to the conventional dermatology service.

For the analysis, the chi-squared test was used to compare the percentage of referrals to the traditional dermatology service after an initial consultation with the teledermatology service. We considered a dermatology referral resulting from an initial teledermatology consultation any dermatology visits produced in the three subsequent months. The analysis was made comparing years 2015 and 2016 and urban areas with rural areas. The results were considered significant with $p<0.05$. The statistical program SPSS v8 was used for the statistical analyses.

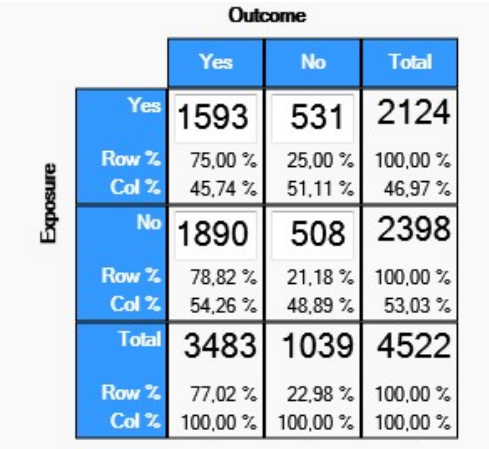
3. Results

Urban centres

During 2015, a total of 2,124 referrals were made to the teledermatology service from the 5 PCTs located in urban centres, originating a total of 531 visits to the dermatology service (25%). This represents a referral rate of 22.3 per 1,000 inhabitants. During 2016, a total of 2,398 referrals were made to the teledermatology service from these urban centres, originating 508 subsequent face-to-face visits to the dermatology service (21.18%). This represents a referral rate of 25.2 per 1,000 inhabitants.

Year	Assigned population	Teledermatology referrals	Referral rates per 1,000 inhabitants.	Dermatology referrals	% referral
2015	95,102	2,124	22.3	531	25%
2016		2,398	25.2	508	21.18%

Between 2015 and 2016, teledermatology consultations increased by 12.9%. In contrast, the number of referrals to dermatology as a consequence of an initial referral to teledermatology decreased significantly from 531 to 508 visits OR=0,81 (0,70-0,93) p=0,001.



Exposure		Outcome: Yes	Outcome: No	Outcome: Total
Yes		1593	531	2124
	Row %	75,00 %	25,00 %	100,00 %
	Col %	45,74 %	51,11 %	46,97 %
No		1890	508	2398
	Row %	78,82 %	21,18 %	100,00 %
	Col %	54,26 %	48,89 %	53,03 %
Total		3483	1039	4522
	Row %	77,02 %	22,98 %	100,00 %
	Col %	100,00 %	100,00 %	100,00 %

Odds-based Parameters			
	Estimate	Lower	Upper
Odds Ratio	0,8063	0,7019	0,9263

Rural centres

During 2015, a total of 3,198 referrals were made to the teledermatology service from the 9 PCTs located in rural areas. Of these referrals, 844 required a face-to-face visit to the dermatology service (26.39%) The referral rate of these centres was 32.4 per 1,000 inhabitants. During 2016, a total of 3,208 referrals were made to the teledermatology service from PCTs located in rural areas. Of these referrals, 596 were subsequently seen in the conventional dermatology clinics (18.58%). This represents a referral rate of 33.5 per 1,000 inhabitants

Year	Assigned population	Teledermatology referrals	Referral rates per 1,000 inhabitants.	Dermatology referrals	% referral
2015	98,795	3,198	32.4	844	26.39%
2016		3,208	33.5	596	18.58%

Between 2015 and 2016, the number of visits to teledermatology increased slightly by 0.3%. The number of referrals to dermatology as a consequence of the initial referral to teledermatology decreased significantly from 844 to 596 visits OR=0,64 (0,57-0,72) p<0,001.

Overall, in the two years analysed, referral rates to the teledermatology service per thousand inhabitants from rural centres was statistically much higher than that of urban centres (p<0.001).

Exposure		Outcome: Yes	Outcome: No	Outcome: Total
Yes		2354	844	3198
	Row %	73,61 %	26,39 %	100,00 %
	Col %	47,40 %	58,61 %	49,92 %
No		2612	596	3208
	Row %	81,42 %	18,58 %	100,00 %
	Col %	52,60 %	41,39 %	50,08 %
Total		4966	1440	6406
	Row %	77,52 %	22,48 %	100,00 %
	Col %	100,00 %	100,00 %	100,00 %

Odds-based Parameters

	Estimate	Lower	Upper
Odds Ratio	0,6364	0,5652	0,7166

4. Discussion

Both in the urban environment and in rural areas there is an increase in referrals to the teledermatology service in 2016 compared to the previous year. This increase could be due to a greater familiarisation with the service by professionals and users. However, the number of referrals to the face-to-face dermatology service after a teledermatology consultation also decreased significantly and this effect was more pronounced in rural centres. This may indicate an educational effect of the teledermatology program for primary care professionals, as some studies have previously suggested (Van Der Heijden et al. 2011; Hall 2005; Barbieri et al. 2015).

The teledermatology consultation rate per thousand inhabitants assigned was greater in rural teams than in the urban ones. This could be explained by the fact that in rural areas, where predominate an increasingly aging population and hospital are often far away, professionals and patients try to avoid hospital visits through the use of telemedicine. It is in rural areas where telemedicine can have a more beneficial effect

from a social point of view, avoiding unnecessary and often long trips to the hospitals (Moffatt & Eley 2010).

These results have important implications for rural family practice as have shown that the impact of this telemedicine program is greater in these practices. The study opens a debate about the need to prioritize telemedicine programs in rural centres above urban centres. However, telemedicine should not represent a negative impact on access to usual health services by rural communities and should not be used as an excuse to reduce health services in these areas.

This study presents some limitations, the main one of which is given by the definition of the concept of rurality, not commonly agreed.

5. Conclusions

The teledermatology service in operation in the Bages County increases the resolution of primary care teams as reduces referrals to the face-to-face dermatology service. This effect is more pronounced in rural than in urban areas and may indicate the need to prioritize telemedicine services in rural primary care practices.

This part of the thesis was included in an article published during 2018 (see Appendix VI) (Vidal-Alaball, Mendioroz Peña, et al. 2018).

CHAPTER 4

ACCEPTANCE OF THE TELEMEDICINE SERVICES AMONG HEALTH PROFESSIONALS IN THE CATALAN CENTRAL REGION

1. Objectives

The primary objective of this study was to assess the acceptance of the telemedicine services among health professionals of the Catalan central region using a validated questionnaire.

2. Methods

This was an observational and cross-sectional study using an anonymous questionnaire administered to all professionals that had access to the telemedicine services in the 17 Primary Health Care Teams in the counties of Bages and Berguedà (Catalan central region).

We measured the degree of satisfaction of health professionals with the telemedicine services in place in the counties of Bages and Berguedà using a technology acceptance model (Chau & Hu 2002). The technology acceptance model proposed by Davis in 1989 is based on the two main concepts of ease of use and perceived usefulness and comprises three dimensions: the individual context, the technological context, and the implementation or organisational context (Davis 1989).

2.1 Questionnaire

2.1.1 Study questionnaire

For our study, we wanted to use a questionnaire in line with the technology acceptance model but we were also willing to assess the clinical impact of the services. Overall we intended to asses 5 different aspects of the telemedicine services in place in Bages and Berguedà:

- Technical quality of the telemedicine services and technical difficulties.
- Healthcare quality offered by the telemedicine services compared to the usual services in place.
- Satisfaction of the professional with the telemedicine services.
- Clinical impact of the telemedicine services.
- Future utilization of the service.

We wanted to use a short questionnaire to favour participation.

2.1.2 Validated questionnaires

Although we conducted an extensive literature review, it has not been possible to find a short validated questionnaire to assess perceptions of health care professionals with asynchronous telemedicine services that used the technology acceptance model.

In the REgioNs of Europe WorkINg toGether for HEALTH (RENEWING HEALTH) project, Kidholm *et al.* reviewed the scientific literature to find questionnaires used in European projects of telemedicine in which the opinion of stakeholders was assessed. The authors did not find any validated questionnaires to assess perceptions of telemedicine applications by the health care professionals. They recommended to assess perceptions of healthcare professionals by collecting answers to ten questions on the effects on collaboration, usability, work processes, communication and satisfaction (Kidholm et al. 2011).

Kidholm *et al.* mentioned a questionnaire for healthcare professionals used in the EU project Health Optimum, where surveys were carried out in three different countries on patients' and healthcare professionals' perceptions of specific telemedicine applications. Health Optimum (Delivery OPTIMisation through telemedicine) was a European Commission approved project targeting people with chronic conditions that wanted to ensure healthcare services through virtual medical assistance for a wide range of medical specialties such as haematology, nephrology, dermatology, oncology, radiology, endocrinology, cardiology, endocrinology, orthopaedics, plastic surgery, neurosurgery, psychiatry, alcoholism recuperation, home monitoring for old people and general healthcare (Momentum 2002). The questionnaire for professionals had questions quite general and independent of medical specialities and focuses on the physicians' perception of the quality of the telemedicine service, their comfortability, technical and other difficulties and potential effects on the health of the patients using

the service. However, no information is given regarding the validity or reliability of the questionnaire (Kidholm et al. 2011).

We contacted several individuals responsible for the EU project Health Optimum to ask whether their questionnaire was validated or not, they confirmed that the questionnaire was not validated (Martí & Strübin 2018).

2.1.3 Validation of the study questionnaire

We decided to translate, adapt and validate the questionnaire used in the EU project Health Optimum, as it allowed to asses most of the aspects we were planning to assess using a short and easy to answer questionnaire (see Health Optimum questionnaire at Appendix IV).

To validate the questionnaire, we sent a pilot questionnaire using Google forms and asked healthcare professionals that had used telemedicine at some point to answer it. To disseminate the questionnaire, we used WhatsApp professional groups and asked members to answer the questionnaire and to disseminate it to their professional contacts. We also send a twitter message asking the thesis' author followers to reply the questionnaire. The questionnaire it is now closed but can be accessed at: https://docs.google.com/forms/d/1ZH7h3E6ydNzSIpsiA4U1fD_OngwPgWzn3aMRbGGUdMw/closedform

2.1.3.1 Translation

To translate the questionnaire into Catalan language, the thesis's author translated it and asked one of the thesis directors, Gemma Flores to independently translate it as well. After several drafts, they agreed a final translated version of the questionnaire.

2.1.3.2 Likert scale

We felt that the original questionnaire could be improved methodologically. It used an incomplete Likert scale and we thought that this was an important negative point of the

questionnaire. The Likert scale is a series of questions designed to measure people's attitudes, opinions, or perceptions asking participants to select a rating on a scale that ranges from one extreme to another, such as "strongly agree" to "strongly disagree" (Jamieson 2017).

Moreover, the original questionnaire had a pair number of answers to the questions when it is recommended that questionnaires use an odd number of answers. Furthermore, there were more options towards the positive than the negative in the first two questions. We decided to add one category of response to the first four questions in order to have an odd number of options and therefore obtain a complete Likert scale.

It is recommended to include 5 or 7 categories of response in a Likert scale and some authors argued that the ones with 7 categories are more appropriate to obtain a bigger degree of detail and precision (Cohen et al. 2007). In our questionnaire, we felt that we could get an appropriate detail just using a Likert scale with 5 categories of response (see final questionnaire at Appendix V).

2.1.3.3 Internal consistency

To test the internal consistency of the 8 questions included in the final questionnaire we sent a pilot questionnaire to several healthcare professionals and calculated the **Cronbach's α** (alpha). This statistical test allows checking the consistency of a scale of measurement. It is an average of the variances between the variables that are part of a scale (Frías Navarro 2014; George & Mallery 2003).

Figure 7: Cronbach's α formula (Goforth 2015):

$$\alpha = \left(\frac{k}{k-1}\right)\left(1-\frac{\sum_{i=1}^{k}\sigma_{y_i}^2}{\sigma_x^2}\right)$$

...where: k refers to the number of scale items

$\sigma_{y_i}^2$ refers to the variance associated with item i

σ_x^2 refers to the variance associated with the observed total scores

It is usually accepted that values of α above 0,7 indicate an acceptable internal consistency.

Table 25. Internal consistency according to Cronbach's α value.

Cronbach's	Internal consistency
$\alpha \geq 0,9$	Excellent
$0,8 \leq \alpha < 0,9$	Good
$0,7 \leq \alpha < 0,8$	Acceptable
$0,6 \leq \alpha < 0,7$	Questionable
$0,5 \leq \alpha < 0,6$	Poor
$\alpha < 0,5$	Unacceptable

2.1.3.4 Temporal Stability - reliability

For a questionnaire, it is important to be sure that it produces similar results on repeated measurements over time in the same groups of respondents, this is known as reliability or temporal stability (Bolarinwa 2015).

To check the temporal intra-observer stability of our questionnaire we used a test-retest methodology. We sent a pilot questionnaire to a convenience sample of health professionals and resent it again to the same respondents two weeks later.

Test-retest reliability is calculated with intraclass correlations between the scores at time 1 and scores at time 2 at the individual item level. Intraclass correlation coefficients (ICC) over 0,75 are considered good to show reliability and over 0,90 excellent (Koo & Li 2016).

Table 26. Reliability according to intraclass correlation coefficient values (ICC).

ICC	Reliability
ICC > 0,9	Excellent
0,75 ≤ ICC ≤ 0,9	Good
0,5 ≤ ICC < 0,75	Moderate
ICC < 0,5	Poor

2.1.3.5 Additional information

We have added additional information to supplement the data regarding basic characteristics of the respondents. We have asked their age, gender and professional role (medicine, nursery, dentistry or other). We have also asked which of the telemedicine service in place in the Catalan central region they have used (teledermatology, teleulcers or teleaudiometries).

2.1.4 Dissemination of the study questionnaire

We have used an internet polling tool LimeSurvey (www.limesurvey.org) to anonymously send the questionnaire to all primary health care professionals working at the Institut Català de la Salut in the counties of Bages and Berguedà that potentially had contact with the telemedicine services: physicians (family physicians and paediatricians), nurses and dentists.

In order to maximize the number of responses, the poll was sent from the Central Catalonia Research Unit to the healthcare professional e-mail addresses. A reminder was sent 2 weeks after the initial message. The e-mails were not associated with the answers to guarantee the anonymity of the participants. No personal identification data was requested or stored.

2.1.5 Analysis of the study questionnaire

We have analysed the results of the study questionnaire using t-Student and chi-squared tests. The results were considered significant with $p<0,05$. The statistical programs Epi Info™ v7.2.2.1 and SPSS v23 (SPSS Inc., Chicago, USA) were used for the statistical analyses.

3. Results

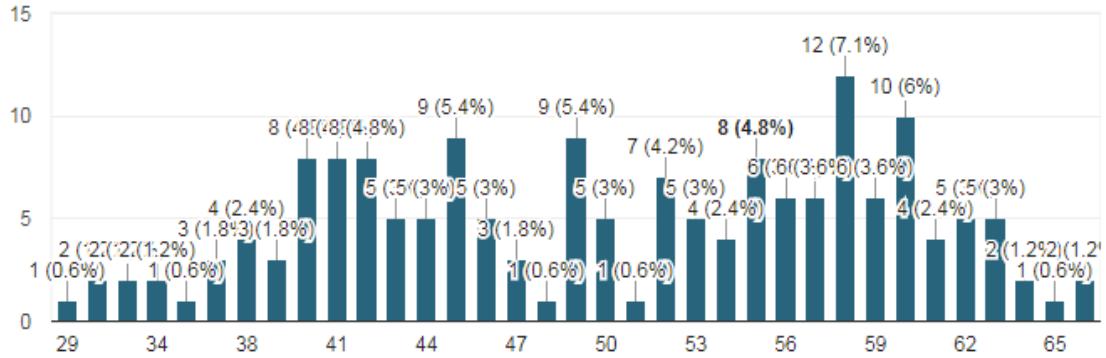
3.1 Validation of the questionnaire

The pilot questionnaire was sent for the first time at the beginning of April 2018 and was closed for replies 3 days later. In order to check for consistency, the questionnaire was resent 2 weeks later, asking participants to answer again the same questionnaire. We definitely closed the questionnaire 5 days later.

3.1.1 Results of the validation pilot questionnaire

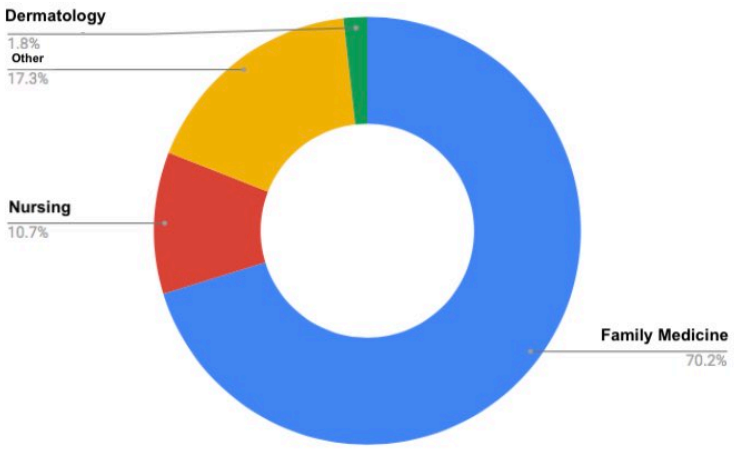
Overall, we received 212 responses, 69.6% from women and 30.5% from men. The average age of respondents was 50.2 years.

Figure 8: Ages of respondents (validation questionnaire)



Of the respondents, 70.2% were family physicians, 10.7% nurses, 1.8% dermatologist and 17.3% had other specialities.

Figure 9: Profession of respondents (validation questionnaire)



3.1.2 Cronbach's alpha

We checked the internal consistency of our pilot questionnaire using the Cronbach's α test. Calculations with SPSS gave an α value of **0.84**.

Table 27. Average of the variances between the variables and Cronbach's α calculation

Questions	VAR	VAR
Q1	0,727	3,354
Q2	0,754	3,290
Q3	0,748	2,853
Q4	0,795	3,507
Q5	0,373	2,544
Q6	0,313	1,924
Q7	0,326	1,986
Q8	0,265	2,434
Total	**16,056**	**22,562**
k	8	
sum variances	4,301	
Total VAR	16,056	
alfa	0,84	

3.1.3 Test-retest

Overall, 38 persons responded twice to the questionnaire. One respondent responded three times and was therefore excluded from the calculations.

After checking response times, we found five respondents that although responded twice to the questionnaire did not wait the necessary minimum two weeks period between the responses. These five respondents were also excluded.

After excluding six respondents, calculations were made using 33 participants.

Calculations with SPSS gave a intraclass correlation coefficient value of 0,93 (95% CI: 0,852-0,964)

Table 28. Intraclass correlation coefficient calculation (validation questionnaire)

Intraclass correlation coefficient

	Intraclass correlation [b]	95% confidence interval		Test F with true value 0	
		Lower limit	Upper limit	Value	df1
Unique measures	,864[a]	,741	,930	14,259	32
Average measures	,927[c]	,852	,964	14,259	32

a. The estimator is the same, whether the interaction effect is present or not.
b. Intraclass correlation coefficients type A that use an absolute agreement definition.
c. This estimate is calculated assuming that the interaction effect is absent, otherwise it cannot be estimated.

3.2 Questionnaire's results

The validated questionnaire was sent on the 18th of May 2018 to a convenience sample of 661 primary health care professionals, including physicians, nurses and dentists. We included doctors in training as well. A reminder was sent on the 30th of May and the questionnaire was definitely closed on the 8th of June.

The survey received a total of 163 responses (148 complete responses and 15 partial responses). This was a response rate of 24,7%. For the calculations, we excluded incomplete or partial responses for each question.

It has to be noted that the first question asked whether the health professional had used a telemedicine service at any time, if the response was "Yes", they continued with the questionnaire. However, if the response was "Not", the questionnaire ended. 40 respondents stated that they had never used a telemedicine service and were excluded from the analysis.

3.2.1 Characteristics of the respondents

3.2.1.1 Gender

A total of 108 participants responded the question about their gender: 83 (76,85%) women and 25 (23,15%) men.

3.2.1.2 Age

A total of 108 participants responded the question asking for their age. The average age was 48,4 with a minimum age of 26 and a maximum age of 64 years.

By gender, the average age of respondents was 48,44 years amongst men and 48,21 years for women.

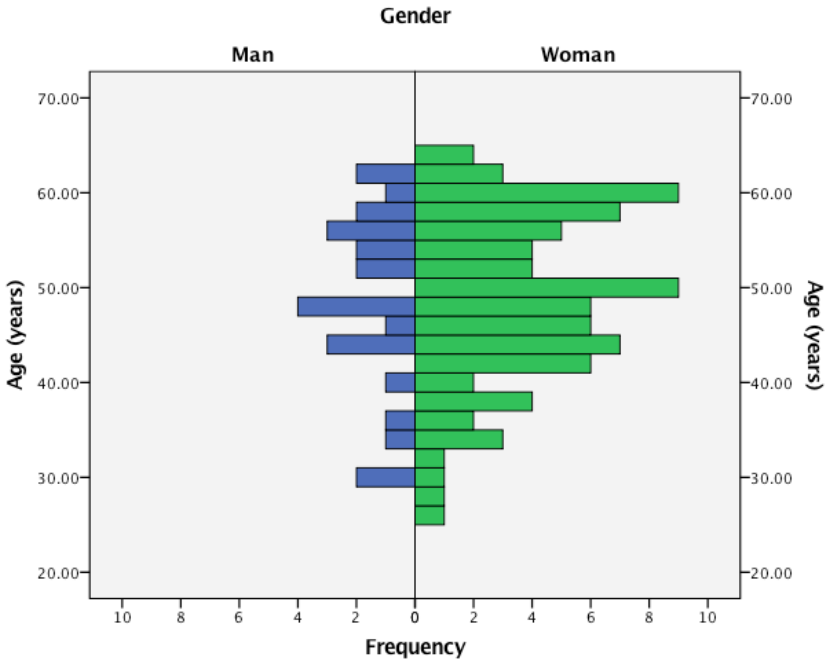
Table 29: Average age of respondents

	Obs	Total	Mean	Var	Std Dev	Min	Max
Age (years):	108	5229	48,4167	83,6285	9,1449	26	64

Table 30: Average age of respondents by gender

Age (years): * Sex:	Obs	Total	Mean	Var	Std Dev	Min	Max
Man	25	1211	48,44	86,007	9,274	30	61
Woman	81	3905	48,21	84,068	9,1689	26	64

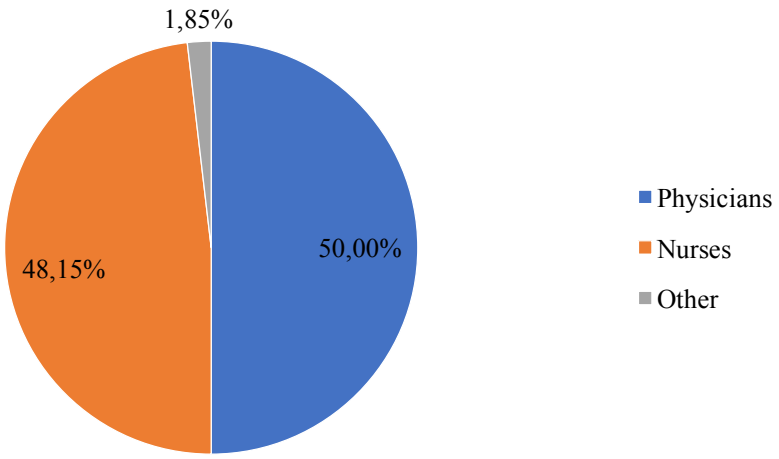
Figure 10: Population pyramid of respondents



3.2.1.3 Health professional category

Of the 108 health professionals responding to this question, 54 (50%) were physicians, 52 (48,15%) nurses and 2 (1,85%) from other specialities.

Figure 11: Health profession category of respondents to the questionnaire



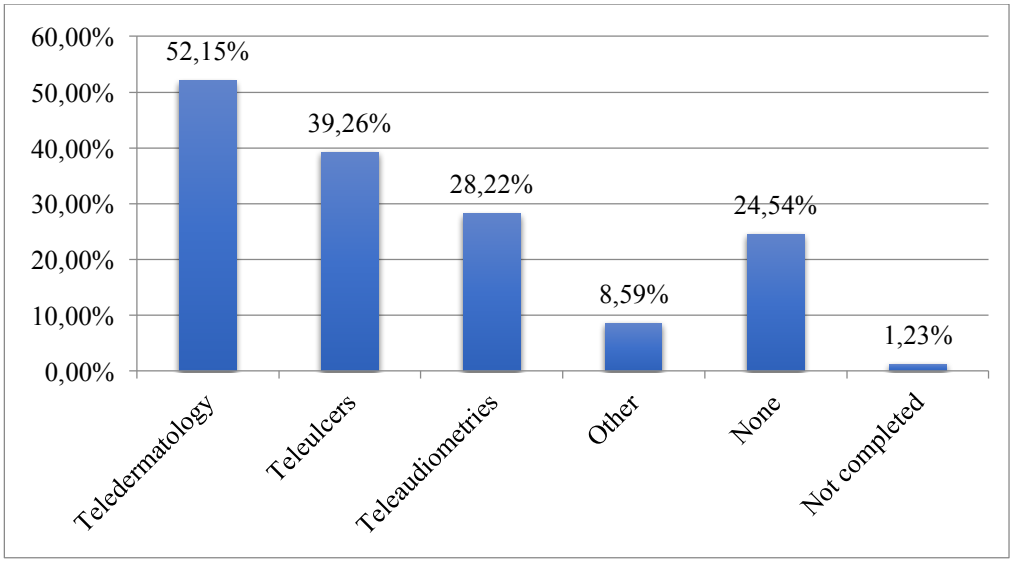
3.2.2 Utilization of telemedicine services

We asked the respondents which of the different telemedicine services available in the area they had used at some point. They could choose more than one service if applicable.

The most used service of all was Teledermatology with 85 respondents (52,15%) stating they have used this service previously. 64 respondents (39,26%) stated they had used Teleulcers and 46 respondents (28,22%) teleaudiometries. 14 respondents (8,59%) reported using other telemedicine services.

Finally, 40 respondents (24,54%) stated they had not used any of the telemedicine services available in the area and 2 respondents did not complete this part of the questionnaire.

Figure 12: Type of telemedicine service used



3.2.2.1 Times used a telemedicine service

We asked how many times had health professional used any of the telemedicine services in the last year. The 108 respondents stated that they had used some of the telemedicine services a total on 2.465 times, this was an average of 22,82 times per respondent. The minimum time used was 0 and the maximum 200.

Table 31: Times used a telemedicine service

Times used a telemedicine service

	Obs	Total	Mean	Var	Std Dev	Min	Median	Max	Mode
Times used a telemedicine service	108	2465	22,82	1801,45	42,44	0	5	200	3

We identified 5 responses that we thought were clearly outliers as there were observations that were very distant from other observations. 4 respondents stated that they used 200 times the telemedicine service in the last year and 1 stated using them 150 times. This is clearly difficult to believe as it would mean using the service nearly every day. Probably these respondents understood that we were asking for the total use of telemedicine over several years and not just in the last year. These extreme values made a big standard deviation to appear (42,44). Moreover, the median (middle

number) is 5 and the mode (number which appears most often in a set of numbers) is 3 which also identify these 5 extreme responses as outliers.

Figure 13: Histogram Times Used a telemedicine service

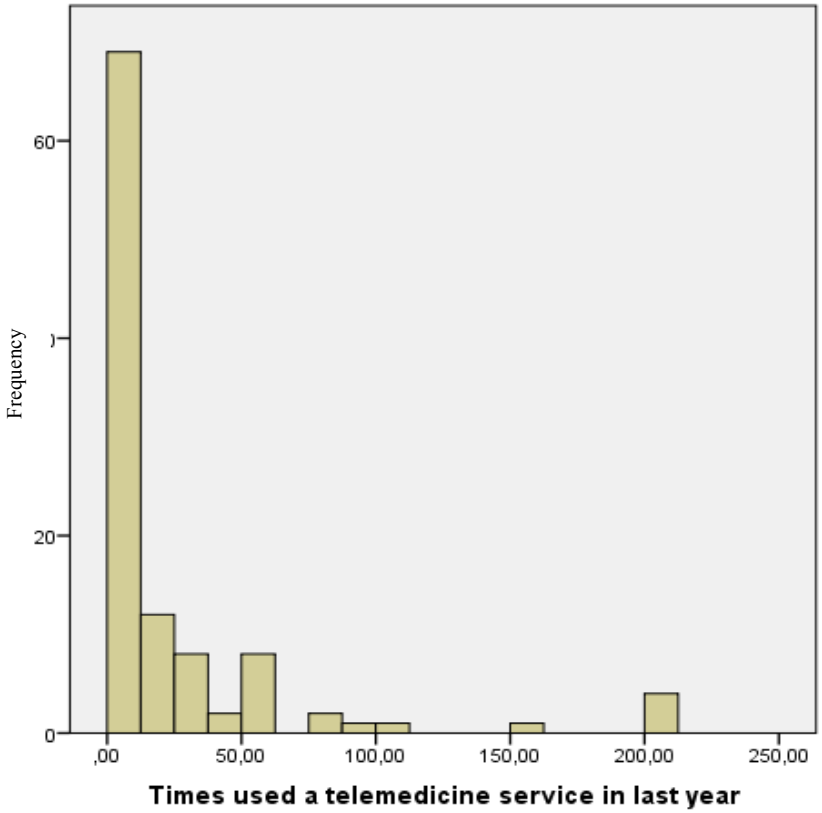
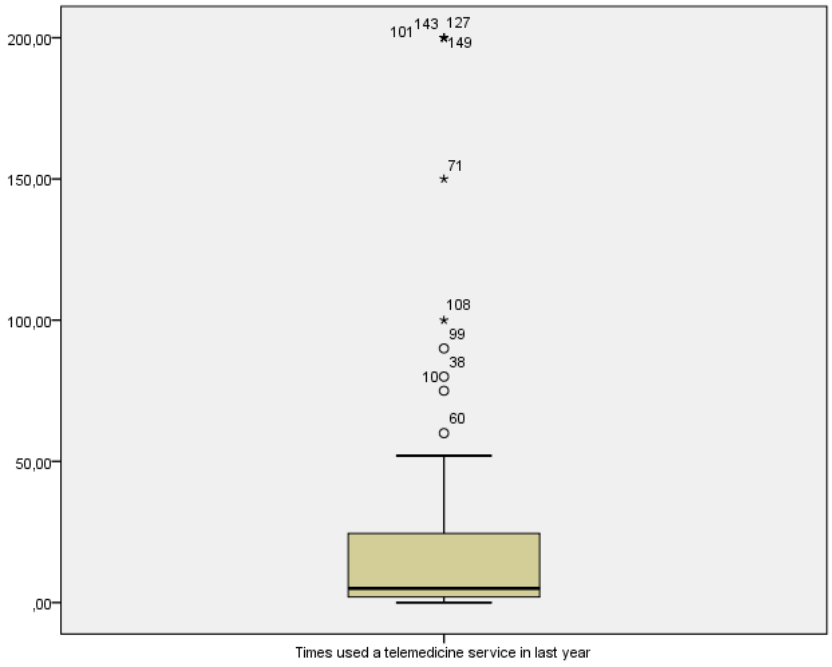


Figure 14: Box Plot Times Used a telemedicine service



For all these reasons, we decided to exclude the variable “times used a telemedicine service” for these 5 respondents but maintaining the all the rest of the variables for these respondents.

Excluding these 5 respondents we found that the remaining 103 respondents had used some of the telemedicine services a total on 1.515 times, this was an average of 14,71 times per respondent. The minimum time used was 0 and the maximum 100. Standard deviation was 20,82 with a median of 5 and a mode of 3.

Table 32: Times used a telemedicine service without outliers

Times used a telemedicine service

	Obs	Total	Mean	Var	Std Dev	Min	Median	Max	Mode
Times used a telemedicine service	103	1515	14,71	433,66	20,82	0	5	100	3

Figure 15: Histogram Times Used a telemedicine service without outliers

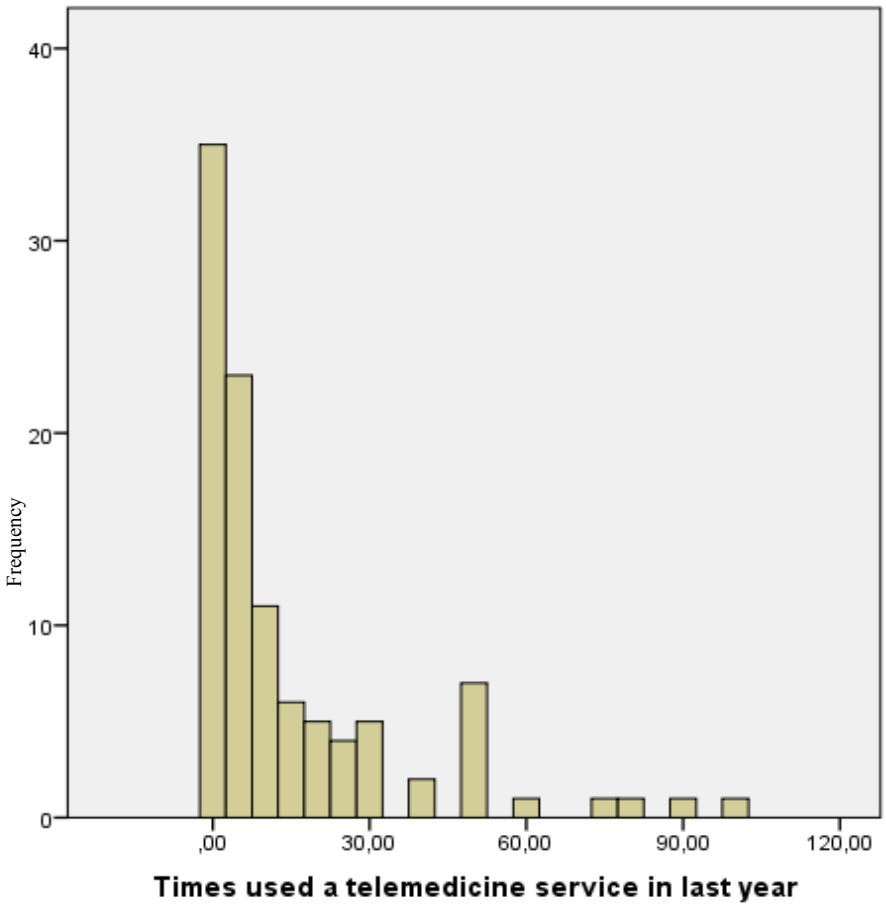
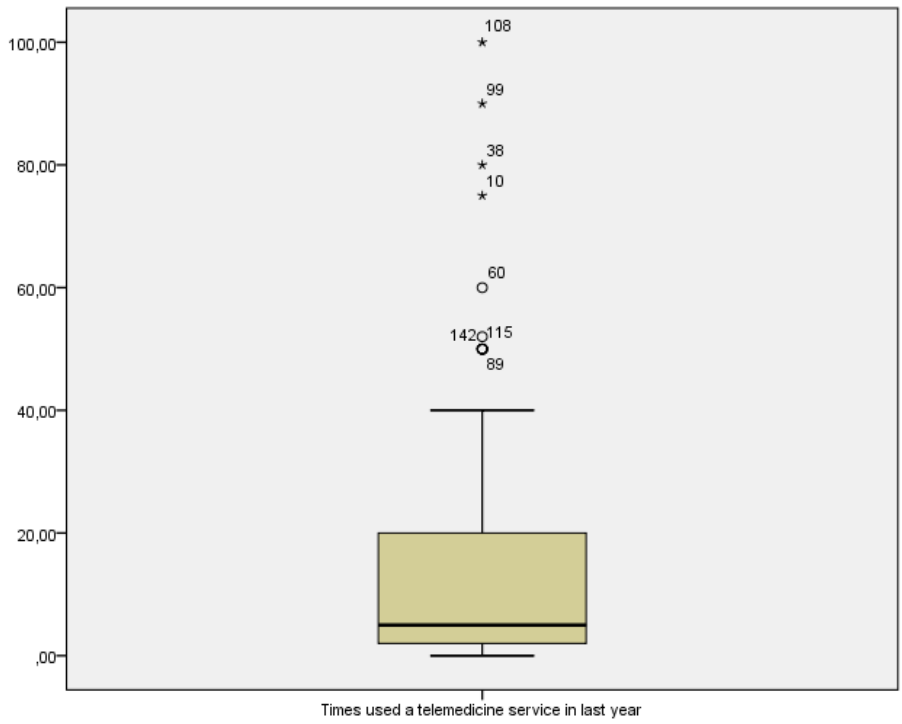


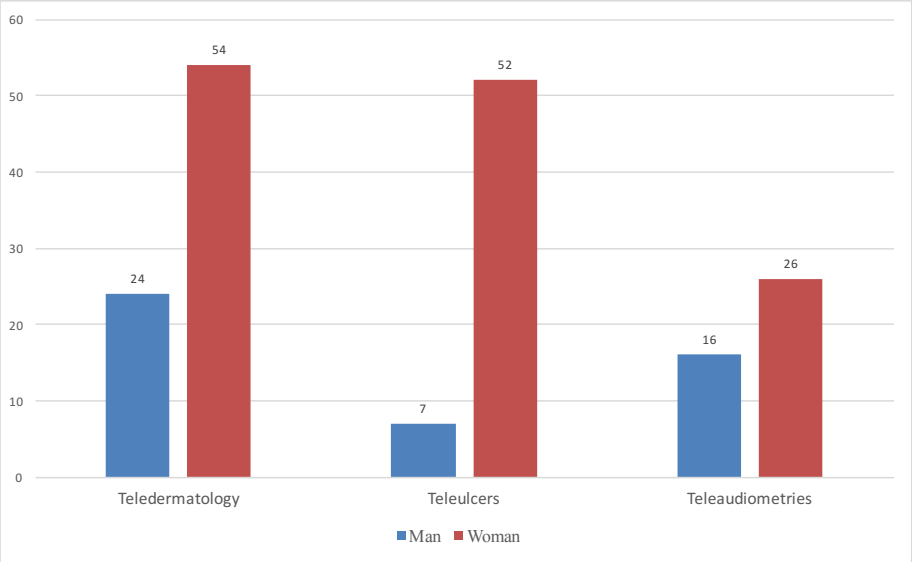
Figure 16: Box Plot Times Used a telemedicine service without outliers



3.2.2.2 Utilization of telemedicine services by gender

We looked at differences in utilization of the telemedicine services by gender. We found that amongst respondents that stated using teledermatology, 54 out of 78 respondents (69,2%) were women and 24 out of 79 respondents (30,8%) were men. Of the respondents that used teleulcers, 52 out of 59 respondents (88,1%) were women and 7 out of 59 respondents 11,9% were men. Amongst the users of teleaudiometries, 26 out of 42 respondents (61,9%) were women and 16 out of 42 respondents (38,1%) were men.

Figure 17: Utilization of telemedicine by gender



Looking at the utilization of the different telemedicine services by men; 24 out of 25 (96%) used teledermatology, 7 out of 25 (28%) stated using teleulcers and 16 out of 25 (64%) used teleaudiometries. Amongst women, 54 out of 83 respondents (65,1%) used teledermatology, 52 out of 83 respondents (62,7%) used teleulcers and 26 out of 83 respondents (31,3%) used the teleaudiometries service.

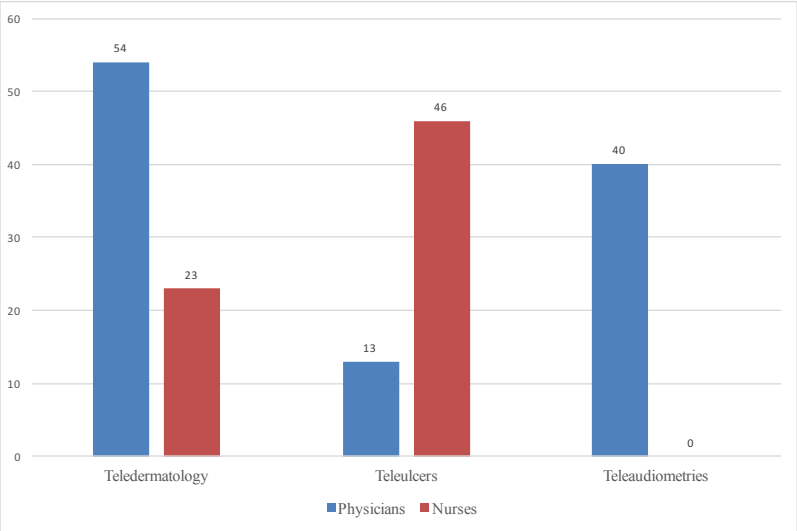
Table 33: Utilization of telemedicine by gender

		Gender		
		Man	Woman	**Total**
Teledermatology	Count	24	54	**78**
	% within TELEMEDICINE	30,8%	69,2%	
	% within gender	96,0%	65,1%	
Teleulcers	Count	7	52	**59**
	% within TELEMEDICINE	11,9%	88,1%	
	% within gender	28,0%	62,7%	
Teleaudiometries	Count	16	26	**42**
	% within TELEMEDICINE	38,1%	61,9%	
	% within gender	64,0%	31,3%	
	Count	**25**	**83**	**108**

3.2.2.3 Utilization of telemedicine services by professional category

We have looked at differences in utilization of the telemedicine services by professional category (physicians/nurses). We have found that amongst respondents that stated using teledermatology, 54 out of 77 respondents (70,1%) were physicians and 23 out of 77 respondents (29,9%) were nurses. Of the respondents that used teleulcers, 46 out of 59 respondents (78%) were nurses and 13 out of 59 respondents (22%) were physicians. Amongst the users of teleaudiometries, 40 out of 40 respondents (100%) were physicians.

Figure 18: Utilization of telemedicine by professional category



Looking at the utilization of the telemedicine services by physicians; 54 out of 54 respondents (100%) used teledermatology, 13 out of 54 respondents (24,1%) stated using teleulcers and 40 out of 54 respondents (74,1%) used teleaudiometries. Amongst nurses, 23 out of 52 respondents (44,2%) used teledermatology, 46 out of 52 respondents (85,5%) used teleulcers and none of them stated using the teleaudiometries service.

Table 34: Utilization of telemedicine by professional category

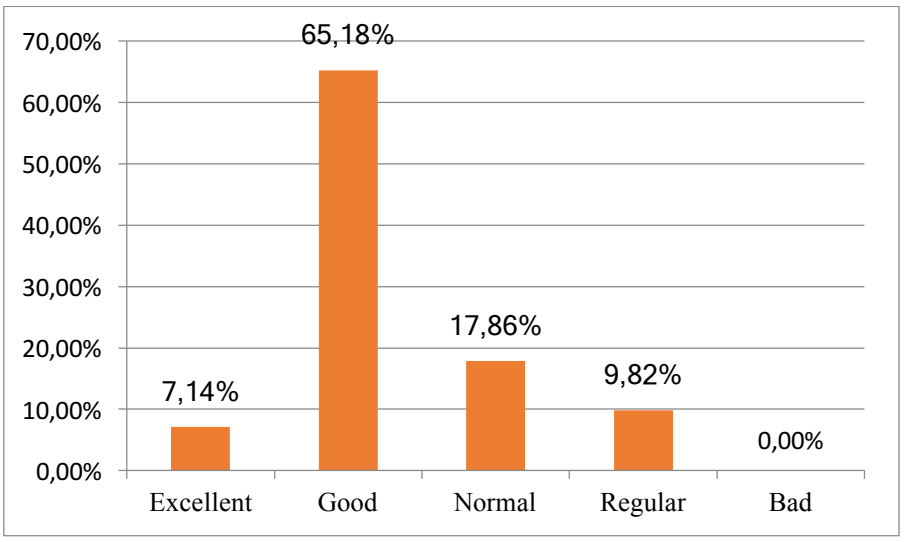
		Professional category		Total
		Physicians	Nurses	
Teledermatology	Count	54	23	**77**
	% within TELEMEDICINE	70,1%	29,9%	
	% within PROFESSION	100,0%	44,2%	
Teleulcers	Count	13	46	**59**
	% within TELEMEDICINE	22,0%	78,0%	
	% within PROFESSION	24,1%	88,5%	
Teleaudiometries	Count	40	0	**40**
	% within TELEMEDICINE	100,0%	0,0%	
	% within PROFESSION	74,1%	0,0%	
	Count	**54**	**52**	**106**

3.2.3 Descriptive results Q1-Q8

3.2.3.1 Question 1: rating of the overall quality of the telemedicine consultation

We asked participants to rate the overall quality of the telemedicine consultations. Of the total 112 respondents to this question, 8 (7,14%) rated the quality of telemedicine consultations as excellent, 73 (65,18%) rated the quality as good, 20 (17,86%) as normal and 11 (9,82%) rated the quality as regular. None of the respondents rated the quality as being bad.

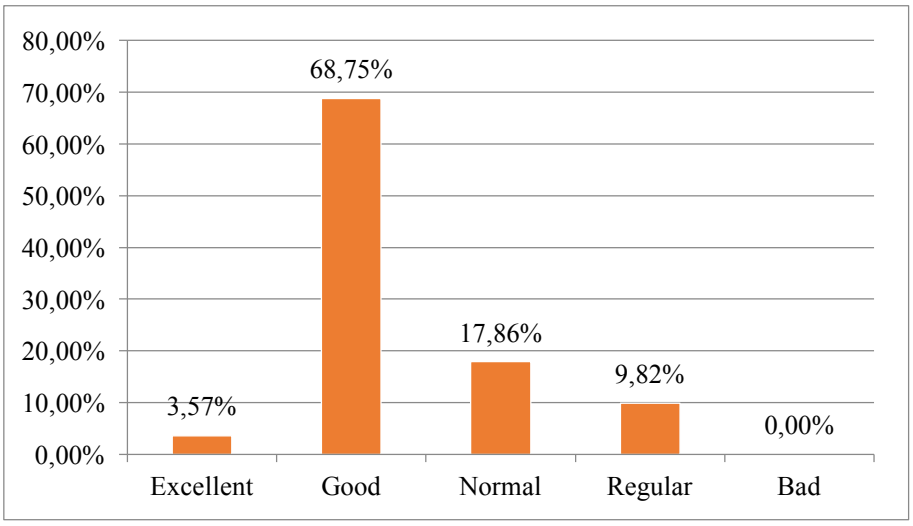
Figure 19: Overall quality of the telemedicine consultation



3.2.3.2 Question 2: rating of the technical quality of the telemedicine consultation

We asked participants to rate the technical quality of the telemedicine consultations. Of the 112 respondents to this question, 4 (3,57%) rated the technical quality of telemedicine consultations as excellent, 77 (68,75%) rated it as good, 20 (17,86%) as normal and 11 (9,82%) rated the technical quality as regular. None of the respondents rated the quality as bad.

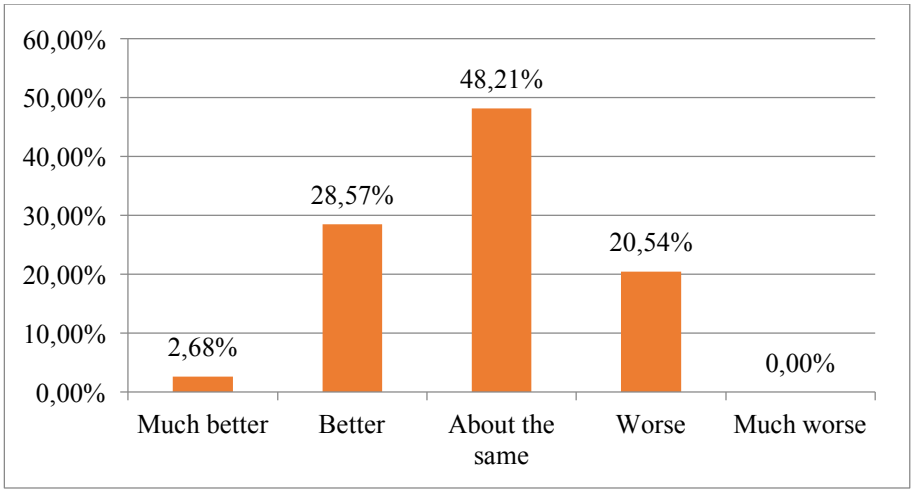
Figure 20: Technical quality of the telemedicine consultation



3.2.3.3 Question 3: rating of the quality of care delivered by the telemedicine service compared to the quality of traditional care

We asked participants to rate the quality of care delivered by the telemedicine services compared to the standard care. Of the 112 respondents to this question, 3 (2,68%) considered the quality of care of telemedicine services to be much better than traditional care, 32 (28,57%) to be better, 54 (48,21%) to be about the same and 23 (20,54%) to be worse. None of the respondents considered that the care delivered by the telemedicine services was much worse.

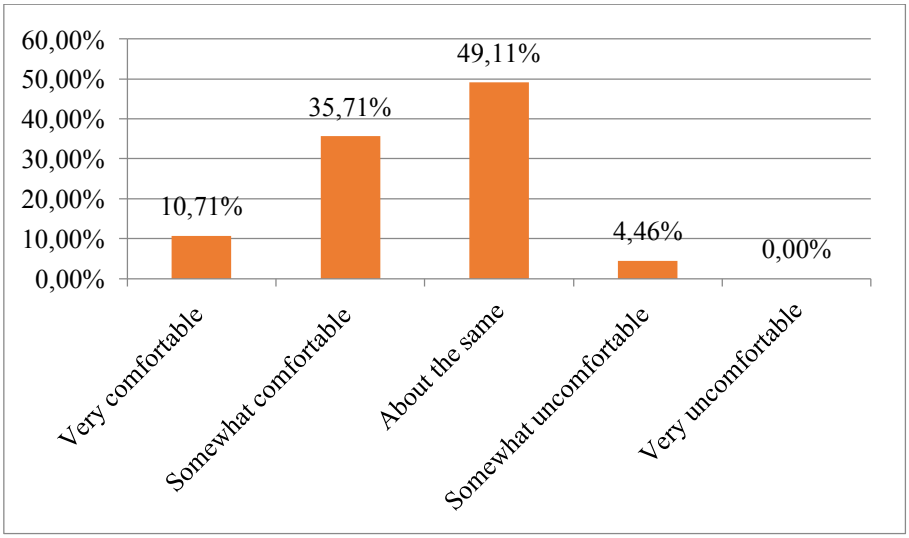
Figure 21: Quality of care of the telemedicine consultation



3.2.3.4 Question 4: feeling during the telemedicine consultation

We asked respondents whether they felt comfortable during the telemedicine consultation. Of the 112 respondents to this question, 12 (10,71%) responded that they felt very comfortable during the telemedicine consultation, 40 (35,71%) somewhat comfortable, 55 (49,11%) felt about the same and 5 (4,46%) felt somewhat uncomfortable during the telemedicine consultation. None of the respondents felt very uncomfortable during telemedicine consultations.

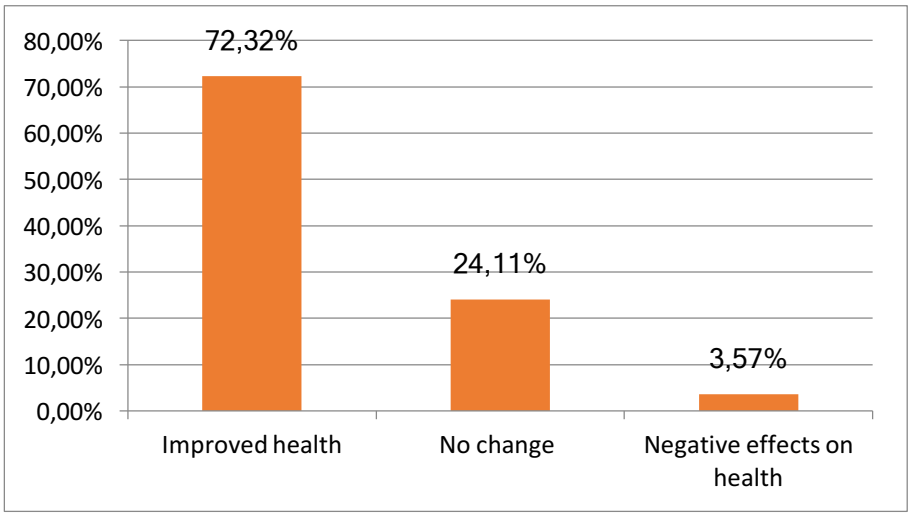
Figure 22: Feeling during the telemedicine consultation



3.2.3.5 Question 5: influence in the health status of the patients

We asked professionals whether they thought that telemedicine services could influence the health status of their patients. Of the 112 respondents to this question, 81 (72,32%) felt that telemedicine services could improve the health of their patients, 27 (24,11%) felt that these services made no change to the health of the patients and 4 (3,57%) felt that telemedicine services could have negative effects on the health of their patients.

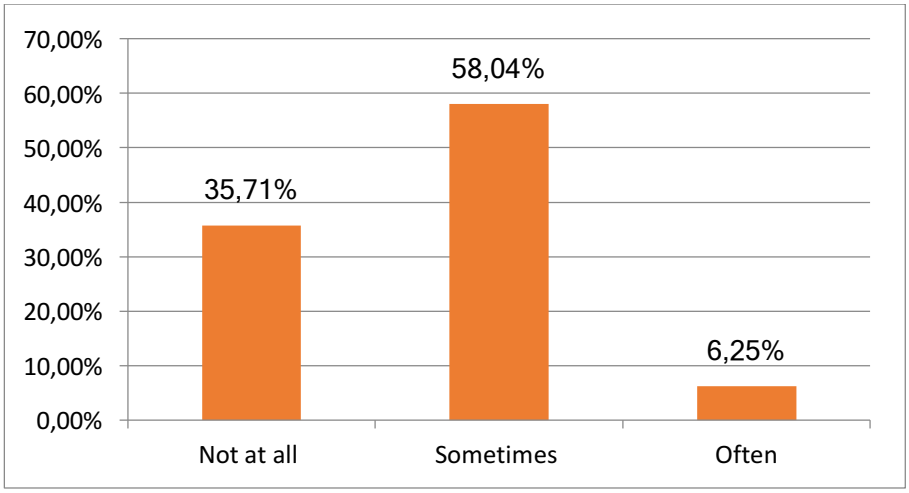
Figure 23: Influence in the health status of patients



3.2.3.6 Question 6: technical difficulties that might affect the quality of care delivered by the telemedicine service

We asked professionals whether they had experienced technical difficulties that might have affected the quality of care delivered by the telemedicine services. Of the 112 respondents to this question, 40 (35,71%) stated that they have not experienced any technical difficulties, 65 (58,04%) reposted experiencing technical difficulties sometimes and 7 (6,25%) stated experiencing technical difficulties often.

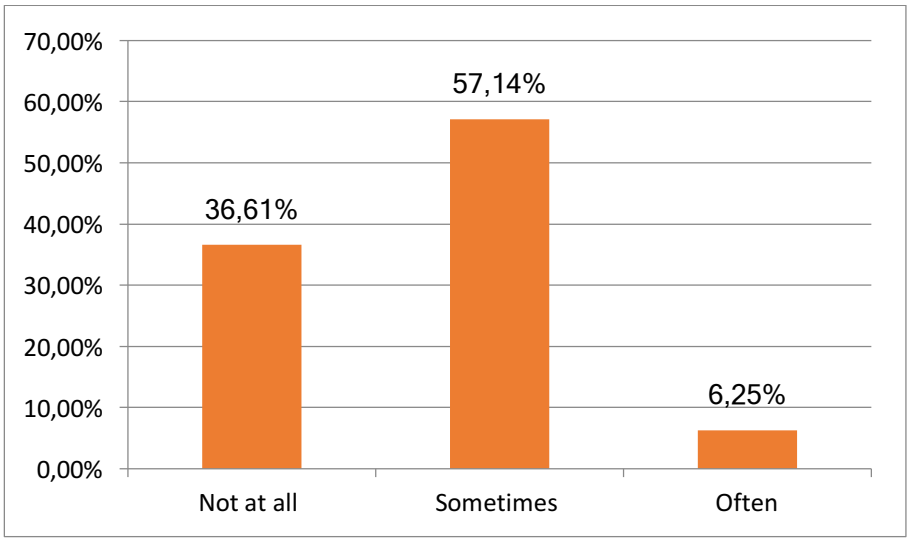
Figure 24: Technical difficulties



3.2.3.7 Question 7: organisational or other difficulties that might affect the quality of care delivered by the telemedicine service

We asked professionals whether they had experienced organisational or other difficulties that might have affected the quality of care delivered by the telemedicine services. Of the 112 respondents to this question, 41 (36,61%) stated that they have not experienced any organisational or other difficulties, 64 (57,14%) reported experiencing organisational difficulties sometimes and 7 (6,25%) stated that often had experienced organisational or other difficulties that could have affected the quality of the care delivered by the telemedicine service.

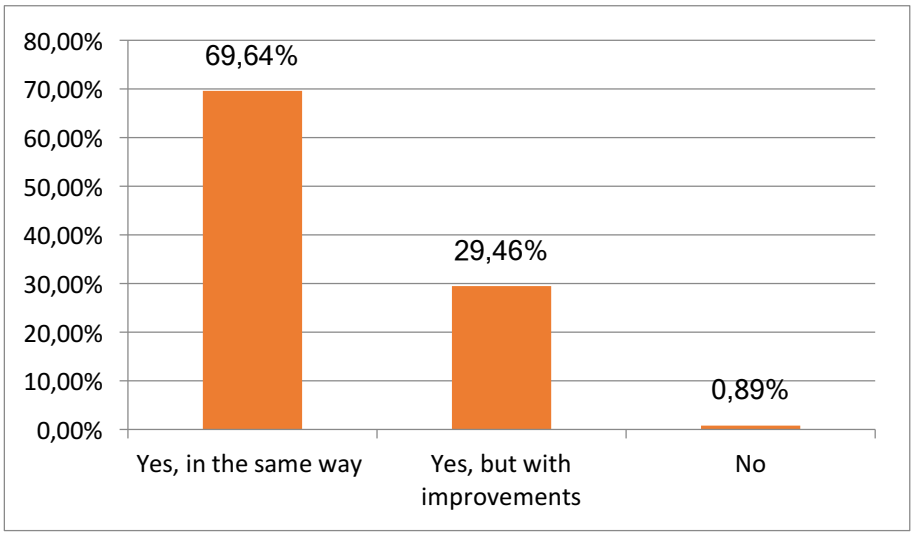
Figure 25: Organisational difficulties



3.2.3.8 Question 8: future use of telemedicine services

Finally, we asked professionals whether they would continue to use telemedicine consultations in the future. Of the 112 respondents to this question, 78 (69,64%) stated they would continue using the service in the same way, 33 (29,46%) stated they would continue using the service but with improvements and 1 (0,89%) respondent stated that he or she would not use telemedicine in the future.

Figure 26: Future use of telemedicine services



3.2.4 Analytic results

3.2.4.1 Characteristics of the respondents

The average age amongst nursing staff was 49 years (minimum 26, maximum 63) and the average amongst medical staff was 47,5 (minimum 30, maximum 64). There were no significant statistical differences in age between professional categories (p=0,407). We can assume equal variances as indicated by the Levene´s test (indicates no significant differences between variances).

Table 35: Age in years by professional categories

Age (years): * Professional category:	Obs	Total	Mean	Var	Std Dev	Min	Max
Nursing	52	2549	49,019	88,568	9,4111	26	63
Medicine	54	2567	47,537	79,536	8,9183	30	64

T-Test

		Prueba de Levene de igualdad de varianzas		prueba t para la igualdad de medias						
									95% de intervalo de confianza de la diferencia	
		F	Sig.	t	gl	Sig. (bilateral)	Diferencia de medias	Diferencia de error estándar	Inferior	Superior
Age (years)	Se asumen varianzas iguales	,349	,556	-,833	104	,407	-1,48219	1,78035	-5,01269	2,04830
	No se asumen varianzas iguales			-,832	103,131	,408	-1,48219	1,78217	-5,01665	2,05227

3.2.4.2 Responses Q1-Q8 by professional category

We looked at differences in responses to the 8 questions of the questionnaire by professional categories and we found significant statistical differences in responses to three questions:

- We found significant differences ($p<0,001$) in the answers to question 3 relating to the rating of the quality of care delivered by the telemedicine services. Nursing staff rated the quality of care of this services significantly better compared with medical staff.
- We found significant differences ($p=0,0026$) in the answers to question 6 relating to technical difficulties that might have affected the quality of care delivered by the telemedicine services. Medical staff stated having experienced more technical difficulties compared with nursing staff.
- We found significant differences ($p<0,001$) in the answers to question 7 relating to organisational and other difficulties that might have affected the quality of care delivered by the telemedicine services. Medical staff stated having experienced more organisational and other difficulties compared with nursing staff.

Table 36: Overall quality of the telemedicine consultation by professional categories

Professional category: * Rating of the overall quality of the telemedicine consultation

Professional category:	Excellent	Good	Normal	Regular	TOTAL
Medicine	4	30	14	6	**54**
Nursing	4	39	5	4	**52**
TOTAL	**8**	**69**	**19**	**10**	**106**

Chi-square	df	Probability
5,8014	3	0,1217

Table 37: Technical quality of the telemedicine consultation by professional categories

Professional category: * Rating of the technical quality of the telemedicine consultatior

Professional category:	Excellent	Good	Normal	Regular	TOTAL
Medicine	1	36	11	6	**54**
Nursing	3	37	8	4	**52**
TOTAL	**4**	**73**	**19**	**10**	**106**

Chi-square	df	Probability
1,8503	3	0,604

Table 38: Quality of care of the telemedicine consultation by professional categories

Professional category: * Rating of the quality of care delivered by the telemedicine

Professional category:	About the same	Better	Much better	Worse	TOTAL
Medicine	26	7	2	19	**54**
Nursing	24	24	1	3	**52**
TOTAL	**50**	**31**	**3**	**22**	**106**

Chi-square	df	Probability
21,3421	3	0,0001

Table 39: Feeling during the telemedicine consultation by professional categories

Professional category: * Feeling during the telemedicine consultation

Professional category:	About the same	Somewhat comfortable	Somewhat uncomfortable	Very comfortable	TOTAL
Medicine	25	20	4	5	**54**
Nursing	24	20	1	7	**52**
TOTAL	**49**	**40**	**5**	**12**	**106**

Chi-square	df	Probability
2,1168	3	0,5485

Table 40: Influence in the health status of patients by professional categories

Professional category: * Influence in the health status of the patients

Professional category:	Improve health	Negative effects on heal	No change	TOTAL
Medicine	35	3	16	**54**
Nursing	42	0	10	**52**
TOTAL	**77**	**3**	**26**	**106**

Chi-square	df	Probability
4,985	2	0,0827

Table 41: Technical difficulties by professional categories

Professional category: * Technical difficulties that might affect the quality of care

Professional category:	Not at all	Often	Sometimes	TOTAL
Medicine	10	5	39	**54**
Nursing	26	2	24	**52**
TOTAL	**36**	**7**	**63**	**106**

Chi-square	df	Probability
11,9348	2	0,0026

Table 42: Organisational difficulties by professional categories

Professional category: * Organisational or other difficulties that might affec

Professional category:	Often	Sometimes	No	TOTAL
Medicine	5	39	10	**54**
Nursing	2	22	28	**52**
TOTAL	**7**	**61**	**38**	**106**

Chi-square	df	Probability
14,5172	2	0,0007

Table 43: Future use of telemedicine services by professional categories

Professional category: * Future use of telemedicine services

Professional category:	Si, igual que ara	Si, però amb millores	No	TOTAL
Medicine	33	21	0	**54**
Nursing	40	11	1	**52**
TOTAL	**73**	**32**	**1**	**106**

Chi-square	df	Probability
4,7602	2	0,0925

3.2.4.3 Responses Q1-Q8 by gender

We looked at differences in responses to the 8 questions of the questionnaire by gender (man/woman) and we have no significant statistical differences in responses to the questions.

Table 44: Overall quality of the telemedicine consultation by gender

Sex: * Rating of the overall quality of the telemedicine consultation

Sex:	Excellent	Good	Normal	Regular	TOTAL
Man	2	16	5	2	**25**
Woman	6	54	14	9	**83**
TOTAL	**8**	**70**	**19**	**11**	**108**

Chi-square	df	Probability
0,2784	3	0,964

Table 45: Technical quality of the telemedicine consultation by gender

Sex: * Rating of the technical quality of the telemedicine consultation

Sex:	Excellent	Good	Normal	Regular	TOTAL
Man	1	15	7	2	**25**
Woman	3	59	12	9	**83**
TOTAL	**4**	**74**	**19**	**11**	**108**

Chi-square	df	Probability
2,5075	3	0,4739

Table 46: Quality of care of the telemedicine consultation by gender

Sex: * Rating of the quality of care delivered by the telemedicine

Sex:	About the same	Better	Much better	Worse	TOTAL
Man	9	7	1	8	**25**
Woman	41	25	2	15	**83**
TOTAL	**50**	**32**	**3**	**23**	**108**

Chi-square	df	Probability
2,699	3	0,4404

Table 47: Feeling during the telemedicine consultation by gender

Sex: * Feeling during the telemedicine consultation

Sex:	About the same	Somewhat comfortable	Somewhat uncomfortable	Very comfortable	TOTAL
Man	10	10	1	4	**25**
Woman	41	30	4	8	**83**
TOTAL	**51**	**40**	**5**	**12**	**108**

Chi-square	df	Probability
1,164	3	0,7616

Table 48: Influence in the health status of patients by gender

Sex: * Influence in the health status of the patients

Sex:	Improve health	Negative effects on heal	No change	TOTAL
Man	18	1	6	**25**
Woman	60	2	21	**83**
TOTAL	**78**	**3**	**27**	**108**

Chi-square	df	Probability
0,1882	2	0,9102

Table 49: Technical difficulties by gender

Sex: * Technical difficulties that might affect the quality of care del

Sex:	Not at all	Often	Sometimes	TOTAL
Man	5	2	18	**25**
Woman	32	5	46	**83**
TOTAL	**37**	**7**	**64**	**108**

Chi-square	df	Probability
2,9375	2	0,2302

Table 50: Organisational difficulties by gender

Sex: * Organisational or other difficulties that might affect the quali

Sex:	Often	Sometimes	No	TOTAL
Man	1	18	6	**25**
Woman	6	44	33	**83**
TOTAL	**7**	**62**	**39**	**108**

Chi-square	df	Probability
2,837	2	0,2421

Table 51: Future use of telemedicine services by gender

Sex: * Future use of telemedicine services

Sex:	Si, igual que ara	Si, però amb millores	No	TOTAL
Man	18	7	0	**25**
Woman	57	25	1	**83**
TOTAL	**75**	**32**	**1**	**108**

Chi-square	df	Probability
0,361	2	0,8349

3.2.4.4 Responses Q1-Q8 by times used telemedicine in last year

We have looked at differences in responses to the 8 questions of the questionnaire in relation to the number of times respondents have used any of the different telemedicine services in the previous year and we have found significant statistical differences in responses to three questions (we have used the Kruskal-Wallis test instead of the ANOVA test because we found that the variable times used telemedicine in the last year is not a variable normally distributed):

- We found significant differences ($p=0,05$) in the answers to question 3 relating to the rating of the quality of care delivered by the telemedicine services. Respondents who used more often the telemedicine services rated the quality of care of this services significantly worse compared with respondents using them less often.
- We found significant differences ($p<0,001$) in the answers to question 6 relating to technical difficulties that might have affected the quality of care delivered by the telemedicine services. Respondents who used more often the telemedicine services stated having experienced more technical difficulties compared with respondents using them less often.

- We found significant differences (p<0,001) in the answers to question 7 relating to organisational and other difficulties that might have affected the quality of care delivered by the telemedicine services. Respondents who used more often the telemedicine services stated having experienced more organisational and other difficulties compared with respondents that used telemedicine less often.

Figure 27: Overall quality of the telemedicine consultation by times used telemedicine

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Times used a telemedicine service in last year is the same across categories of Rating of the overall quality of the telemedicine consultation.	Independent-Samples Kruskal-Wallis Test	.885	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

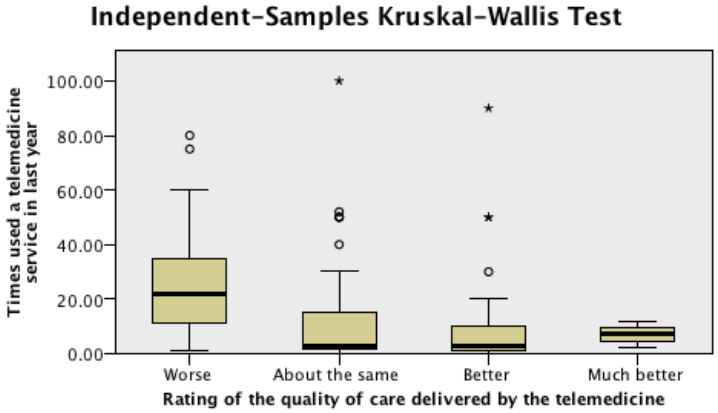
Figure 28: Technical quality of the telemedicine consultation by times used telemedicine

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Times used a telemedicine service in last year is the same across categories of Rating of the technical quality of the telemedicine consultation.	Independent-Samples Kruskal-Wallis Test	.685	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure 29: Quality of care of the telemedicine consultation by times used telemedicine



Total N	103
Test Statistic	12.892
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	.005

Figure 30: Feeling during the telemedicine consultation by times used telemedicine

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Times used a telemedicine service in last year is the same across categories of Feeling during the telemedicine consultation.	Independent-Samples Kruskal-Wallis Test	.202	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

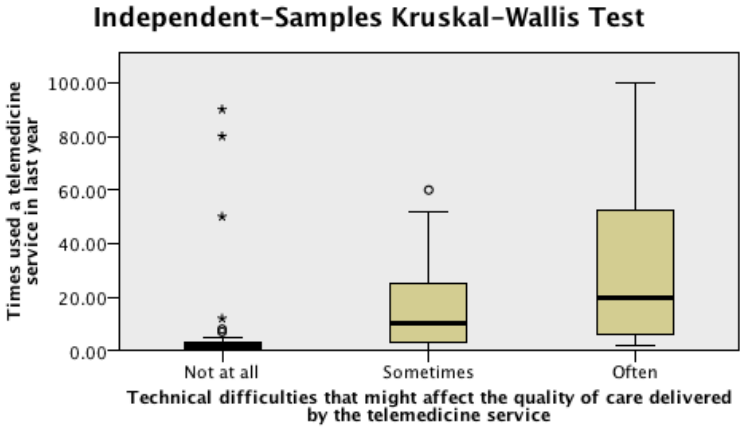
Figure 31: Influence in the health status of patients by times used telemedicine

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Times used a telemedicine service in last year is the same across categories of Influence in the health status of the patients.	Independent-Samples Kruskal-Wallis Test	.277	Retain the null hypothesis.

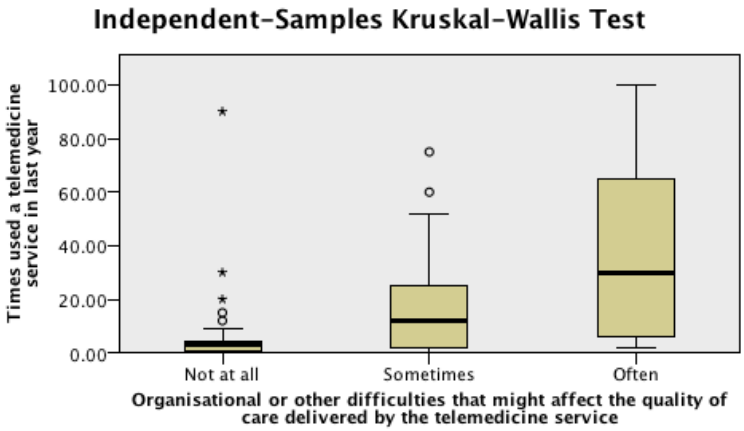
Asymptotic significances are displayed. The significance level is .05.

Figure 32: Technical difficulties by times used telemedicine



Total N	103
Test Statistic	16.998
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	.000

Figure 33: Organisational difficulties by times used telemedicine



Total N	103
Test Statistic	16.400
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	.000

Figure 34: Future use of telemedicine services by times used telemedicine

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Times used a telemedicine service in last year is the same across categories of Future use of telemedicine services.	Independent-Samples Kruskal-Wallis Test	.565	Retain the null hypothesis.

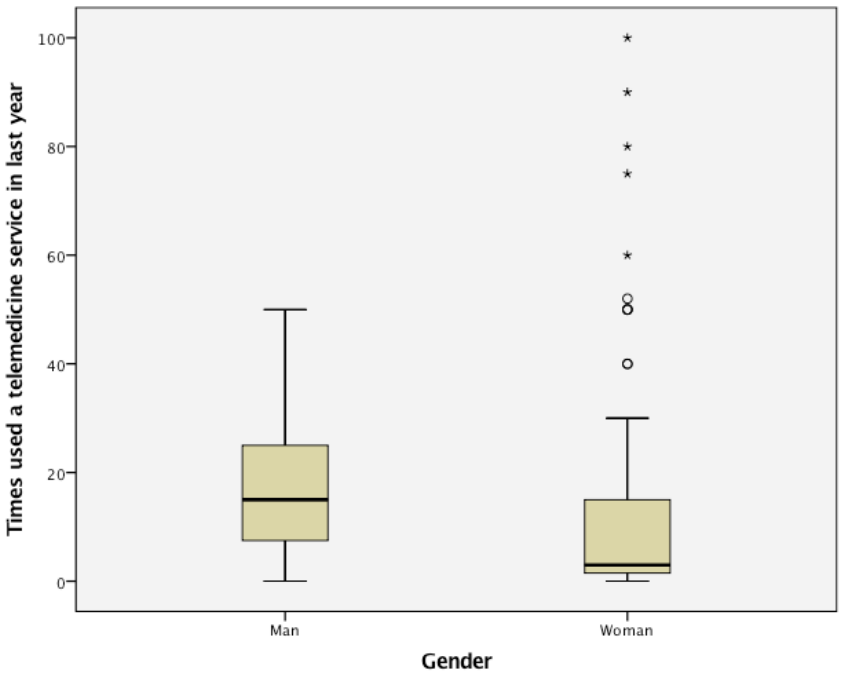
Asymptotic significances are displayed. The significance level is .05.

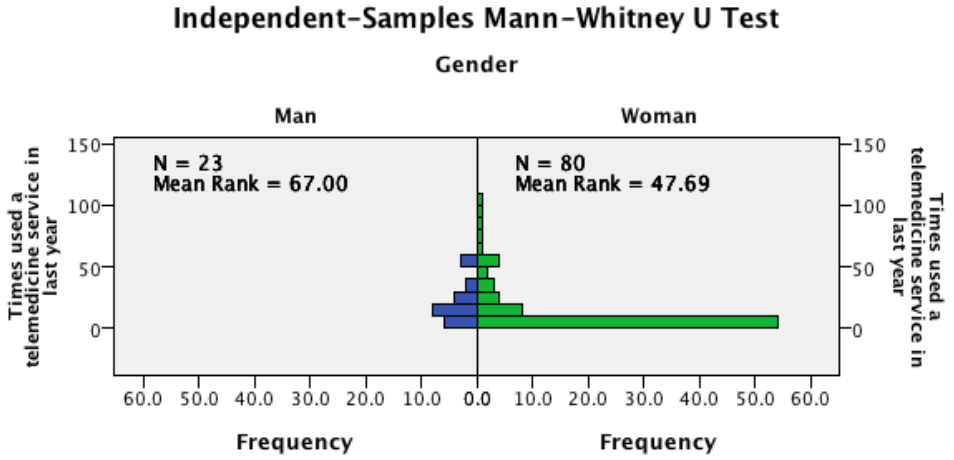
3.2.4.5 Times used a telemedicine service by gender

We looked at differences in the number of times respondents have used any of the different telemedicine services in the last year by gender (man/woman) and we found significant statistical differences (p=0,006). We have used the Mann-Whitney test instead of the T student test because we found that the variable times used telemedicine in the last year is not a variable normally distributed.

We found that men used the telemedicine service significantly more often than women.

Figure 35: Times used a telemedicine service by gender





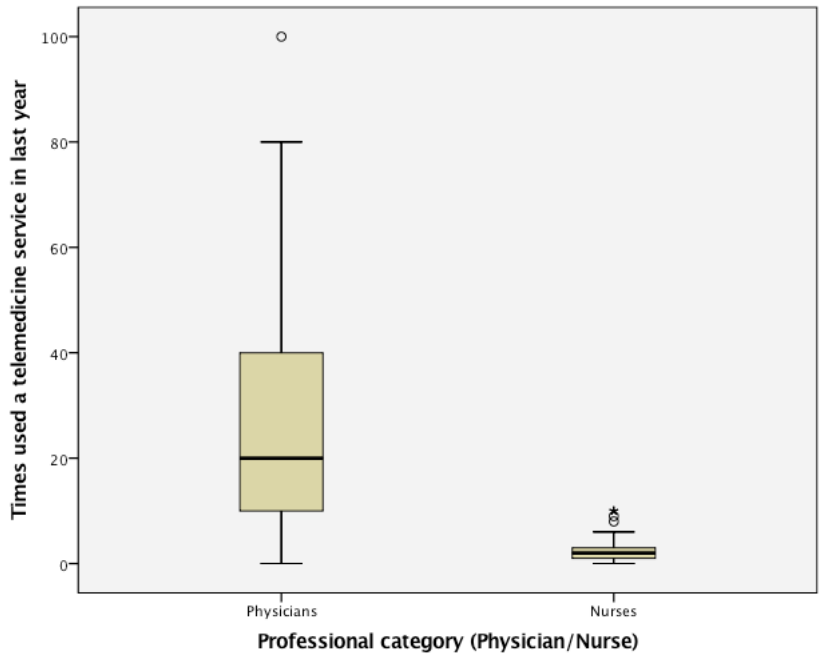
Total N	103
Mann-Whitney U	575.000
Wilcoxon W	3,815.000
Test Statistic	575.000
Standard Error	125.792
Standardized Test Statistic	-2.743
Asymptotic Sig. (2-sided test)	.006

3.2.4.6 Times used a telemedicine service by professional category

We looked at differences in the number of times respondents have used any of the different telemedicine services available in the last year by professional category (physicians/nurses) and we found significant statistical differences ($p<0,001$).

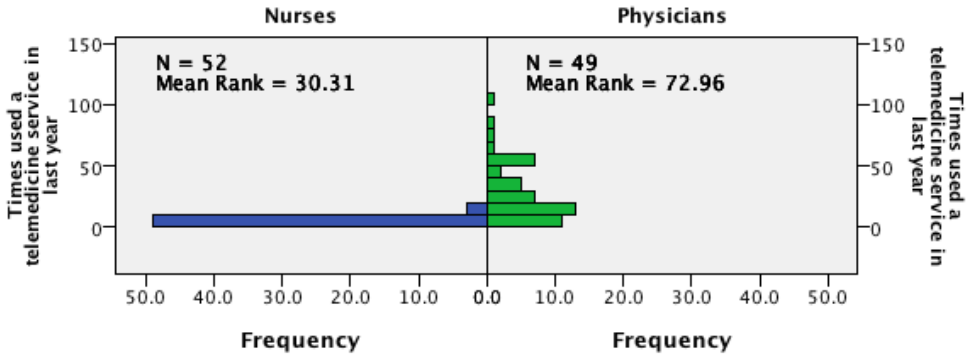
We found that physicians used the telemedicine service significantly more often than nurses.

Figure 36: Times used a telemedicine service by professional category



Independent-Samples Mann-Whitney U Test

Professional category (Physician/Nurse)



Total N	101
Mann-Whitney U	198.000
Wilcoxon W	1,576.000
Test Statistic	198.000
Standard Error	146.565
Standardized Test Statistic	-7.341
Asymptotic Sig. (2-sided test)	.000

3.2.4.7 Type of telemedicine service used by gender

We looked at whether the differences in the type of medicine used by respondents and by gender were statistically significant using the Pearson chi-square test (we used this test as none of the cells had an expected count of less than 5). To check the directions of the differences, we used the Odds Ratio (OD).

We found that with teledermatology, differences in use between men and women were statistically significant (p=0,002). We also found differences with teleulcers (p=0,002) and teleaudiometries (p=0,003).

With teledermatology we found an OR of 1,476 (95% CI: 1,236-1,761) between men and women that meant that men used 1.5 times more often teledermatology that women.

With teleulcers we found an OR of 0,447 (95% CI: 0,233-0,856) between men and women that meant that men used 0,5 times less often teleulcers that women.

With teleaudiometries we found an OR of 2,043 (95% CI: 1,324-3,152) between men and women that meant that men used 2 times more often teleaudiometries that women.

Table 52: Teledermatology use by gender

			Teledermatology		Total
			NO	YES	
Gender	Man	Count	1	24	25
		% within Gender	4,0%	96,0%	100,0%
	Woman	Count	29	54	83
		% within Gender	34,9%	65,1%	100,0%
Total		Count	30	78	108
		% within Gender	27,8%	72,2%	100,0%

Risk Estimate

	Value	95% Confidence Interval	
		Lower	Upper
For cohort Teledermatology = YES	1,476	1,236	1,761
N of Valid Cases	108		

Table 53: Teleulcers use by gender

			Teleulcers		
			NO	YES	Total
Gender	Man	Count	18	7	25
		% within Gender	72,0%	28,0%	100,0%
	Woman	Count	31	52	83
		% within Gender	37,3%	62,7%	100,0%
Total		Count	49	59	108
		% within Gender	45,4%	54,6%	100,0%

		Interval	
	Value	Lower	Upper
For cohort Teleulcers = YES	0,447	0,233	0,856
N of Valid Cases	108		

Table 54: Teleaudiometries use by gender

			Teleaudiometries		
			NO	YES	Total
Gender	Man	Count	9	16	25
		% within Gender	36,0%	64,0%	100,0%
	Woman	Count	57	26	83
		% within Gender	68,7%	31,3%	100,0%
Total		Count	66	42	108
		% within Gender	61,1%	38,9%	100,0%

		95% Confidence Interval	
	Value	Lower	Upper
For cohort Teleaudiometries = YES	2,043	1,324	3,152
N of Valid Cases	108		

3.2.4.8 Type of telemedicine service used by professional category

We looked at whether the differences in the type of medicine used by respondents and by professional category were statistically significant using the Pearson chi-square test (we used this test as none of the cells had an expected count of less than 5). To check the directions of the differences, we used the Odds Ratio (OD).

We found that with the teledermatology service, differences in use between physicians and nurses were a statistically significant (p<0.001). We also found differences with the teleulcers service (p<0.001) and teleaudiometries (p<0.001).

With teledermatology we found an OR of 2,261 (95% CI: 1,666-3,068) between physicians and nurses that meant that physicians used 2.3 times more teledermatology that nurses.

With teleulcers we found an OR of 0,272 (95% CI: 0,168-0,441) between physicians and nurses that meant that physicians used 0.7 times less the teleulcers services that nurses.

With teleaudiometries we did not perform an OR between physicians and nurses as none of the nurses that respondent to the questionnaire stated using teleaudiometries.

Table 55: Teledermatology use by professional category

			Teledermatology		Total
			NO	YES	
Professional category (Physician/Nurse)	Physicians	Count	0	54	54
		% within Professional category (Physician/Nurse)	0,0%	100,0%	100,0%
	Nurses	Count	29	23	52
		% within Professional category (Physician/Nurse)	55,8%	44,2%	100,0%
Total		Count	29	77	106
		% within Professional category (Physician/Nurse)	27,4%	72,6%	100,0%

	Value	95% Confidence Interval	
		Lower	Upper
For cohort Teledermatology = YES	2,261	1,666	3,068
N of Valid Cases	106		

Table 56: Teleulcers use by professional category

			Teleulcers		
			NO	YES	Total
Professional category (Physician/Nurse)	Physicians	Count	41	13	54
		% within Professional category (Physician/Nurse)	75,9%	24,1%	100,0%
	Nurses	Count	6	46	52
		% within Professional category (Physician/Nurse)	11,5%	88,5%	100,0%
Total		Count	47	59	106
		% within Professional category (Physician/Nurse)	44,3%	55,7%	100,0%

		Interval	
	Value	Lower	Upper
For cohort Teleulcers = YES	0,272	0,168	0,441
N of Valid Cases	106		

Table 57: Teleaudiometries use by professional category

			Teleaudiometries		
			NO	YES	Total
Professional category (Physician/Nurse)	Physicians	Count	14	40	54
		% within Professional category (Physician/Nurse)	25,9%	74,1%	100,0%
	Nurses	Count	52	0	52
		% within Professional category (Physician/Nurse)	100,0%	0,0%	100,0%
Total		Count	66	40	106
		% within Professional category (Physician/Nurse)	62,3%	37,7%	100,0%

3.2.5 Correlations

Although we were aware that we had ordinal qualitative variables and not continuous variables, we performed correlations between the responses to questions 1 to 8 to check if we could find any correlations statistically significant.

Although we found several correlations statistically significant (p=0,01) we just considered then relevant when the absolute value of the Pearson correlation coefficient was >0,5.

We found the following correlations:

- Positive correlation (PCC=0,728) between the overall quality of the telemedicine consultation and rating of the technical quality of the telemedicine consultation.
- Positive correlation (PCC=0,583) between the overall quality of the telemedicine consultation and the future use of telemedicine.
- Positive correlation (PCC=0,505) between the technical quality of the telemedicine consultation and the future use of telemedicine
- Negative correlation (PCC=0,-531) between organisational or other difficulties that might affect the quality of care delivered by the telemedicine service and the future use of telemedicine

Table 58: Correlations between Q1-Q8

		Rating of the overall quality of the telemedicine consultation	Rating of the technical quality of the telemedicine consultation	Rating of the quality of care delivered by the telemedicine	Feeling during the telemedicine consultation	Influence in the health status o the patients	Technical difficulties that might affect the quality of care delivered by the telemedicine service	Organisational or other difficulties that might affect the quality of care delivered by the telemedicine service	Future use of telemedicine services
Rating of the overall quality of the telemedicin consultation	Pearson Correlation	1	,728**	,388**	,468**	,346**	-,271**	-,422**	,583**
	Sig. (2-tailed)		0,000	0,000	0,000	0,000	0,004	0,000	0,000
	N	112	112	112	112	112	112	112	112
Rating of the technical quality of the telemedicin consultation	Pearson Correlation	,728**	1	,419**	,480**	,384**	-,379**	-,363**	,505**
	Sig. (2-tailed)	0,000		0,000	0,000	0,000	0,000	0,000	0,000
	N	112	112	112	112	112	112	112	112
Rating of the quality of care delivered by the telemedicine	Pearson Correlation	,388**	,419**	1	,301**	,322**	-,256**	-,353**	,308**
	Sig. (2-tailed)	0,000	0,000		0,001	0,001	0,007	0,000	0,001
	N	112	112	112	112	112	112	112	112
Feeling during the telemedicine consultatior	Pearson Correlation	,468**	,480**	,301**	1	,324**	-0,054	-,312**	,384**
	Sig. (2-tailed)	0,000	0,000	0,001		0,000	0,569	0,001	0,000
	N	112	112	112	112	112	112	112	112
Influence in the health status of the patients	Pearson Correlation	,346**	,384**	,322**	,324**	1	-0,183	-0,162	,348**
	Sig. (2-tailed)	0,000	0,000	0,001	0,000		0,054	0,088	0,000
	N	112	112	112	112	112	112	112	112
Technical difficulties that might affect the quality of care delivered by the telemedicine service	Pearson Correlation	-,271**	-,379**	-,256**	-0,054	-0,183	1	,506**	-,331**
	Sig. (2-tailed)	0,004	0,000	0,007	0,569	0,054		0,000	0,000
	N	112	112	112	112	112	112	112	112
Organisational or other difficulties that might affect the quality of care delivered by the telemedicine service	Pearson Correlation	-,422**	-,363**	-,353**	-,312**	-0,162	,506**	1	-,531**
	Sig. (2-tailed)	0,000	0,000	0,000	0,001	0,088	0,000		0,000
	N	112	112	112	112	112	112	112	112
Future use of telemedicir services	Pearson Correlation	,583**	,505**	,308**	,384**	,348**	-,331**	-,531**	1
	Sig. (2-tailed)	0,000	0,000	0,001	0,000	0,000	0,000	0,000	
	N	112	112	112	112	112	112	112	112

**. Correlation is significant at the 0.01 level (2-tailed).

As an exercise of curiosity, we have used a multivariate linear regression model to look at which variables could predict the future use of the telemedicine services. We have found 2 variables that significantly contribute to predict the future use of the telemedicine services: the overall quality of the telemedicine consultation (p=0,004) that can positively predict the future use and organisational or other difficulties that might affect the quality of care delivered by the telemedicine service (p=0,001) that can negatively predict its future use.

Table 59: Variables that can predict future use of the telemedicine services

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1,817	0,336		5,404	0,000
	Rating of the overall quality of the telemedicin consultation	0,209	0,072	0,322	2,918	0,004
	Rating of the technical quality of the telemedicin consultation	0,049	0,079	0,071	0,615	0,540
	Rating of the quality of care delivered by the telemedicine	-0,020	0,053	-0,032	-0,387	0,699
	Feeling during the telemedicine consultation	0,040	0,057	0,061	0,695	0,489
	Influence in the health status of the patients	0,128	0,072	0,142	1,769	0,080
	Technical difficulties that might affect the quality of care delivered by the telemedicine service	-0,027	0,075	-0,032	-0,364	0,717
	Organisational or other difficulties that might affect the quality of care delivered by the telemedicine service	-0,268	0,077	-0,322	-3,495	0,001

a. Dependent Variable: Future use of telemedicine services

ANOVÂ

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12,195	7	1,742	13,064	,000[b]
	Residual	13,868	104	0,133		
	Total	26,063	111			

a. Dependent Variable: Future use of telemedicine services

b. Predictors: (Constant), Organisational or other difficulties that might affect the quality of care delivered by the telemedicine service, Influence in the health status of the patients, Feeling durir telemedicine consultation, Rating of the quality of care delivered by the telemedicine , Technical difficulties that might affect the quality of care delivered by the telemedicine service, Rating of th overall quality of the telemedicine consultation, Rating of the technical quality of the telemedicin consultation

4. Discussion

4.1 Validation of the questionnaire

Despite conducting a literature review, we could not find a short validated questionnaire to assess perceptions of health care professionals with asynchronous telemedicine services.

We found a study evaluating teledermatology adoption by health-care professionals using a modified Technology Acceptance Model conducted by Orruño *et al* in 2011. The researchers used a well designed questionnaire with 33 items grouped into eight theoretical dimensions. They calculated the Cronbach's alpha for each theoretical variable and checked internal consistency of the questionnaire reporting good results (Orruño et al. 2011). Overall we think this is a very good questionnaire; however, although the researchers reported very good response rates (62%), in our opinion, it has too many items that could hinder participation.

Larcher *et al.* also conducted a user satisfaction study assessing satisfaction with a teleoncology program. They also reported good response rates but again they used a long questionnaire with 39 closed-response questions (Larcher et al. 2003).

Barbieri *et al.* conducted a web-based survey to 30 primary care providers. The survey had 15 short questions and contained a Likert scale with 5 options. However, the authors did not follow a technology acceptance model as the survey did not comprise the technological context and the implementation or organisational context. Moreover, the authors did not indicate whether the survey was validated (Barbieri et al. 2015).

For these reasons, we decided to translate, adapt and validate the questionnaire found in the EU project Health Optimum. We used a pilot questionnaire to validate the final translated version of the questionnaire. The pilot questionnaire achieved good internal

consistency (0,84) and excellent intraclass correlation [0,93 (95% CI:0,852-0,964)] which indicates that we constructed a robust questionnaire.

4.2 Questionnaire's results

We had an overall low response rate of just 24.7%. However, it should be noticed that we sent the questionnaire to all physicians, nurses and dentists of the counties of Bages and Berguedà, regardless if they used a teledermatology service or not. Although several respondents (40) stated that they never had used a telemedicine service, it has to be expected that many professionals not using the services did not reply the survey as they could have assumed the questionnaire was just for those using telemedicine.

4.2.1 Characteristics of the respondents

76,85% of respondents to the questionnaire were women compared to only 23,15% men. This was consistent with the proportion of women working at the Institut Català de la Salut, which was 75,3% in 2017 (Institut Català de la Salut 2017).

The average age of respondent was 48,4 years, with 47,53 years for physicians and 49,01 years for nurses. Differences in age between categories were not significant statistically. This was different from the average age of healthcare professionals in Catalonia in 2005, which was 44,6 years for physicians and 39 years for nurses (Solsona i Pairo et al. 2004).

By professional category, 50% of respondents were physicians, 48,15% nurses and 1,85% from other categories. None of the respondents were dentist.

4.2.2 Utilization of telemedicine services

Of the three telemedicine services available in the region (teledermatology, teleulcers and teleaudiometries) the most used by healthcare professionals was teledermatology, followed by teleulcers and teleaudiometries. It was expected to find that

teledermatology was the most used service as it had been established for a long time and figures shown that every year more than 5.000 patients are referred to this service (see table 12). However, it was remarkable that nearly 40% of respondents stated using teleulcers, as teleulcers referrals are significantly less (84 in 2015 and 94 in 2016) than referrals to teledermatology (see Appendix I). It was a surprise to find that just 28% of respondents stated using teleaudiometries when this service was used by 1.627 professionals during 2017 (see Appendix II). Maybe this can be explained because we had a high percentage of nurses answering the questionnaire and nurses use mainly teleulcers.

When evaluating the times that respondents stated using any of the telemedicine services in the last year, we decided to partially exclude from calculations 5 extreme responses that we thought were outliers. Probably these responses were mistakes as it was difficult to believe that somebody used the telemedicine services 200 times in just a year.

We looked at the type of telemedicine services used by gender. As most of the respondents were women, all three telemedicine services were used mostly by women. When we evaluated the services used by men, they stated using mainly teledermatology and teleaudiometries and just 28% used teleulcers. In the contrary, amongst women, the most commonly used services were teledermatology, teleulcers and the least used was teleaudiometries.

We have looked at the type of telemedicine services used by professional category. Telemedicine and teleaudiometries were mostly used by physicians and teleulcers was used mainly by nurses. When we evaluated services used by physicians, all of them used teledermatology and most of them teleaudiometries. Nurses overwhelmedly used teleulcers and in a much less proportion, teledermatology. It was expected that

physicians would use telemedicine and teleaudiometries and that nurses would use teleulcers, but it was surprising to find that nurses reported using the teledermatology service as this service was initially targeted for the physicians' use.

4.2.3 Descriptive results

2/3 of respondents rated the overall quality and the technical quality of the telemedicine consultations as good.

When asked for the quality of care delivered by the telemedicine service compared to the quality of traditional care, nearly half of respondents stated that the quality was about the same. Around 30% considered the quality of care was better or much better and just 20% considered the quality of care to be worse.

When asking whether they felt comfortable during the telemedicine consultation, also about half of the respondents stated feeling about the same. A little less of half of the rest of respondents stated feeling somewhat comfortable and very comfortable and just 4% felt somewhat uncomfortable.

More than 2/3 of respondents considered that telemedicine services could improve the health status of patients. About 1/4 of respondents considered that telemedicine had no effect on the health status of patients and less than 4% considered it had negative effects on their health.

Nearly 60% of respondents stated that they had technical, organisational or other difficulties that might affected the quality of care delivered by the telemedicine services. Around 1/3 of respondents stated not having such difficulties and about 6% said they had this kind of difficulties often.

When asked about future use of the telemedicine services, it is remarkable that more than 2/3 of respondents wanted to keep using the services in the same way, the rest wanted to use the service but with some improvements.

4.2.4 Analytic results

4.2.4.1 Responses Q1-Q8 by professional category and gender

When analysing the results to the questionnaire by professional categories, we found that nursing staff rated the overall quality of care delivered by the telemedicine services statistically significantly better that medical staff.

Medical staff stated having more technical, organisational and other difficulties that might have affected the quality of care delivered by the telemedicine services, compared with nursing staff. These differences were statistically significant.

It is relevant that physicians stated having more difficulties that could have affected the quality of care compared with nurses. Nurses rated the quality of care delivered by telemedicine significantly better than physicians.

We did not find statistically significant differences in responses to the 8 questions by the gender of the respondents.

4.2.4.2 Responses Q1-Q8 by times used telemedicine in the last year

We found that respondents to the questionnaire, who used more often the telemedicine services in the previous year, significantly rated the quality of care of these services worse than respondents who used them less often. They also stated having experienced more technical, organisational and other difficulties that could affected the quality of care delivered. It seems that the more often you use the services, more difficulties you encounter and therefore you rate the quality of care worse. Professionals using the service less often encounter fewer difficulties and rated the quality of the service better.

4.2.4.3 Times used telemedicine in the last year by gender and professional category

We found that despite in absolute numbers, fewer men used the telemedicine services, men used the services a number of times higher than women and this was statistically significant.

We found that physicians used the telemedicine services a number of times higher than nurses and this was statistically significant.

4.2.4.4 Type of telemedicine service used by gender and professional category

We found statistically significant differences in the type of telemedicine services used by men and women. Men used 1,5 times more teledermatology and 2 times more teleaudiometries but used 0,5 times less teleulcers.

We found statistically significant differences in the type of telemedicine services used by physicians and nurses. Physicians used 2,3 times more teledermatology and were the only professionals that used teleaudiometries. However, physicians used 0,7 less times teleulcers.

We think the differences are explained by the fact that in the area, most of the nurses are women and nurses used mainly teleulcers. Moreover, nurses used less teledermatology and teleaudiometries.

4.2.4.5 Correlations

We performed correlations between responses to questions 1 to 8 and we found two positive significant and relevant correlations related with the future use of the telemedicine services. People who rated the overall and technical quality of the service higher were more in favour of using the services in the future. We also found a positive correlation between overall quality of the telemedicine service and the technical quality

of the consultation. People rating the quality better, were also rating the technical quality better.

We found a negative correlation between organisational and other difficulties that might have affected the quality of care delivered by telemedicine services and the future use of the service. Respondents having had difficulties were more reluctant to use the services in the future.

Using these correlations, as a purely illustration of the observed conditions, we tried to evaluate which variables could predict future use of the telemedicine services using a multivariate linear regression model. Although we are aware of the methodological limitations of this exercise, the aim of this was to try to reduce the questionnaire to even fewer questions. We found that just using two questions, we might be able to predict future use. The two questions were: rating of the overall quality of the telemedicine consultation and organisational and other difficulties that might affect the quality delivered by the telemedicine service.

4.3 Limitations

4.3.1 Selection bias

We had a lower response rate to the survey and this needs to be taking in consideration when analysing the results.

The fact of using a Web-based survey implies a possible bias in obtaining answers by those with better technology management.

It is possible that the survey had been answered by people more in favour of the telemedicine services. People not using them or people that had bad experiences with the services may had not responded to the questionnaire.

There was another possible bias in relation with the high percentage of physicians and nurses that responded the questionnaire, caused for the higher number of those

professional categories compared with the other clinical category included in the survey (odontologists).

4.3.2 Small numbers

It should be noted that Chi-square test can give inaccurate results when the expected numbers are small as it happens in some of the results obtained in this study where for same variables, expected numbers are less than 5.

We have tried to solve the problem by grouping some of the variables. In questions 1 and 2, we have grouped together the positive variables such as excellent and good in one hand and the negative variables such as regular and bad in the other hand. In question 3, we have grouped much better with better and worse with much worse. In question 4 we have grouped very comfortable with somewhat conformable and somewhat uncomfortable and very uncomfortable.

We recalculated the Chi-square again and we did not find any differences in the results. Anyway, despite the grouping, we still had expected values of less than 5.

4.3.3 Correlations

We performed correlations using ordinal qualitative variables from questions 1 to 8. Although we are aware that this was not statistically very neat, we thought that it could help us to understand relations among the factors we were dealing with, like satisfaction, difficulties and future use. We only considered Pearson correlation coefficients bigger than 0,5. We also used a multivariate linear regression model as a qualitative and naïf exercise to propose possible relations between variables, and also in order to propose the key questions to measure the success of teledermatology. Our purpose was not to draw exact conclusions or certainties, not to quantify relations, but to observe possible relations and to find possible indicators of success.

4.3.4 Staff training

It is important to remark that staff using the telemedicine services in the Catalan central region did not receive any training relating for example to the quality of the photographs taken, prior utilization of the services. New health professionals who join the primary care teams neither receive any training.

Professionals that had difficulties were more reluctant to use the services in the future; probably if professionals had received some form of previous training they would have had less technical and organisational difficulties that may negatively affect the future use of the services.

5. Conclusions

We validated and distributed a questionnaire to assess the acceptance of telemedicine services amongst health professionals in the Catalan central region. We obtained a 24,7% response rate. Respondents were physicians and nurses, and mainly women (77%).

Of the three telemedicine services available in the region the most used by healthcare professionals was teledermatology (52,15%), followed by teleulcers (39,26%) and teleaudiometries (28,22%).

2/3 of respondents rated the overall quality and the technical quality of the telemedicine consultations as good. More than 2/3 of respondents considered that telemedicine services could improve the health status of patients and more than 2/3 of respondents wanted to keep using the services in the same way as they were using it.

Nursing staff rated the overall quality of care delivered by the telemedicine services statistically significantly better that medical staff. Physicians stated having more difficulties that could have affected the quality of care compared with nurses.

Respondents to the questionnaire, who used more often the telemedicine services in the previous year, significantly rated the quality of care of these services worse than respondents who used them less often. They also stated having experienced more technical, organisational and other difficulties that could affected the quality of care delivered.

Physicians used 2,3 times more teledermatology and were the only professionals that used teleaudiometries. However, physicians used 0,7 less times teleulcers.

We found a negative correlation between organisational and other difficulties that might have affected the quality of care delivered by telemedicine services and the future use of

the service. Respondents having had difficulties were more reluctant to use the services in the future.

ACCEPTANCE OF TELEMEDICINE; AN EXPERIMENTAL TWITTER POLL

1. Introduction

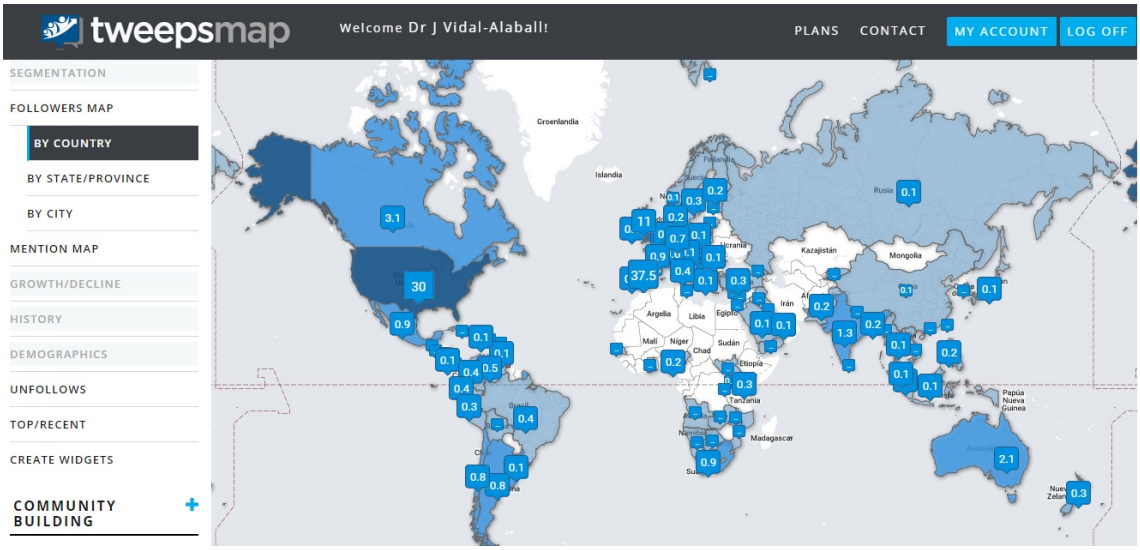
Twitter is an "online news and social networking service where users post and interact with messages, called "tweets". Twitter had 319 million active users in 2016 (Wikipedia 2017). Since 2015 Twitter has introduced the possibility of posting anonymous polls. Just registered users can post tweets and reply to polls; unregistered users can only read tweets and polls, but not reply to them.

Twitter has been used as a platform to disseminate guidelines and perform polls by the European Association of Urology (Dal Moro 2013; Borgmann et al. 2015; Loeb et al. 2017). With Twitter polls it is possible to reach big audiences very quickly and very efficiently. Moreover, the fact that Twitter polls do not allow knowing the identity of respondents and only one answer is allowed give additional robustness to these polls.

The objective of this study was to explore the utility of twitter polls to assess acceptance of telemedicine among twitter users.

2. Methodology

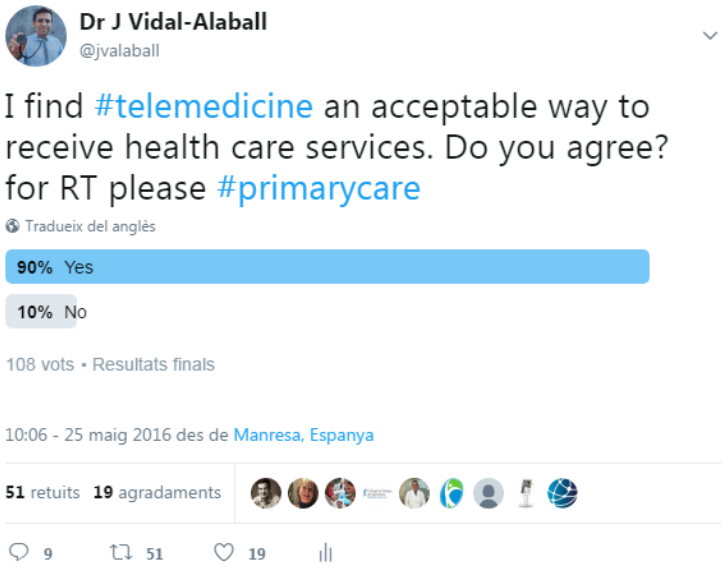
We conducted two twitter polls using questions from previously used questionnaires in 2016 and 2017 to explore acceptance of telemedicine among twitter users. We posted the polls on one of the author's twitter timeline https://twitter.com/jvalaball and asked his followers to answer the poll and retweet it to reach a bigger audience. @jvalaball has more than 8,600 followers worldwide, mainly from Spain (37.5%), United States (30%) and United Kingdom (11%).



3. Results

The first poll was posted in May 2016 and was pinned in the top of one of the author's timeline for 7 days. We used a question from the Telemedicine satisfaction questionnaire, a validated questionnaire developed by Yip *et al.* in 2002 (Yip et al. 2002). The question posted was "I find telemedicine an acceptable way to receive health care services. Do you agree?" There were only allowed two answers, "yes" or "no".

The poll was retweeted 51 times and had 6.698 impressions. It received a total of 108 votes, 90% of which were positive and 10% negative.



The second poll was posted during November 2017 and also pinned in the top of the timeline for 7 days. We used a question from the Physician questionnaire in the EU project Health Optimum (Kidholm et al. 2011). The question posted was "How do you rate the quality of care delivered by telemedicine when compared to the quality of traditional care?" Four answers were allowed: "better", "about the same", "not as good" and "not sure".

The poll was retweeted 49 times and had 4.364 impressions. The poll received a total of 113 votes. 39% of the respondents stated that they rated the quality of care delivered by telemedicine not as good as the traditional care, 19% found the quality of care about the same, 22% rated the quality of care as better and 20% were not sure.

4. Discussion

This is a novel experiment of using the twitter poll tool with questions from previously used questionnaires to assess acceptance of telemedicine amongst Twitter users. The first poll showed an overwhelming support towards telemedicine as an acceptable way to receive health care services. However, in the second poll, when asked Twitter users to rate the quality of care delivered by telemedicine when compared to the quality of

traditional care, a majority of users found that telemedicine was not as good as traditional care.

We are aware of the limitations of the methodology used but this is an experiment aiming to explore this new feature of twitter. Josep Vidal-Alaball has more than 8.600 followers and it can be argued that his followers are more in favour of telemedicine and new technologies as he often twit about this topic. It is also known that twitter users are not representative of the general population in terms of demographics. Mellon and Prosser studied twitter users and concluded that they are considerably younger than the general population (mean age: 34), slightly more male and have higher levels of education (Mellon & Prosser 2016). We tried to contact Twitter, Inc. to obtain more information about the characteristics of the respondents, but the company never replied.

However it is also true that with this tool it is possible to reach huge audiences very quickly and very efficiently. The fact that Twitter polls do not allow knowing the identity of respondents and that we have used previously used questionnaires for the polls give an extra plus of scientific robustness to this study.

5. Conclusions

In our opinion, targeted Twitter polls can be used to quickly perform surveys to assess the opinion of users regarding acceptance of telemedicine and even to validate questionnaires.

CHAPTER 5

FINAL CONCLUSIONS OF THE THESIS

This PhD thesis evaluates a fully operational telemedicine service, a service that has been implemented in the professional´s daily clinical work since 2012.

Our economic study showed that using a teledermatology service instead of a face-to-face dermatology service could save up to 51.164€ a year in the county of Bages. This is equivalent to a saving of 11,4€ per patient attended. Most of the savings come from a society point of view. Extrapolating the savings for the whole population of Catalonia would amount to a savings of 2,085,061 € a year.

Although in 2016 there were more teledermatology visits than in 2015 (5.71% increase), this did not correlate with an increase in the conventional dermatology referrals, as at the contrary, they decreased 8.9%. Referrals to conventional dermatology after an initial teledermatology consultation also decreased 19.71% in 2016 compared to 2015. Therefore, we can conclude that teledermatology service in operation in the Bages County increases the resolution of primary care teams as reduces referrals to the face-to-face dermatology service. This effect is more pronounced in rural than in urban areas.

The validated questionnaire we distributed amongst primary care professionals showed that 2/3 of respondents rated the overall quality and the technical quality of the telemedicine consultations as good. More than 2/3 of respondents considered that telemedicine services could improve the health status of patients and more than 2/3 of respondents wanted to keep using the services in the same way as they were using it. Nursing staff rated the overall quality of care delivered by the telemedicine services statistically significantly better that medical staff. Physicians stated having more difficulties that could have affected the quality of care.

Respondents to the questionnaire, who used more often the telemedicine services in the previous year, significantly rated the quality of care of these services worse than respondents who used them less often.

Targeted Twitter polls can be used to quickly perform surveys to assess the opinion of users regarding acceptance of telemedicine and even to validate questionnaires.

We can finally conclude that the asynchronous telemedicine services in the Catalan central region are efficient as can save economic resources and enjoy a good acceptance among health professionals.

FUTURE RESEARCH

It is relevant that respondents to the questionnaire, who used more often the telemedicine services in the previous year, significantly rated the quality of care of these services worse than respondents who used them less often and the fact that respondents having had difficulties were more reluctant to use the services in the future. In the future, we are planning to investigate the reasons for this as it can put the continuity of the programme at risk.

1. Comparing different models of telemedicine

In the Catalan central region, the county of Anoia has a distinct teledermatology service where patients are accurately selected before are referred to the service. This service was implemented in 2007 with the approval of primary physicians and dermatologists. Primary care professionals received photography training and have updates in teledermatology related topics regularly, which is not happening in Bages and Berguedà. In the future, we may distribute the questionnaire to the professionals using the teledermatology service in Anoia to check if we find any differences in responses compared with their colleagues of Bages and Berguedà.

2. Patient satisfaction

With the current questionnaire, we measured professional's satisfaction; in future projects, we are planning to assess patient's satisfaction with a validated questionnaire.

3. Artificial intelligence

In recent years, there has been a substantial improvement in the field of artificial intelligence applied to the classification of medical images, through deep-learning techniques using convolutional neural networks (CNN) achieving in some cases comparable returns to those achieved using specialist doctors.

These CNN have been used for example to detect diabetic retinopathy in photographic images taken from the fundus of the eye (Quellec et al. 2017), achieving sensitivities of 96.8% (95% CI, 94.4% - 99.3%) and specificities of 59.4% (95% CI, 55.7% - 63.0 %) (Somfai et al. 2014; Kar & Maity 2018) with accuracies of up to 96% (Takahashi et al. 2017).

Maybe in the future, teledermatology images sent by primary care professionals may be analysed first by an artificial intelligence validated algorithm and only those who had some doubt sent to a dermatologist. We think this is a good research line for the future.

4. Study on the quality of teledermatology images

In parallel with this PhD thesis, the thesis's author has been collaborating with another pre-doctoral colleague in a study assessing the quality of the images used in teledermatology.

The study aims to demonstrate that smartphones and/or tablets are good tools for capturing dermatological images when comparing its quality with the images taken with a digital camera (Boissin et al. 2015; Boissin et al. 2017; Toomey et al. 2014).

We have developed a web survey asking clinicians (dermatologists, primary care or emergency doctors) to assess the quality of the images taken with three different devices (smartphone, tablet and digital camera) and their validity to assess the existence of pathology. We have estimated the overall quality of the images using a Likert scale and other aspects relating to the characteristics of the images. The acceptability of the use of the different devices to obtain the images has also been assessed.

We are now analysing the results.

APPENDICES

Appendix I: Referrals to Teleulcers by primary care centres (Bages and Berguedà) 2015-2016

Primary Care Centre	2015	2016
CAP BARRI ANTIC	3	3
CAP CARDONA	6	2
CAP CASTELLBELL I EL VILAR	1	2
CAP CASTELLGALÍ		2
CAP CASTELLTERÇOL		3
CAP GORETTI BADIA	3	10
CAP I BERGUEDA	14	5
CAP I GIRONELLA	5	3
CAP I GUARDIOLA DE BERGUEDÀ		2
CAP LES BASES	5	2
CAP MANRESA 2	7	16
CAP MOIA	1	
CAP MONISTROL DE MONTSERRAT	1	
CAP NAVARCLES	1	2
CAP NAVAS		1
CAP PONT DE VILOMARA	4	1
CAP SAGRADA FAMILIA	3	9
CAP SALLENT	6	2
CAP SANT FRUITÓS	5	4
CAP SANT JOAN DE VILATORRADA	6	3
CAP SANT VICENÇ DE CASTELLET	1	1

CAP SANTPEDOR	3	5
CAP VACARISSES		2
CONSULTORI ARTES	3	1
CONSULTORI AVINYÓ		2
CONSULTORI D'AVIÀ		1
CONSULTORI DE BAGÀ	1	2
CONSULTORI DE CASSERRES	1	
CONSULTORI DE LA POBLA DE LILLET		3
CONSULTORI DE SANT JORDI		1
CONSULTORI DE ST. JULIÀ DE CERDANYOLA		3
CONSULTORI DE VILADA	1	
CONSULTORI FONOLLOSA	1	
CONSULTORI ST. SALVADOR DE GUARDIOLA	2	2
Total	**84**	**95**

Appendix II: Referrals to Teleaudiometries by primary care teams (Bages) 2014-2017

Primary Care Team	2014	2015	2016	2017	Total
EAP ARTÉS	52	88	87	68	295
EAP CARDONA	36	34	39	47	156
EAP MANRESA 1	129	115	88	121	453
EAP MANRESA 2 PLAÇA CATALUNYA	246	301	276	251	1.074
EAP MANRESA 3	90	96	73	82	341
EAP MANRESA 4 SAGRADA FAMÍLIA	243	329	276	297	1.145
EAP MOIÀ	35	62	51	35	183
EAP MONTSERRAT	29	55	76	43	203
EAP NAVARCLES - SANT FRUITÒS	145	176	170	182	673
EAP NAVÀS - BALSARENY	44	61	69	75	249
EAP SALLENT	44	60	56	83	243
EAP SANT JOAN DE VILATORRADA	126	133	147	129	535
EAP SANT VICENÇ DE CASTELLET	122	153	128	115	518
EAP SÚRIA	47	69	89	84	289
Not assigned	98	73	35	15	221
Total general	**1.486**	**1.805**	**1.660**	**1.627**	**6.578**

Appendix III: Referrals rates to Teleaudiometries by primary care teams (Bages) 2014-2017

	Referral rate x 1.000 h			
Primary Care Team	**2014**	**2015**	**2016**	**2017**
EAP ARTÉS	4,9	8,2	8,1	6,4
EAP CARDONA	7,2	6,8	7,8	9,4
EAP MANRESA 1	*6,0*	*5,7*	*4,4*	*5,5*
EAP MANRESA 2 PLAÇA CATALUNYA	10,7	13,1	12,0	10,9
EAP MANRESA 3	*6,0*	*5,7*	*4,4*	*5,5*
EAP MANRESA 4 SAGRADA FAMÍLIA	10,7	14,5	12,2	13,1
EAP MOIÀ	3,6	6,4	5,3	3,6
EAP MONTSERRAT	2,4	4,6	6,3	3,6
EAP NAVARCLES - SANT FRUITÒS	6,7	8,1	7,8	8,4
EAP NAVÀS - BALSARENY	4,6	6,4	7,3	7,9
EAP SALLENT	6,7	9,1	8,5	12,6
EAP SANT JOAN DE VILATORRADA	9,9	10,5	11,6	10,1
EAP SANT VICENÇ DE CASTELLET	8,4	10,5	8,8	7,9
EAP SÚRIA	5,2	7,7	9,9	9,4

Appendix IV: Physician questionnaire in Health Optimum

1. **How do you rate the overall quality of the telemedicine consultation?**

[ ] Excellent

[ ] Good

[ ] Fair

[ ] Poor

2. **How would you rate the technical quality of the telemedicine consultation?**

[ ] Excellent

[ ] Good

[ ] Fair

[ ] Poor

3. **How do you rate the quality of care delivered by the telemedicine service when compared to the quality of traditional care?**

[ ] Better

[ ] About the same

[ ] Not as good

[ ] Not sure

4. **Were you comfortable during the telemedicine consultation?**

[ ] Yes, very comfortable

[ ] Yes, somewhat comfortable

[ ] No, somewhat uncomfortable

[ ] No, very uncomfortable

5. **Do you feel that the telemedicine consultation service may influence the health status of your patients?**

[ ] Improved health

[ ] No change

[ ] Negative effects on health

6. **Did you experience technical difficulties that might affect the quality of care delivered by the telemedicine service?**

[ ] Not at all

[ ] Sometimes

[ ] Often

7. **Did you experience organisational or other difficulties that might affect the quality of care delivered by the telemedicine service?**

[ ] Not at all

[ ] Sometimes

[ ] Often

8. **Would you continue to use the telemedicine service?**

[ ] Yes, in the same way as the service has be deployed

[ ] Yes, but with improvements

[ ] No.

Appendix V: Final satisfaction questionnaire

Quin dels següents serveis de telemedicina del Bages-Berguedà has utilitzat alguna vegada:

1. Teledermatologia
2. Teleúlceres
3. Teleaudiometries
4. Altres
5. Cap

Quantes vegades en el darrer any has utilitzat algun servei de telemedicina:

1. Com qualificaries la qualitat global de les consultes de telemedicina?

1. [ ] Excel·lent
2. [ ] Bona
3. [ ] Normal
4. [ ] Regular
5. [ ] Dolenta

2. Com qualificaries la qualitat tècnica de les consultes de telemedicina?

1. [ ] Excel·lent
2. [ ] Bona
3. [ ] Normal
4. [ ] Regular
5. [ ] Dolenta

3. Com qualificaries la qualitat assistencial proporcionada pels serveis de telemedicina comparant-la amb la qualitat de l'atenció habitual?

1. [ ] Molt millor
2. [ ] Millor

3. [ ] Igual
4. [ ] Pitjor
5. [ ] Molt pitjor

4. Et sents còmode durant les consultes de telemedicina?

1. [ ] Si, molt còmode
2. [ ] Si, bastant còmode
3. [ ] Ni còmode, ni incòmode
4. [ ] No, bastant incòmode
5. [ ] No, molt incòmode

5. Creus que els serveis de telemedicina poden influir en l'estat de salut dels teus pacients?

1. [ ] Si, poden millorar la seva salut
2. [ ] No, no canvien la seva salut
3. [ ] Si, poden tenir efectes negatius en la seva salut

6. Has experimentat dificultats tècniques que poden haver afectat la qualitat de l'atenció proporcionada pels serveis de telemedicina?

1. [ ] No, mai
2. [ ] Alguns cops
3. [ ] Sovint

7. Has experimentat dificultats de tipus organitzatiu o d'altres dificultats que poden haver afectat la qualitat de l'atenció proporcionada pels serveis de telemedicina?

1. [ ] No
2. [ ] Algunes vegades
3. [ ] Sovint

8. Continuaràs utilitzant els serveis de telemedicina?

1. [ ] Si, igual que ara
2. [ ] Si, però amb millores
3. [ ] No

Edat (en anys)**:**

Sex**e:**

1. Home
2. Dona

Categoria professional:

1. Medicina
2. Infermeria
3. Odontologia
4. Altres

Appendix VI: Copy of published articles

Vidal-Alaball et al. BMC Health Services Research (2018) 18:650
https://doi.org/10.1186/s12913-018-3464-4

BMC Health Services Research

RESEARCH ARTICLE Open Access

A cost savings analysis of asynchronous teledermatology compared to face-to-face dermatology in Catalonia

Josep Vidal-Alaball[1,2,3*], Josep Lluís Garcia Domingo[3], Francesc Garcia Cuyàs[4,5], Jacobo Mendioroz Peña[1,2], Gemma Flores Mateo[6], Joan Deniel Rosanas[1,2] and Glòria Sauch Valmaña[1,2]

Abstract

Background: A teledermatology pilot scheme was first conducted in the town of Manresa (Barcelona) in the summer of 2010. The clinical success of the scheme prompted its expansion to the whole county of Bages in 2011 and to the adjacent county of Berguedà in 2012.
In the teledermatology service, primary care physicians take a photograph of the lesion and attach it to the electronic medical records of the patient together with a brief clinical account. In the referral hospital, the consultant dermatologists access the electronic medical records, review the images and suggest a treatment or action plan. Next, the primary care physicians review these recommendations and call the patient to report the results. This whole process is usually completed in less than 5 working days.

Methods: A cost saving analysis comparing teledermatology with dermatology face-to-face visits was performed in the county of Bages measuring the cost difference attributable to visits saved.

Results: The estimated added costs of the teledermatology service during 2016 amounted to 61,870 €. For the same period, the estimated costs of traditional outpatient dermatology services were of 113,034 €. This represents savings of 51,164 € per year. After subtraction of societal costs, the savings equal 10,350 € per year.

Conclusions: Using a teledermatology service instead of face-to-face dermatology consultations could save 51,164 € per year (11.4 € per patient visited) in the county of Bages. Societal savings are the most significant.

Keywords: Teledermatology, Telemedicine, Telehealth, Cost savings analysis, Primary care

Background

Telemedicine can be defined as "*the use of telecommunications technology to provide medical information and services*" [1] or as "*medicine practiced at a distance*" [2]. There are three main types of telemedicine: (1) real-time or synchronous telemedicine; (2) not real-time or asynchronous telemedicine; and (3) remote patient monitoring [3, 4].

In the last 25 years, telemedicine services have been implemented in many countries. In 2010, a World Health Organization survey found that 38% countries provided some kind of telemedicine and 30% countries had agencies that included telemedicine services [5]. Globally, teleradiology is the most common telemedicine service, followed by telepathology and teledermatology [5].

In Manresa (Barcelona), telemedicine was first introduced as a teledermatology pilot scheme in the summer of 2010 to solve the rising dermatology waiting list aggravated by generalized healthcare cuts. Early evidence of positive clinical impact and acceptance by professionals prompted the expansion of teledermatology services to all the county of Bages in 2011 and to the adjacent county of Berguedà in 2012. In 2014, a study on the impact of teledermatology on decreasing dermatology waiting lists

* Correspondence: jvidal.ccics@gencat.cat
[1]Health Promotion in Rural Areas Research Group (PRoSaARu), Gerència Territorial de la Catalunya Central, Catalan Health Institute, Carrer Pica d'Estats, 36, 08272 Sant Fruitós de Bages, Barcelona, Spain
[2]Unitat de Suport a la Recerca de la Catalunya Central, Institut Universitari d'Investigació en Atenció Primària Jordi Gol (IDIAP Jordi Gol), Barcelona, Spain
Full list of author information is available at the end of the article

in the Bages region during the 2009–2012 period was published. The results showed a reduction in dermatology waiting times from a mean of 30 days (95% CI: 29–32) before the implementation of teledermatology to a mean of 16 days (95% CI: 15–17) after its implementation [6]. The county of Bages is located in the centre of Catalonia, with a population of 184,403 inhabitants (91,260 men and 93,143 women) and a surface area of 1299.1 km^2. It has a lower population density (141.9 inhabitants/Km^2) than the average of Catalonia (234.2 inhabitants/Km^2) [7].

When primary care physicians decide to use the teledermatology service, they take a photograph of the lesion and attach it to the electronic medical records of the patient together with a brief clinical account. The use of electronic medical records guarantees the security of the images, since it avoids potentially insecure electronic storage systems and email. The dermatologists in the hospital access the electronic medical records, review the images and suggest a treatment or action plan. Next, the primary care physicians review these recommendations and phone the patient to explain the results of the consultation. The whole process takes usually less than 5 working days. The dermatologist might occasionally ask the primary care professional to refer the patient for a face-to-face visit. Except for urgent cases, the teledermatology service can be used for all dermatological conditions and the follow up is mostly performed by general practitioners.

The main objective of this study was to assess the economic impact of asynchronous telemedicine services in the Catalan central region comparing the cost of teledermatology with the cost of traditional outpatient consultations to determine whether to expand the service to other regions of Catalonia. Cost savings are estimated per patient visited and extrapolated to the whole Catalan territory.

Methods

A cost saving analysis comparing teledermatology with traditional dermatology consultations in the county of Bages was performed measuring direct and indirect costs and the cost of the visits saved. This analysis was selected because there is evidence that the effectiveness of traditional outpatient consultations and asynchronous teledermatology is the same [8, 9].

The population of reference included all patients allocated to the 14 Primary Health Care Teams in the county of Bages.

Data collection

The Catalan Institute of Health provided anonymized quantitative data regarding patients and number of visits to traditional outpatient dermatology services and teledermatology during 2016. Secondary data were obtained from the literature and expert opinion.

Number of visits

Data regarding number of dermatology visits, teledermatology visits and number of traditional outpatient visits after an initial teledermatology consultation were analysed.

The number of traditional outpatient consultations saved by the teledermatology service was calculated by subtracting the number of outpatient visits requested after an initial teledermatology consultation from the total number of teledermatology consultations.

Identification of costs

Costs directly attributable to teledermatology and to the traditional dermatology service included cameras, hardware and staff. Costs not directly attributable to teledermatology and to the traditional dermatology service included building maintenance, Information technology (IT) services, gas, electricity, telephone-internet connections and medical insurance. Costs incurred by patients and society such as lost productive time, lost salaries, leisure time lost, time spent travelling to visits and petrol were also considered.

Equipment costs

The market cost of an iPad Air with Wi-Fi and Cellular with 32GB was used [10].

Staff costs

To calculate the hourly rate of a primary care physician, we used the average (37,982 € per year in 2015) of the highest and lowest salaries paid by the Catalan Institute of Health, the main provider of primary care services in Catalonia. Taking into consideration that a primary care physician works 1642 h per year, the estimated hourly rate of this professional was 23.1 € [11]. To calculate the hourly rate of a dermatologist, the average (34,574.38€ per year in 2015) of the highest and lowest salaries agreed in the Collective Work Agreement used by the majority of hospitals in Catalonia was used. Taking into consideration that a dermatologist works 1688 h per year, the hourly rate of this professional was estimated at 20.5 € [12].

Productivity loss

The shortest time indicated in Google maps to travel by car from the village or town where the patient lives to the hospital located in Manresa (Hospital Sant Joan de Déu, C/ Dr. Joan Soler, s/n, 08243 Manresa) was used.

The time spent travelling to the hospital and the average hourly cost of labour was used to calculate the lost productive time. The average hourly wage in the last quarter of 2015 was used (21.2 €) [13]. To account for the time spent in consultation with the dermatologist (15 min on average for first visits in the local hospital according to the dermatology consultants) [14] and the

waiting time before entering this consultation, an average of 25 min was added.

We considered that most patients live in the town of the primary care centre where the photograph was taken, and therefore no travelling time was added. An average of 20 min was added to account for the time spent in consultation with the general practitioner (10 min plus waiting time).

Travel cost

To calculate the cost of petrol to drive to the hospital, the average price of mileage paid by companies in Spain in 2015 was used. Since this price ranges from 0.07€/km to a maximum of 0.75€/km, the average was calculated at 0.25€/km [15]. The mileage by car from the patient's address to the Hospital in Manresa was calculated using Google maps. Because in the county of Bages many towns and villages do not have regular public transport service, it was assumed that private transport was used on all occasions.

Costs excluded

Although friends and relatives of the patient are often affected by the patient's condition, it is still unclear how to account for this specific item [16]. In this study, the costs to patient companions were excluded, since information on whether the patients went to the consultations on their own or accompanied was unavailable.

The costs of lost leisure time were also excluded because we could not differentiate whether working hours or leisure hours had been lost, and it was assumed that consultations in hospital and in primary care took place during working hours.

Training costs were excluded because no extra training was provided for family care physicians and dermatologists. Structural costs, technical costs and medical insurance costs were excluded since they were not considered significant. Table 1 shows excluded costs.

Table 1 Costs excluded and reason for exclusion

Costs	Reason for exclusion
Technical costs	No significant added costs[a]
Building maintenance	No significant added costs[a]
Electricity, heating	No significant added costs[a]
Medical insurance	No significant added costs[a]
Telephone calls	No significant added costs
Training costs	No significant added costs
Time of patient companions	Very difficult to quantify through secondary data

[a]Teledermatology represents 1.4% of the total activity of the hospital [17]

Results

Number of visits saved

During 2016, 5606 patients were referred to the teledermatology service, of which 1104 patients were further referred to traditional outpatient consultation (within the next 3 months). Consequently, the teledermatology service saved a total of 4502 face-to-face visits.

Equipment costs

It was assumed that if each of the 14 primary care practices in the Bages area acquired an iPad Air (Wi-Fi + Cellular 32GB) at a price of 559 € each, the initial cost of this equipment would be of 7826 € (559 € × 14 = 7826 €). The equipment is expected to last approximately 5 years. Taking into account this obsolescence, the annual cost of this equipment was calculated at **1565 €**.

Primary care physician costs

During 2016, 4502 visits were potentially saved by the use of the teledermatology service. Since a teledermatology primary care appointment needs an initial 10 min consultation with the primary care physician, a total of 45,020 min (750.3 h) were spent in teledermatology-related appointments. The estimated hourly rate of this professional was calculated at 23.1 €, therefore the cost of the total time spent in teledermatology-related consultations during 2016 was **17,333 €**. After the initial consultation and having received the dermatologist's recommendations, the primary care physician contacted the patient by phone to explain the further management of the condition. This phone call was estimated to last an average of 2 min and thus a total of 9004 min (150.1 h) were spent in teledermatology-related telephone calls in 2016. Since the hourly rate of the GP was 23.1€, the cost was calculated at **3467 €** per year. The total costs of the time spent by primary care physicians in teledermatology-related appointments was **20,799 €** during 2016.

Dermatologist costs

During 2016, 4502 visits were potentially saved by the teledermatology service. Assuming that a traditional face-to-face dermatology appointment requires a 15 min consultation, a total of 67,530 min (1125.5 h) would have been spent in traditional dermatology appointments during 2016 if the teledermatology service had not been in place. With the estimated hourly rate of dermatologists calculated at 20.5 €, the cost of this time would have been **23,073 €** per year.

Considering that a teledermatology appointment needs a 5-min consultation by a dermatologist, a total of 22,510 min (375.2 h) were spent in teledermatology-related appointments. With the estimated hourly rate of this professional

Table 2 Cost of primary care physicians and dermatologists

Service		Primary care		Dermatology	
		Initial consultations	Telephone calls	Face-to-face	Teledermatology
N. Visits	min	45,020	9004	67,530	22,510
4502	hours	750,3	150,1	1125,5	375,2
	Cost	17,333	3467	23,073	7691

at 20.5 €, the cost of this time was calculated at **7691 €** per year.

Table 2 shows the cost of primary care physicians and dermatologists.

Cost of time lost

The time spent travelling to the hospital to visit the dermatologist was calculated for each of the primary care centres, adding 25 min for the visit plus the waiting time. During 2016, a total of 2840 h would have been spent if all patients had attended a hospital visit instead of using teledermatology. Since the average hourly wage was 21.2 € [13], the total cost for 2016 would be **60,208 €**.

The time spent travelling to the primary care centre to take a photograph, adding 20 min for the visit and the waiting time, was estimated at 1500.7 h for 2016. Considering that the average hourly cost of labour is 21.2 €, the total cost was **31,815 €**. Table 3 shows cost of time lost by primary care centre.

Cost of petrol

Table 4 shows that patients would have travelled a total of 49,684 km if they had attended traditional outpatient consultations instead of using teledermatology. This amounts to **12,421 €** in petrol.

Total costs

Table 5 shows that the estimated added costs of the teledermatology service during 2016 were of **61,870 €**. For the same period, the estimated costs of the traditional outpatient services if all patients had been referred to face-to-face visits would have been of **113,034€**. This represents cost savings of **51,164 €** during 2016. Since in 2016 a total of 4502 patients used these services, the savings amount to 11.4 € per patient visited.

In the analysis, societal costs emerge as the variable with the biggest impact on our calculations; savings due to teledermatology amounted to **40,814 €** per annum. The main savings derived from time saved by not travelling to the hospital. When removing societal costs, teledermatology savings amounted to **10,350 €** in 2016.

Staff costs were also significant, particularly in the hospital, since the use of teledermatology saved considerable time to dermatology consultants. With traditional outpatient consultations, staff costs in hospital amounted to 23,073 € per year, whereas with teledermatology this amount was reduced to 7691 € per year (annual savings of 15,382 €). In primary care, staff costs increased slightly with teledermatology because primary care physicians were required to phone patients to explain the results. With conventional dermatology, the staff costs in primary care were 17,332 € per year, whereas with teledermatology costs increased to 20,799 € per year (annual increase of 3467 €).

Discussion

This cost savings study has compared the marginal cost of the resources associated with the use of a teledermatology programme in the Catalan Central Region with the cost of face-to-face dermatology consultations in

Table 3 Cost of time lost by primary care centre

	TeleDM Visits	Referrals	Saved visits	Time to hospital (mins)	Time spent in hospital		Time spent in primary care	
					(25 mins)	Hours	(20 mins)	Hours
CAP MANRESA 2	1067	227	840	9	28,560	476	16,800	280,0
CAP SAGRADA FAMILIA	828	178	650	3	18,200	303,3	13,000	216,7
CAP SALLENT	376	53	323	15	12,920	215,3	6460	107,7
CAP SANT FRUITÓS	294	64	230	7	7360	122,7	4600	76,7
CAP SANT JOAN DE VILATORRADA	494	105	389	11	14,004	233,4	7780	129,7
CAP SANT VICENÇ DE CASTELLET	345	69	276	12	10,212	170,2	5520	92,0
CAP SANTPEDOR	286	59	227	11	8172	136,2	4540	75,7
Other	1916	349	1567			1183		522,7
Total	5606	1104	4502		Total time	2840		1500,7
					Total €	60,208		31,815

Table 4 Cost of petrol by primary care centre

Primary care centre	Saved visits	Km to Hospital	Saved Km	Cost Km saved
CAP MANRESA 2	840	2,8	2352	588
CAP SAGRADA FAMILIA	650	1,2	780	195
CAP SALLENT	323	15	4845	1211
CAP SANT FRUITÓS	230	6	1380	345
CAP SANT JOAN DE VILATORRADA	389	9	3501	875
CAP SANT VICENÇ DE CASTELLET	276	9,2	2539	635
CAP SANTPEDOR	227	9,2	2088	522
Other	1567		32,199	8050
Total	4502		49,684	12,421

order to elucidate whether teledermatology generates savings.

The analysis suggests that the teledermatology programme implemented in the Catalan Central Region could generate important cost savings (up to 51,164 € per year) when compared with the traditional outpatient consultation model.

These results are consistent with other studies. Armstrong et al. published in 2007 an economic evaluation comparing the hourly costs of a teledermatology service with a face-to-face dermatology clinic in the United States. They concluded that the hourly cost of operating the teledermatology practice was lower than that of the conventional clinic [18].

A number of limitations need to be taken into consideration when evaluating the results of the study. Firstly, we have compared the cost of teledermatology versus traditional outpatient consultation using our day-to-day clinical experience, data obtained from experts and a review of the literature. Secondly, it is unclear why some patients are referred for face-to-face dermatology visits after an initial teledermatology consultation and whether they attend them.

The costs excluded and included are amongst the most controversial aspects of economic studies. The current study excluded general costs of regular clinical practice. It also excluded costs considered similar between teledermatology and traditional dermatology practice and costs difficult to quantify through secondary data such as the costs to patient companions, costs of leisure time lost and costs of carbon emissions. These decisions are justified in the methods section.

Table 5 Annual costs of teledermatology compared with traditional outpatient dermatology consultations

Cost per year in €	Teledermatology	Dermatology	Difference
Equipment	1565	0	1565
Primary care staff	20,799	17,332	3467
Hospital staff	7691	23,073	−15,382
Subtotal	30,055	40,405	−10,350
Society			
Time	31,815	60,208	−28,393
Petrol		12,421	−12,421
Total	61,870	113,034	−51,164

Despite evidence that the clinical effectiveness of teledermatology is comparable with face-to-face consultations, some authors have recently raised concerns about the methodologies that determine the effectiveness of telemedicine [19].

This health economic evaluation assumed that the resources saved would be efficiently allocated to provide other dermatology services. If that were not the case, savings would be considered negligible.

In 2010 Eminović et al. conducted a cost minimisation analysis in store-and-forward teledermatology. The authors calculated that teledermatology was 32.5 € (95% CI, − 29.0 to 74.7) more expensive than conventional dermatology visits. They concluded that teledermatology could only generate savings if the distance to a dermatologist in hospital was larger (≥75 km) or when more consultations (≥37%) could be prevented with the use of teledermatology. In consequence, teledermatology should only be applied in those cases with a reasonable probability that a face-to-face consultation could be prevented [20]. The study included similar costs to ours and additional training for primary care physicians and dermatologists and costs of diagnostics and treatment. They also included the societal costs of travel of the patient and a patient companion based on the estimate that about 20% of patients (children and elderly) visit a health professional accompanied.

The setting of this study is the county of Bages. However, we believe that the data can be extrapolated to the other regions of Catalonia. We calculated that the savings for the whole population of Catalonia (7,519,000 inhabitants) would amount to 2,085,061 €. Caution should be exercised when extrapolating these results to other countries, since different fees apply to different health systems.

Conclusions

The results of this study show that using teledermatology instead of face-to-face dermatology consultations can save 51,164 € per year (11.4 € per patient visited) in the county of Bages. Most savings were societal (40,814 € per year). When removing societal costs, the savings amounted to 10,350 € per year.

Abbreviations

IT: Information technology; TeleDM (table): Teledermatology

Acknowledgements

To the personnel of the Technical and Support Area of Gerència Territorial de la Catalunya Central for their implication in data collection.

Availability of data and materials

The datasets used and/or analysed for the current study are available from the corresponding author on reasonable request.

Authors' contributions

JV-A: Study design, literature review, collection, analysis and interpretation of data, health economic evaluation, drafting and revision the manuscript. JLGD: Study design, supervision of the study, analysis and interpretation of data, health economic evaluation, drafting and reviewing the manuscript. FGC: Study design, data collection, supervision of the study, drafting and reviewing the manuscript. JMP: Analysis and interpretation of data, drafting and reviewing the manuscript. GFM: Supervision of the study, drafting and reviewing the manuscript. JDR: Analysis and interpretation of data, drafting and reviewing the manuscript. GSV: Analysis and interpretation of data, drafting and reviewing the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

This study protocol has been approved by the University Institute for Primary Care Research (IDIAP) Jordi Gol Health Care Ethics Committee (Code P16/046).

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

Author details

[1]Health Promotion in Rural Areas Research Group (PRoSaRRu), Gerència Territorial de la Catalunya Central, Catalan Health Institute, Carrer Pica d'Estats, 36, 08272 Sant Fruitós de Bages, Barcelona, Spain. [2]Unitat de Suport a la Recerca de la Catalunya Central, Institut Universitari d'Investigació en Atenció Primària Jordi Gol (IDIAP Jordi Gol), Barcelona, Spain. [3]Department of Economics and Business, University of Vic- Central University of Catalonia, Vic, Barcelona, Spain. [4]General Surgery Department, Autonomous University of Barcelona, Barcelona, Spain. [5]Chair in ICT and Healthcare, University of Vic-Central University of Catalonia, Vic, Barcelona, Spain. [6]Xarxa Sanitària i Social de Santa Tecla, Tarragona, Spain.

Received: 13 November 2017 Accepted: 13 August 2018
Published online: 22 August 2018

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International Medical Society
http://imedicalsociety.org

INTERNATIONAL ARCHIVES OF MEDICINE
SECTION: PRIMARY CARE
ISSN: 1755-7682

2018
Vol. 11 No. 30
doi: 10.3823/2571

Rural-Urban Differences in the Pattern of Referrals to an Asynchronous Teledermatology Service

ORIGINAL

Josep Vidal-Alaball[1], Jacobo Mendioroz Peña[1], Glòria Sauch Valmaña[1]

1 Health Promotion in Rural Areas Research Group. Gerència Territorial de la Catalunya Central, Catalan Health Institute, Sant Fruitós de Bages, Barcelona, Spain.

Contact information:

Josep Vidal-Alaball.

Address: Gerència Territorial de la Catalunya Central. Institut Català de la Salut. Carrer Pica d'Estats, 36, 08272 Sant Fruitós de Bages, Barcelona.

Tel: 00 34 693 00 40.

jvidal.cc.ics@gencat.cat

Abstract

Background: Telemedicine is particularly useful in rural areas where can facilitate access to specialised care in regions far from urban hospitals and can prevent unnecessary travel. The purpose of this research was to evaluate the degree of resolution of an asynchronous teledermatology service in the Bages County, comparing urban and rural primary care centres.

Methods and findings: A longitudinal descriptive study of referrals from 14 Primary Care Teams to a hospital dermatology service as a result of a previous referral to a teledermatology program was performed, comparing years 2015 and 2016 and urban with rural practices.

Both in urban and rural areas there was an increase in referrals to the teledermatology service in 2016 compared to the previous year (12.9% and 0.3% respectively). In the two years analysed, referral rates to the teledermatology service per thousand inhabitants from rural centres was statistically much higher than that of urban centres ($p<0.001$). The number of referrals to the face-to-face dermatology service after a teledermatology consultation decreased significantly in both urban [OR=0.81 (0.70-0.93) p=0.001] and rural centres [OR=0.64 (0.57-0.72) $p<0.001$].

Conclusions: The asynchronous teledermatology service established in the Bages County increases the resolution of primary care teams as reduces referrals to the face-to-face dermatology service. This effect is more pronounced in rural than in urban areas. Such finding may indicate the need to prioritize telemedicine services in rural primary care practices.

Keywords
Dermatology; Ehealth; Primary Care; Telehealth; Teledermatology; Telemedicine

Introduction

Telemedicine has been defined as the "*medicine practiced at a distance*" [1]. According to the timing of the information transmitted, three main types of telemedicine can be distinguished: store-and-forward or asynchronous (not real-time) telemedicine, videoconference or synchronous (real-time time) telemedicine and remote patient monitoring [2 ,3].

Telemedicine has shown in several studies its effectiveness, efficiency, safety and capacity to reduce costs [4-6]. These effects are especially important in rural areas where telemedicine can enhance access to health for patients living in rural or remote areas [7-9]. Telemedicine benefit patients as they improve access, but also professionals, as they increase contact with specialists and allow them to have better access to professional development [10]. Primary care physicians have reported the educational benefits of telemedicine [3].

Telemedicine services are well accepted by users [11, 12]; satisfaction has been reported to be higher in rural settings than in urban settings, since it can prevent unnecessary travel to hospitals [13]. By facilitating access to specialised care in regions far from urban hospitals, telemedicine can help reducing inequalities between rural and urban areas [8, 14].

In three counties of Central Catalonia; Anoia, Bages and Berguedà, asynchronous telemedicine services between primary care and local hospitals have been developed. Among the programs of telemedicine, the most successful has been teledermatology and the most innovative teleulcers and teleaudiometries. In the teledermatology program set in Bages, in operation since 2010, primary care professionals take photographs of dermatological lesions and attach them into the patient's computerised medical records together with a clinical description. The use of electronic medical records guarantees the confidentiality of the images at all times, since it is not necessary to send them by e-mail or store them in an external server. The dermatologists at the hospital access the patient's medical history, review the images and propose a treatment or plan of action to follow. The primary care professionals review the proposal and make a phone call to the patient to explain the results of the consultation. The whole process usually takes less than a week. If the dermatologists consider it convenient, can ask the primary care professionals to refer the patient for a face-to-face visit.

This program has had considerable success in reducing the dermatology waiting lists, achieving an average reduction in patient wait time from 30 to 16 days [15]. The objective of this study is to evaluate the degree of resolution (as the capacity to solve health problems within primary care) of the Bages asynchronous teledermatology service and analyse whether there are differences between rural and urban primary care teams.

Methods

We conducted a longitudinal descriptive study of the referrals to the hospital dermatology service as a consequence of a previous referral to the teledermatology program in the Bages region during the years 2015 and 2016.

As population of reference we took the entire population included in the 14 Primary Care Teams (PCTs) of the County of Bages that used the teledermatology service at some point. The PCTs of Bages have to two different health care providers: Institut Català de la Salut (12) and Althaia, Xarxa Assistencial Universitària (2). These teams refer patients to a district hospital located in Manresa (Sant Joan de Déu Hospital). The PCTs include Primary Care Centres and Surgeries located in populations of less than 12,000 inhabitants, except Manresa, which is a city of almost 75,000 inhabitants [16].

Although there is no consensus about when a population is considered rural or urban, for this study we have used the analysis done by Dominguez Amorós *et al.* that classified all Catalan populations in rural and urban according to the number of in-

habitants, density of population and sectors of economic activity. Considering this study, except Manresa (with four PCTs) and Sant Joan de Vilatorrada, which are considered urban areas, the rest of the Bages population is considered rural [17]. For each of the PCTs, we extracted from computerized medical records data relating to the population assigned to the centres together with the origin and the total of the consultations to the teledermatology service and the referrals made to the conventional dermatology service.

For the analysis, the chi-squared test was used to compare the percentage of referrals to the traditional dermatology service after an initial consultation with the teledermatology service. We considered a dermatology referral resulting from an initial teledermatology consultation any dermatology visits produced in the three subsequent months. The analysis was made comparing years 2015 and 2016 and urban areas with rural areas. The results were considered significant with $p<0.05$. The statistical program SPSS v8 was used for the statistical analyses.

Results

We found that during 2015, a total of 2,124 referrals were made to the teledermatology service from the 5 PCTs located in urban centres, originating a total of 531 visits to the dermatology service (25%). This represents a referral rate of 22.3 per 1,000 inhabitants. During 2016, a total of 2,398 referrals were made to the teledermatology service from these urban centres, originating 508 subsequent face-to-face visits to the dermatology service (21.18%). This represents a referral rate of 25.2 per 1,000 inhabitants.

Between 2015 and 2016, teledermatology consultations increased by 12.9%. In contrast, the number of referrals to dermatology as a consequence of an initial referral to teledermatology decreased significantly from 531 to 508 visits OR=0.81 (0.70-0.93) p=0.001. **(Table 1)**

During 2015, a total of 3,198 referrals were made to the teledermatology service from the 9 PCTs located in rural areas. Of these referrals, 844 required a face-to-face visit to the dermatology service (26.39%) The referral rate of these centres was 32.4 per 1,000 inhabitants. During 2016, a total of 3,208 referrals were made to the teledermatology service from PCTs located in rural areas. Of these referrals, 596 were subsequently seen in the conventional dermatology clinics (18.58%). This represents a referral rate of 33.5 per 1,000 inhabitants

Between 2015 and 2016, the number of visits to teledermatology increased slightly by 0.3%. The number of referrals to dermatology as a consequence of the initial referral to teledermatology decreased significantly from 844 to 596 visits OR=0.64 (0.57-0.72) p<0.001.

Overall, in the two years analysed, referral rates to the teledermatology service per thousand inhabitants from rural centres was statistically much higher than that of urban centres (p<0.001). **(Table 2)**

Table 1. Referrals to the teledermatology service from urban centres.

Year	Assigned population	Teledermatology referrals	Referral rates per 1,000 inhabitants.	Dermatology referrals	% referral
2015	95,102	2,124	22.3	531	25%
2016		2,398	25.2	508	21.18%

Table 2. Referrals to the teledermatology service from rural centres

Year	Assigned population	Teledermatology referrals	Referral rates per 1,000 inhabitants.	Dermatology referrals	% referral
2015	98,795	3,198	32.4	844	26.39
2016		3,208	33.5	596	18.58

Both in the urban environment and in rural areas there is an increase in referrals to the teledermatology service in 2016 compared to the previous year. This increase could be due to a greater familiarisation with the service by professionals and users. However, the number of referrals to the face-to-face dermatology service after a teledermatology consultation also decreased significantly and this effect was more pronounced in rural centres. This may indicate an educational effect of the teledermatology program for primary care professionals, as some studies have previously suggested [18, 19].

The teledermatology consultation rate per thousand inhabitants assigned was greater in rural teams than in the urban ones. This could be explained by the fact that in rural areas, where predominate an increasingly aging population and hospital are often far away, professionals and patients try to avoid hospital visits through the use of telemedicine. It is in rural areas where telemedicine can have a more beneficial effect from a social point of view, avoiding unnecessary and often long trips to the hospitals [10].

Discussion

These results have important implications for rural family practice as have shown that the impact of telemedicine programs is greater in these practices and open a debate about the need to prioritize telemedicine in rural areas. However, telemedicine should not represent a negative impact on access to usual health services by rural communities and should not be used as an excuse to reduce health services in these areas.

This study presents some limitations, the main one of which is given by the definition of the concept of rurality, not commonly agreed.

Conclusions

We can conclude that the asynchronous teledermatology service in operation in the Bages County increases the resolution of primary care teams as reduces referrals to the face-to-face dermatology service. This effect is more pronounced in rural than in urban primary care practices.

Acknowledgements:

To the Technical and Support Area of Gerència Territorial de la Catalunya Central for its implication in the data collection.

Funding

No funding was received.

Conflict of interest

None.

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