

Dadansoddi ar gyfer Polisi



Analysis for Policy



Llywodraeth Cymru  
Welsh Government

Ymchwil gymdeithasol

Social research

Number: 10/2014

[www.cymru.gov.uk](http://www.cymru.gov.uk)

# The Application of Operational Research Techniques to Service Improvement - Teledermatology



## **Dr Tracey England**

**Research Fellow, Welsh Government**

**Research Associate, Cardiff University and Mathematical  
Modeller, Modelling Unit, ABCi**

## **Sarah Lowe, Claire Davies, Matthew Wellington and Huw Brain**

**Knowledge and Analytical Services, Welsh Government**

Views expressed in this report include those of the academic researcher and are not necessarily those of the Welsh Government

For further information please contact:

Sarah Lowe

Knowledge and Analytical Services

Welsh Government

Cathays Park

Cardiff

CF10 3NQ

Tel: 029 2082 6229

Fax: 029 2082 6255

Email: [sarah.lowe@wales.gsi.gov.uk](mailto:sarah.lowe@wales.gsi.gov.uk)

Welsh Government Social Research, 2014

ISBN 978-1-4734-0910-1

© Crown Copyright 2014

## Table of Contents

Glossary of acronyms .....	3
Glossary of Terms .....	4
1 Introduction.....	5
2 Evidence Review .....	9
4 Store and Forward Clinics in Hywel Dda LHB .....	17
5 Videoconference Clinics in Hywel Dda Health Board .....	25
6 The Clinicians' Role.....	27
7 The Simulation Models .....	30
8 Cost Analysis.....	36
9 Conclusions.....	41
Appendix 1: Patient Travel Analysis – Aberaeron and Borth .....	46
Appendix 2: Acknowledgements.....	51
Bibliography.....	52

## **Glossary of acronyms**

CPD	Continuing Professional Development
DSN	Dermatology Specialist Nurse
ESRC	Economic and Social Research Council
GP	General Practitioner
HM Treasury	Her Majesty's Treasury
KAS	Knowledge and Analytical Services
LHB	Local Health Board
NHS	National Health Service
OR	Operational Research
RHIG	Rural Health Implementation Group
RHIP	Rural Health Implementation Plan
SWCN	South Wales Cancer Network
WG	Welsh Government

## Glossary of Terms

Cost Benefit Analysis	Analysis which quantifies in monetary terms as many of the costs and benefits of a proposal as feasible.
Electronic Referral	Electronic document that contains details about the patient as well as the digital image of the skin condition that needs to be assessed.
Patient postcode	First 5 digits of the patient's postcode of their home address.
Patient travel	Distance travelled by the patient to attend the clinic.
Round trip distance	Combined distance of outward and return journey.
Round trip travel time	Combined travel time of outward and return journey.
Referral date	Date of the clinic and when the image is sent through to the consultant.
Rural Health Plan	A plan produced by the Welsh Government to ensure that the future health needs of rural communities are met in ways that reflect the particular conditions and characteristics of rural Wales.
Simulation Model	A computer model which aims to represent what happens in real life.
Storage Bin	A facility in Simul8 which allows you to model the queue in a real-life system.
Store and forward	The transmission of images and data for review immediately or at a later time.
Telemedicine	The use of technology to support delivery of healthcare at a distance.
Videoconference clinic	Clinic where the patient has a virtual appointment with the consultant via a videoconference link. The patient is in Bronglais Hospital and the dermatologist is in Glangwili Hospital.

## 1 Introduction

The overarching aim of the Welsh Government (WG) Programme to Maximise the Use of Existing Data is to identify and evaluate ways to maximise the use of existing data and expert knowledge in order to improve the evidence base for policymaking. Four Knowledge Transfer Research Fellows were jointly funded by WG and the Economic and Social Research Council (ESRC) for 2011-13, one of whom was given the remit to demonstrate how maximising the use of existing data could help with service improvement.

There is potential for the Welsh Government and public services in Wales to improve the way services are delivered in terms of:

- improving the patient or service user experience;
- helping practitioners to do their jobs in the most effective way; and
- identifying efficiency savings.

In particular, techniques from the discipline of Operational Research such as simulation and computer modelling were identified as methods that could potentially add value in terms of informing service optimisation activities.

As the result of a prioritisation exercise for which around twenty potential projects were proposed by policy and analytical colleagues from across WG, two projects were chosen to demonstrate that making use of information already collected as part of service delivery can be used to inform service improvement. A project on 'Teledermatology' was selected to be delivered by the Knowledge Transfer Research Fellow. Analysts from WG Knowledge and Analytical Services (KAS) 'OR Pool' delivered components of the project as part of their Continuing Professional Development (CPD) and both Pool members and analysts from other parts of KAS provided quality assurance for the report.

Teledermatology is the use of telemedicine to deliver dermatology services, where dermatology is the study of skin diseases and telemedicine is "the delivery of health care and the exchange of related information across distances"; it is the access to specialist knowledge using telecommunications and information technology (Wootton & Oakley, 2002).

Telemedicine falls under the WG Programme for Government theme of "Rural Communities", which includes the following commitments:

- Look to ensure that local health services are provided as close to people's homes as possible while acknowledging some specialist services will be located further afield in order to be most effective; and
- To continue to improve access to care in rural areas through innovation such as telemedicine, mobile outreach services and building on community ownership and in line with the Rural Health Plan.

The Rural Health Plan was produced in December 2009 and was designed to ensure that future health needs are met in ways that reflect the particular conditions and characteristics of rural Wales. The Rural Health Plan identified the need to rethink the way primary care and community services are provided in rural areas, including considering non-traditional models of care.

The Rural Health Implementation Group (RHIG) was set up by WG in April 2010 to support the implementation of the Rural Health Implementation Plan (RHIP). The Rural Health Implementation Group Phase II Implementation Plan for Telehealthcare (2011 – 2013) identified Teledermatology as an area for further work. The RHIG wanted to ensure the use of Telemedicine is maximised across rural Wales. In addition to demonstrating how the use of existing data can be maximised, it was expected that the demonstration project would inform the work of the RHIG. Policy colleagues within the Welsh Government highlighted that Hywel Dda Local Health Board (LHB) had been using telemedicine for several years – this meant that sufficient data was likely to be available to model the telemedicine service.

The Telemedicine Project Manager for Hywel Dda LHB reported that telemedicine had been in routine use in Ceredigion since 2000 when a telemedicine service was established for the South Wales Cancer Network (SWCN). She reported that telemedicine had been used effectively both within the SWCN and Hywel Dda Local Health Board (LHB) for a variety of purposes:

- to facilitate virtual multidisciplinary team meetings;
- for video-consultations between patients and consultants (e.g. neurologist, speech therapist);
- for transmission of images (e.g. dermatology, paediatric cardiac); and
- to support palliative care.

In terms of delivering dermatology services, telemedicine works in two main ways, “store and forward” and videoconferencing. The “store and forward” system allows

images of a patient's skin lesions and rashes, taken by a specialist nurse e.g. located at a rural GP surgery, to be transmitted using a secure portal to a consultant dermatologist. "Store and forward" is useful in the triage and diagnosis of dermatology conditions, allowing patients to begin their treatment plan as soon as the specialist nurse has received the consultant's diagnosis of the image.

Videoconferencing allows the consultant and patient to have a real-time consultation exactly as they would otherwise do in an outpatient's clinic but via a video-link.

The Teledermatology Service for Hywel Dda has been in service since May 2008 in North Ceredigion and uses both "store and forward" and videoconferencing. The videoconferencing clinics are hosted free through the Wales Health Video Network. For the "store and forward" clinics, images and data are transmitted via a secure NHS network server and can be reviewed by clinicians either immediately or at a later time.

### **Project Aims and Objectives**

As noted above, one objective of the demonstration project was to support the work of the Rural Health Implementation Group (RHIG) in ensuring that the use of Telemedicine is maximised across rural Wales. The Teledermatology Demonstration Project was designed to provide evidence to support future decision making, to identify potential improvements in services and to identify any efficiency savings that might be associated with treating dermatology patients using telemedicine in Hywel Dda LHB.

The demonstration project examined the use of teledermatology within Hywel Dda LHB. The project:

1. Undertook a review to identify where Teledermatology has been used successfully internationally.
2. Examined the extent to which patient travelling time could be reduced by introducing telemedicine ("store and forward" and videoconference clinics) in Hywel Dda.
3. Examined the working pattern of the consultant dermatologist and the specialist dermatology nurse to see how much of their time was spent seeing patients when running "store and forward" or videoconference clinics compared with running traditional outpatient clinics.



4. Developed two simulation models representing the patient pathways using teledermatology and the use of traditional outpatient clinics.
5. Used the simulation models to consider “what if” scenarios, some designed to answer questions raised by the clinicians involved in the Study, such as:
  - a: What would happen if the consultant could reduce the current time delay in the teledermatology system by looking at the electronic referrals more quickly? One approach would be to adapt her current working pattern; another would be to reduce the number of days it takes to look at the referrals in the simulation model and rerun the model.
  - b: What would happen if the waiting time in the outpatient system was the same as in the teledermatology clinic system?
6. Undertook a cost analysis comparing teledermatology ‘store and forward’ with the outpatient system.

The results of the literature review are presented in Chapter 2. The methodology used in this Project is outlined in Chapter 3. The way the “Store and forward” clinics and videoconferencing clinics currently work are described in Chapters 4 and 5 respectively. The clinicians’ perspective on teledermatology in Hywel Dda LHB is presented in Chapter 6. Chapter 7 describes the simulation models and their results. The cost analysis is discussed in Chapter 8 and the Project conclusions are presented in Chapter 9. The challenges that emerged during the demonstration process and the benefits of using OR methods to inform service optimisation will be explored in more detail in a Lessons Learned report, publication of which is to follow.

## 2 Evidence Review

This Section summarises the findings of a literature review and an exercise to find out how teledermatology was already being used in areas of Wales beyond Hywel Dda.

### Literature Review

The discipline of teledermatology is relatively new but rapidly growing and so is the associated research literature. The first paper on the topic was published in 1995 (Perednia & Brown, 1995) and PubMed<sup>1</sup> searches in 2001 and 2012 listed 55 and 347 papers respectively.

Research evidence from New Zealand and Norway suggests that Teledermatology can be practised almost anywhere given the right equipment and that it has the potential to improve the care of the patient, particularly if they live in a rural or remote area (Wootton & Oakley, 2002).

A recent survey of health services in the US identified 38 teledermatology programmes (Armstrong, Kovarik, Goldehn, McKoy, Shippy, & Pak, 2012).

Teledermatology in America tends to be used in rural areas, the Army and the prison service (Wootton & Oakley, 2002).

Teledermatology has been widely used in New Zealand since the mid-1990s, where a large number of “store and forward” and videoconference clinics operate. Another country making considerable use of teledermatology is Norway, where the evidence suggests it is useful for patients who live in remote areas with poor access to medical services (Wootton & Oakley, 2002).

Whilst teledermatology originated in the developed world, it is increasingly finding its way into developing countries. In developed countries, the images from “store and forward” clinics are securely transferred electronically across the internet. In the developing world, the images tend to be transferred via the mobile phone network, with countries such as Egypt, Botswana and Guatemala using mobile telephone teledermatology services (Tran, Ayad, Weinberg, & Cherng, 2010).

With regard to reducing costs, Whitten et al (2002) reviewed 55 articles that mentioned the cost effectiveness of telemedicine. A total of 20% of the articles

---

<sup>1</sup>an electronic library system which allows you to search scientific journals

reviewed reported that the use of telemedicine saved money, 11% reported that it saved time and money, and 9% found that telemedicine was cost effective. However, the reviewers' overall conclusion was that there was no persuasive evidence that telemedicine is a cost effective means of health care delivery (Whitten, Mair, Haycox, May, Williams, & Hellmich, 2002). However, they also point out that it is difficult to draw robust conclusions given the lack of methodologically sound studies available in this area (Bergmo, 2009). Economic evaluations of telemedicine have also tended to vary by:

- medical service (e.g. cardiology, dermatology or psychiatry);
- type of technology (e.g. videoconferencing or still images);
- medical setting (e.g. primary or secondary care); and
- geographical context (e.g. rural or urban).

In a systematic review of the literature on teledermatology, Eminovic et al (Eminovic, de Keizer, Bindels, & Hasman, 2007) suggest that teledermatology is a valuable application, but conclude that there is a need for further evidence in order to provide a high level of confidence with regard to both its clinical outcomes and cost effectiveness.

International evidence on the cost effectiveness of "store and forward" teledermatology demonstrates that it can potentially be a cost effective way to manage patient referrals - providing care at a lower cost – but only if the distance between the patient and the dermatologist is greater than 75km and the communication network is already in place (Moreno-Ramirez, et al., 2009, Van der Heijden, de Keizer, Bos, Spuls, & Witkamp, 2011 and Eminovic, Dijkgraaf, Berghout, Prins, Bindels, & de Keizer, 2010).

Findings from a pilot in England also suggest that "store and forward" teledermatology can potentially lead to savings and reduce waiting times (Hampshire, 2009). The pilot study concluded that teledermatology could reduce outpatient attendances by 30% and could produce a net saving of between £619,000 and £1.5 million if it was introduced across the primary care trust in Hampshire. The pilot study demonstrated that teledermatology can offer a more cost effective means of providing dermatology services and managing patient referrals than the traditional outpatient system.

The literature review for this project did not identify any projects that had used simulation methods to model Teledermatology services. Therefore, a key requirement for this project will be to disseminate the findings via telemedicine, healthcare and simulation journals and conferences.

### **Teledermatology in the Rest of Wales**

The researcher tried to identify where teledermatology was being used in areas of Wales beyond Hywel Dda LHB. It was discovered that the Cardiff and Vale University Health Board had introduced a Teledermatology Service in 2006, receiving referrals from 12 GP practices. The Cardiff and Vale service now uses 'store and forward' technology to receive referrals from approximately 50 GP surgeries, connecting them with specialist dermatologists at Cardiff and Vale UHB's Welsh Institute of Dermatology. The consultant dermatologist involved in the Cardiff and Vale Teledermatology Service commented that 'store and forward' technology can be used effectively to bridge the gap between the General Practitioner and hospital based specialists and can help specialists to manage the right patient, in the right place at the right time<sup>2</sup>.

In the Cardiff and Vale Teledermatology Service, GPs send electronic referrals to the specialist dermatologist for diagnosis and ask the patients to come back in a week. During that week, usually within 24 to 48 hours, and often sooner, the dermatologist contacts the GP and feeds back about which patients need to come into a specialist clinic and which can be managed through the GP surgery. The diagnosis, using the electronic referral, may only take between thirty and sixty seconds when in a clinic setting it might take between 5 and 10 minutes [source: discussions with consultant dermatologist, Cardiff and Vale LHB].

The service in Cardiff currently manages over 3,000 Teledermatology referrals a year with 70% - 80% of those patients managed entirely without any further consultation in secondary care. The expert commented that there are approximately 10,000 dermatology referrals that could be considered for triage through teledermatology in Cardiff and Vale UHB, and 70% of those could have their care managed within the GP setting.

---

<sup>2</sup> Discussion with expert from Cardiff and Vale Teledermatology Service

The expansion of the original Cardiff and Vale Teledermatology Service was helped in 2008 by a grant from Informing Healthcare which provided enough digital cameras and technology for 50 GP practices. The grant also paid for a person to provide one year of media support to the practices involved. Since the original investment, the Cardiff and Vale Teledermatology Service has won an NHS Wales Award for Innovation in Healthcare for providing secondary care services in a primary care setting in 2011.

### **3 Methodology**

In order to satisfy the aims and objectives of the project, the study involved three distinct parts:

- patient travel analysis;
- simulation modelling and;
- cost benefit analysis.

#### **Patient Travel Analysis**

A key aim of the project was to determine whether there were any benefits to the patients from using teledermatology, particularly to those living in rural areas. In order to do this, patient data on 143 patients who attended “store and forward” clinics and 19 patients who used videoconference clinics in Hywel Dda LHB was analysed. For each patient, the distance from their home to the clinic they attended was calculated and compared with the distance they would have travelled if they had attended an outpatient appointment with the consultant dermatologist based in Glangwili Hospital, Carmarthen. A full discussion of the patient travel analysis for the 143 patients that used “store and forward” clinics is given in Chapter 4. The patient travel analysis for the 19 videoconference patients is discussed in Chapter 5.

#### **Simulation Model**

As well as considering the potential benefit to the patient from reduced travel to and from the clinics, another key objective of the project was to consider whether teledermatology was an efficient way of seeing routine patients and to compare the use of “store and forward” clinics against the traditional outpatient appointment system.

The researcher had discussions with the telemedicine project manager, consultant dermatologist, specialist dermatology nurse and the GP with a specialist interest in dermatology and gained valuable information on how the “store and forward” clinics and outpatient appointment systems were conducted. On the basis of the information gathered, a flow chart on each clinic system was developed and used as the basis of the simulation models developed and discussed in Chapter 7. The simulation models were developed in Simul8, and compared the pathway of the 123 patients who

attended “store and forward” clinics in Aberystwyth and Aberaeron<sup>3</sup> with what the pathway would have been had they attended a traditional outpatient appointment with the consultant at Glangwili Hospital. The time the patient spent in each system was modelled and compared.

### **Cost Benefit Analysis**

As well as considering the potential benefit to the patients in the study through potential reduced travel time and reduced time spent in the system, the project considered the cost of providing the “store and forward” clinics in comparison to the cost of the outpatient appointment system.

The cost-effectiveness of teledermatology services appears highly dependent upon the context in which those services are provided. Some of the main factors the economic literature cites as influencing the cost effectiveness of teledermatology services include:

- the number of physical patient referrals avoided;
- the distance between patient and dermatologist;
- the reduction in waiting time achieved;
- the number of patients that can be seen under each approach in a given time; and
- the cost of any additional equipment required to deliver teledermatology.

Any assessment of teledermatology must therefore include consideration of all of the above issues. For this Project, the number of patients that can be seen, the distance and the cost of additional equipment have been considered. The simulation model considered the effect of the reduced waiting time. Although as part of the Quality Assurance process for the Study it was suggested that the number of patient referrals avoided might have been taken into account, additional information would have been required in order to do this and it was not possible to acquire this within the limited scope of a demonstration project.

However, a significant challenge identified by the economic literature is the difficulty in valuing some of the typical benefits claimed for telemedicine and teledermatology, such as improved quality of care and the transfer of skills between medical practitioners.

---

<sup>3</sup> The Borth clinic cases were not included because processes were still in their infancy.

The HM Treasury Green Book definition of a 'cost benefit analysis' is: "Analysis which quantifies in monetary terms as many of the costs and benefits of a proposal as feasible including items for which the market does not provide a satisfactory measure of economic value" (p4, HM Treasury (2003)). The concept of cost benefit analysis is therefore very broad.

It should be noted that the result of any cost benefit analysis comparing a teledermatology service against an outpatient dermatology service will only provide a partial, and therefore potentially misleading picture, given that it will fail to take into account those costs and benefits that cannot be valued in monetary terms e.g. the full cost of keeping a patient on a waiting list. The results of such an analysis should therefore not be considered in isolation, as there may be decisive but unquantifiable costs or benefits that are sufficient to override the simple results of a cost benefit analysis. However, this demonstration project includes as complete a cost benefit analysis as was possible given the limited scope of a demonstration project, identifying some of the known costs and savings associated with the outpatient and the 'store and forward' teledermatology services.

The European Commission recently undertook a one-year study to evaluate the different methodologies that have been used to assess telemedicine applications (Commission, 2010). The study recommended that the economic evaluation of a telemedicine application should include:

- The amount of resources used and the cost of those resources
  - Equipment
  - Staff
  - Staff Training
  - Medication
  - Patient's use of time
  - Relative's use of time
  - Transportation
- Related change in use of healthcare resources
  - Primary care
  - Outpatient appointments
  - Hospitalisation
  - Bed days



Looking at both the data and the analysis that would be required to meet these recommendations, it was decided that a full cost benefit analysis would have to remain outside the scope of this project, particularly within the timeframe set for the work. Therefore, in order to establish the relative merits of delivering dermatology services via a telemedicine or outpatient service, the decision was made to compare the costs of both delivery options on the basis of the data already in existence for each service. For the demonstration project, cost data was available for both the staff time involved and the equipment used. The value of a patient's time was calculated by estimating the patient's travel time and attaching a standard cost to that time (Department for Transport's estimate). Information was not available about any relatives that accompanied patients so the cost to patients is likely to be an underestimate.

For the purposes of this Study, it has been assumed that the patient outcome is the same irrespective of whether the consultation was delivered via teledermatology 'store and forward' or an outpatient appointment. On the basis of a discussion with the consultant dermatologist it was agreed that this was a reasonable assumption, since they were able to advise that the digital cameras used produce very high quality images of the skin condition which enable a clear diagnosis to be made.

As noted above, the challenges that emerged during the demonstration process will be explored in more detail in a Lessons Learned report, publication of which is to follow.

## **4 Store and Forward Clinics in Hywel Dda LHB**

“Store and forward” has been used for a number of years within Hywel Dda LHB. In the “store and forward” clinics, images of a patient’s skin lesions and rashes, taken by a specialist nurse located at a rural GP Surgery, are transmitted using a secure NHS portal to a consultant dermatologist at Glangwili Hospital.

At present, patients from Ceredigion (which lies within the LHB) are estimated to spend up to 1.5 hours each way travelling to a 10-minute outpatient appointment at Glangwili Hospital. Attending a “store and forward” clinic at a local facility (Aberaeron, Aberystwyth or Borth) or videoconference clinic in Bronglais Hospital would allow the patient to reduce their travelling time.

Whether they are being offered an interactive videoconference consultation or being entered into the “store and forward” system (a decision that is made by the consultant dermatologist or a member of their clinical team based on the referral letter), the patient is asked whether they are happy to receive treatment using teledermatology rather than by attending an outpatient clinic. The attitudes of both the GP and the patient to Telemedicine may affect the patient’s decision but to examine this issue is beyond the limited scope of this demonstration project.

The “store and forward” process is described below and the approximate timings reported by the telemedicine project manager are summarised in Table 4.1, below.

### **The “store and forward” process**

Once a patient has been to see their GP, the GP writes a referral letter which is posted to the consultant dermatologist (based in Glangwili Hospital, Carmarthen) via the hospital medical records department. It should be noted that although referrals are currently done by post, the telemedicine manager saw the Project as a means of highlighting how using electronic referrals could streamline the current process.

Once medical records have received the referral they send it to the consultant dermatologist who assesses the referral and contacts the specialist nurse by post informing them of available videoconference and “store and forward” appointments. The nurse is based at a GP surgery (Aberystwyth, Aberaeron or Borth). The nurse phones the patient and arranges an appointment for the “store and forward” clinic. At the clinic, the specialist nurse takes digital photographs of the affected skin area and, using a secure portal, electronically sends the images and referral document to the consultant dermatologist.

The consultant dermatologist receives the electronic images and referral document and makes a judgment about the image. The dermatologist writes an electronic referral reply explaining the recommended treatment strategy and sends it back to the specialist nurse, who contacts the patient to arrange a follow up appointment, a prescription, a discharge from the system or, for more complex cases, an outpatient appointment with the consultant.

The data used for the Demonstration Project was provided by the Telemedicine Manager for Hywel Dda Local Health Board and relates to “store and forward” patients attending clinics between 7<sup>th</sup> April 2010 and 9<sup>th</sup> May 2012. There were no clinics between 5<sup>th</sup> April and 28<sup>th</sup> September 2011 as the service was not available due to the unavailability of specialist nursing support. A total of 143 records were provided for patients attending clinics in Aberystwyth, Aberaeron and Borth.

**Table 4.1: Summary of Timings for “Store and Forward” Clinics**

Event	Timing
GP referral letter travels between GP and hospital medical records office	6 working days
The GP referral letter sent from medical records to consultant	1 day
Consultant assesses GP referral	Up to 9 working days (approx. 5 minutes per referral)
Consultant contacts specialist nurse	2 days
Specialist nurse contacts patient to arrange appointment	Up to 3 weeks
Preparing electronic referral forms	20 minutes per patient
Store and forward appointment (taking the photos, completing and sending the referral)	20 minutes per patient
Consultant assesses electronic referral	15 – 20 minutes per referral
Nurse arranges follow-up appointment with consultant (if required)	2 – 3 days per patient

Source: Telemedicine Manager Hywel Dda Health Board

The timings in Table 4.1 were fed into the teledermatology simulation model described in Chapter 7 of this Report.

### **Patient Travel Analysis**

The aim of the patient travel analysis was to see how a patient’s travel time and distance was affected by using “store and forward” technology in their treatment plan. If the patient hadn’t attended a local clinic, they would have had to travel to Glangwili Hospital, Carmarthen. Before a consultant dermatologist was appointed at Glangwili

Hospital, patients had to travel to Singleton Hospital in Swansea. This situation could happen again if the consultant dermatologist left the service for any reason.

Therefore, a second analysis was undertaken to compare the difference between attending a local clinic and travelling to Singleton Hospital.

Before 5<sup>th</sup> April 2011, the majority of the clinics were held in Aberystwyth, with a total of 102 patients being seen. As noted above, no clinics were held from 5<sup>th</sup> April to 28<sup>th</sup> September. After 28<sup>th</sup> September 2011, clinics were held in Borth (20 patients) and Aberaeron (21 patients).

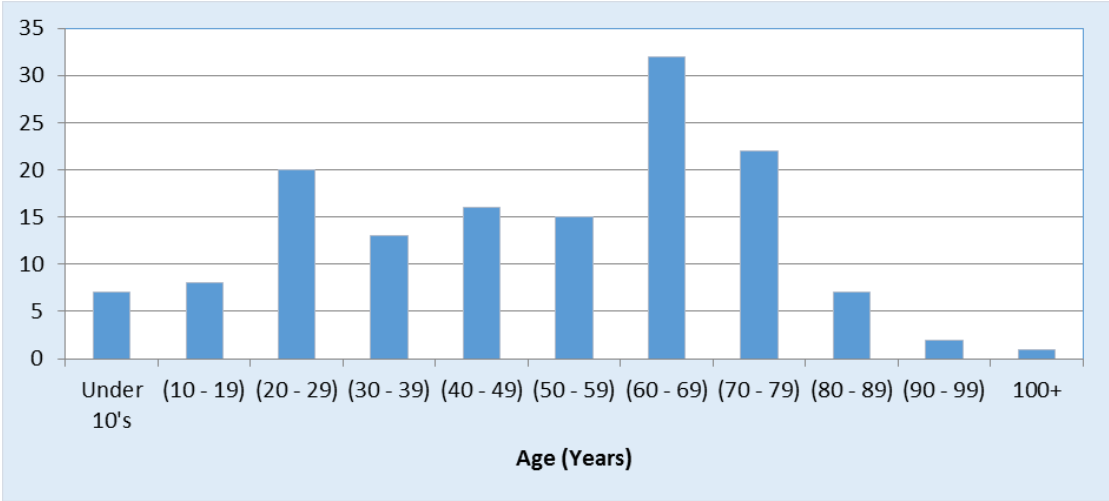
No information was available about the actual journeys made by patients. We therefore knew nothing about mode of transport or whether patients travelled to appointments from locations other than their own homes (e.g. their workplace). To preserve confidentiality, only the first five digits of the patient’s home postcode were provided. Table 4.2, shows the number of patient referrals by postcode area. Each of the patients in this study only attended the clinic once.

**Table 4.2: Number of patient referrals by postcode area**

Postcode area	Number of patient referrals
SA19 8	1
SA45 9	2
SA46 0	10
SA47 0	3
SA48 7 or 8	11
SY20 8	4
SY21 0	1
SY23 1 to 5	95
SY24 5	14
SY25 6	2

The patients’ ages ranged from 2 years to just over 100 years. The distribution of patient age is illustrated in Figure 4.1, below.

**Figure 4.1: Age structure of patients**



The analysis assumed that the patient travelled directly from their home postcode area to their “store and forward” or outpatient appointment and returned directly home using their own transport. The ‘shortest route’ method was used because it was assumed that patients would want to save money on fuel, time and distance when travelling to appointments. The shortest route analysis generated journey times in minutes and journey distances in miles. The shortest routes between the patient postcode areas and their allocated clinics were compared against the shortest comparative routes to Glangwili and Singleton Hospitals.

**Travel Analysis Results**

The results for the Aberystwyth Teledermatology Clinic are discussed in this section and summarised in Table 4.3, below. Due to small numbers, the results for the Aberaeron and Borth clinics are not discussed but are provided in Appendix 1.

There was a lot of variation in the distance travelled by patients to the Aberystwyth Clinic. The 19 patients resident in the ‘SY23 1’ area were estimated to have made the shortest journey, with a round trip of 1.8 miles. The longest individual route is for the patient who has the ‘SY21 0’ postcode, who would make a round trip of 82.7 miles. In total, the 102 patients would be estimated to travel 1,592 miles to attend their teledermatology appointments at the Aberystwyth Clinic.

**Table 4.3: Distance from Patient Postcode Area to Aberystwyth Clinic**

Patient Postcode	Round Trip Distance to Aberystwyth Clinic (miles)	Number of Patients (n)	Total Distance Saving (miles)	
SA46 0		32	1	32
SA47 0		39	2	79
SA48 7		43	1	43
SA48 8		44	2	88
SY20 8		35	2	70
SY21 0		83	1	83
SY23 1		2	19	35
SY23 2		4	10	38
SY23 3		16	31	491
SY23 4		17	14	230
SY23 5		22	7	157
SY24 5		17	10	174
SY25 6		37	2	73
TOTAL			102	1,592

The estimated round trip travel times for the patients who visited the Aberystwyth Clinic are shown in Table 4.4, below. The shortest round trip travel time is 2.6 minutes for the 19 patients who had a 'SY23 1' postcode. The longest round trip travel time is estimated for a patient with a 'SY21 0' postcode and takes 134 minutes (66.8 minutes each way). In total, the 102 patients were estimated to take 2,545 minutes (over 42 hours) to travel to and from "store and forward" clinics.

If we were to combine the round trip travelling time for all 143 patients attending the three "store and forward" clinics, i.e. including Borth and Aberaeron, it would give a total of 3,705 minutes or around 62 hours.

**Table 4.4: Travel Time from Patient Postcode to Aberystwyth Clinic**

Patient Postcode	Round Trip Travel Time (minutes)	Number of Patients (n)	Total Time Saving (minutes)
SA46 0	32	1	32
SA47 0	44	2	88
SA48 7	70	1	70
SA48 8	70	2	139
SY20 8	45	2	90
SY21 0	134	1	134
SY23 1	3	19	51
SY23 2	8	10	78
SY23 3	31	31	961
SY23 4	25	14	353
SY23 5	29	7	205
SY24 5	24	10	242
SY25 6	51	2	102
TOTAL		102	2,545

Table 4.5, below, estimates the round trip distance saving to the patients attending the Aberystwyth “store and forward” Clinic rather than travelling to Glangwili Hospital outpatient clinic. For example, for a patient whose postcode starts ‘SA46 0’, the distances to and from the Aberystwyth Clinic and Glangwili Hospital are, respectively, 32 miles and 59 miles. As expected, the round trip distance to Aberystwyth is shorter than the corresponding distance to Glangwili for all postcode areas.

If all the patients from ‘SY23 1’ were to travel to Glangwili Hospital they would travel 1,624 miles instead of 35 miles, a huge group-wide saving of 1,589 miles. If teledermatology had not been introduced in Aberystwyth Clinic, the 102 patients would have travelled an estimated extra 7,501 miles (see Table 4.5, below).

**Table 4.5: Distance Saving (Aberystwyth Clinic vs. Glangwili Hospital)**

Patient Postcode Area	Round Trip Distance to Aberystwyth Clinic (miles)	Round Trip Distance to Glangwili (miles)	Distance Saved per patient (miles)	Number of Patients (n)	Total Distance Saving (miles)
SA46 0	32	59	27	1	27
SA47 0	44	50	11	2	21
SA48 7	70	47	4	1	4
SA48 8	70	49	5	2	11
SY20 8	45	120	85	2	170
SY21 0	134	167	84	1	84
SY23 1	3	86	84	19	1,590
SY23 2	8	89	85	10	849
SY23 3	31	101	85	31	2,640
SY23 4	25	80	63	14	884
SY23 5	29	66	44	7	306
SY24 5	24	103	85	10	852
SY25 6	51	68	31	2	63
TOTAL				102	7,501

The corresponding savings in journey time are shown in Table 4.6, below. In total, 10,666 minutes (or approx. 178 hours) of travelling time was saved by using the “store and forward” clinic at Aberystwyth. Most of the patients save time travelling to Aberystwyth Clinic. However patients from ‘SA48 7’ and ‘SA48 8’ have a slightly longer journey if they travel to the “store and forward” clinic. Their journey time is 9 minutes longer (indicated by -9 in Total Time Saved column). We had no information about why teledermatology was offered to these patients – they may have requested an appointment close to their work rather than their home address.



**Table 4.6: Travel Time (Aberystwyth Clinic vs. Glangwili Hospital)**

Patient Postcode	Round Trip Travel Time to Aberystwyth (minutes)	Round Trip Travel Time to Glangwili (minutes)	Time Saving (minutes)	Number of Patients (n)	Total Time Saved (minutes)
SA46 0	32	97	66	1	66
SA47 0	44	84	40	2	81
SA48 7	70	61	-9	1	-9
SA48 8	70	65	-4	2	-9
SY20 8	44	167	122	2	244
SY21 0	134	291	157	1	157
SY23 1	2	123	121	19	2,292
SY23 2	8	127	120	10	1,196
SY23 3	32	153	122	31	3,783
SY23 4	25	101	76	14	1,067
SY23 5	30	100	70	7	493
SY24 5	24	146	122	10	1,220
SY25 6	50	94	43	2	86
TOTAL				102	10,667

As noted above, a similar analysis was carried out to investigate the savings that would be made in terms of distance and time by the patients attending Aberystwyth rather than travelling to Singleton Hospital (the previous location of dermatology service). The analysis demonstrated that almost 12,000 miles and over 20,000 minutes (344 hours) would have been saved.

In conclusion, the drive time analysis of data for the 143 “store and forward” patients has shown that, despite the fact the figures are likely to be underestimates, there are large savings to be made by patients in terms of the time taken and the distance travelled to attend appointments. Where some of these journeys are likely to be completed using patient transport, this will also represent a saving to the NHS in Wales. Reduced patient travel may have a benefit to the environment and thereby support the WG’s Sustainable Development objectives.

## 5 Videoconference Clinics in Hywel Dda Health Board

Video-conferencing has also been used in Hywel Dda LHB to provide real-time consultations between the consultant dermatologist and patients who would otherwise have to travel to Glangwili Hospital.

In the videoconference appointment scheme, the patient is sent an appointment letter offering them a videoconference clinic appointment. The letter explains that they have the option of a traditional outpatient appointment if they don't want to use videoconferencing. The patient is asked to return a signed reply form saying which option they want to use.

During the videoconference appointment, the patient is accompanied by a clinician who can explain any treatment plan and diagnosis to the patient. During the study period, both a specialist GP and a specialist nurse were present with the patient during videoconference clinics. As the specialist nurse became more experienced, the expectation was that she would be able to run the clinic without the specialist GP present<sup>4</sup>.

A patient travel analysis was carried out on the 19 patients for whom videoconference data was available to examine whether the distance and time travelled was reduced by attending a videoconference clinic in Bronglais Hospital rather than an outpatient appointment in Carmarthen (see Table 5.1, below).

**Table 5.1: The Patient Travel Distance (Shortest Route) from Patient Postcode to Bronglais Hospital**

Patient Postcode	Round Trip Distance (miles)	Number of Patients (n)	Total Distance (miles)
SY24 5	17	5	84
SY23 1	3	5	16
SY23 4	19	3	56
SA46 0	34	1	34
SY23 5	25	2	50
SY23 2	1	2	3
SY23 3	16	1	16
TOTAL		19	259

<sup>4</sup> (source: meetings with specialist GP and dermatology nurse, April 2012)

The round trip distances vary from 1.4 miles (for 'SY23 2') to 34 miles (for 'SA46 0'). The overall distance travelled by all 19 patients attending videoconference clinics at Bronglais Hospital was 259 miles.

The shortest journey time to the videoconference clinic at Bronglais Hospital was a round trip of 2.5 minutes for patients with a 'SY23 2' postcode. Patients from 'SA46 0' had the longest journey at 36 minutes. The overall, combined journey time for the 19 patients was 344 minutes (close to 6 hours).

The round trip distance savings for patients attending a videoconference at Bronglais Hospital rather than travelling to Glangwili Hospital are shown in Table 5.2, below.

**Table 5.2: Distance Saving (Videoconference vs. Glangwili Hospital)**

Patient Postcode	Number of Patient Records	Round Trip Distance to Bronglais	Round Trip Distance to Glangwili	Distance Savings	Round Trip Group Distance to Glangwili	Total Group Distance Savings
	(n)	(miles)	(miles)	(miles)	(miles)	(miles)
SY24 5	5	17	103	86	513	429
SY23 1	5	3	85	82	428	412
SY23 4	3	19	80	61	239	183
SA46 0	1	34	59	25	59	25
SY23 5	2	25	66	41	132	83
SY23 2	2	1	89	87	177	175
SY23 3	1	16	101	85	101	85
TOTAL	19					1,390

A patient with postcode 'SY24 5' would save 85.8 miles by going to Bronglais rather than Glangwili. If all the patients from this postcode had to travel to Glangwili Hospital, the extra distance travelled would be 429 miles.

Overall, the group of 19 patients saved close to 1,400 miles and around 33 hours by travelling to Bronglais Hospital rather than Glangwili Hospital. As for the "store and forward" system, this represents a significant saving to patients and, where patient transport may be used by some, to the NHS in Wales.

## **6 The Clinicians' Role**

The analysis has so far concentrated on the patient perspective. This section summarises the role of the clinicians involved in running the “store and forward” and videoconference clinics as the medical resource behind the patients' treatment also needs to be included in any simulation of the real-life system. The Teledermatology in Hywel Dda LHB involves three clinicians: the consultant dermatologist, the GP with specialist interest in dermatology and the Dermatology Specialist Nurse.

The working patterns of both the consultant dermatologist and the Dermatology Specialist Nurse have been built into the simulation models of the teledermatology and outpatient systems presented in Chapter 7.

### **The Role of the Consultant Dermatologist**

The consultant dermatologist is based at Glangwili Hospital in Carmarthen and is responsible for outpatient clinics at Glangwili Hospital and Withybush General Hospital. The British Association of Dermatology recommends one consultant per 70-80,000 population. Hywel Dda serves a population of approximately 375,000 so should theoretically have at least four consultant dermatologists. During the study period, there was one consultant and three vacancies.

The typical working pattern for the consultant dermatologist based at Glangwili Hospital is summarised in Table 6.1, below. The working day is 11 hours on a Monday, 7 hours on a Tuesday, Wednesday and Thursday and 9 hours on a Friday. A normal working week is around 40 hours. No time is formally set aside for lunch.

**Table 6.1: Summary of the Consultant dermatologist's working pattern**

Time	Monday	Tuesday	Wednesday	Thursday	Friday
09:00 – 10:00	Outpatient Clinic at WGH			Clinic <sup>5</sup>	Outpatients Clinic at WGH
10:00 – 11:00	Outpatient Clinic at WGH	Admin or Ward Referrals at GGH	Admin or Ward Referrals at GGH	Clinic	Outpatients Clinic at WGH
11:00 – 12:00	Outpatient Clinic at WGH	Admin or Ward Referrals at GGH	Admin or Ward Referrals at GGH	Clinic	Outpatients Clinic at WGH
12:00 – 13:00	Outpatient Clinic at WGH	Multidisc. Team Meeting at GGH	Research admin at GGH	Clinic	Outpatients Clinic at WGH
13:00 – 14:00	Admin / Ward Referrals at WGH	Outpatient Clinic at GGH (Starts at 13:30)	Research or admin at GGH	Admin at GGH	Outpatients Clinic at WGH
14:00 – 15:00	Admin / Ward Referrals (WGH)	Outpatient Clinic at GGH	Research or admin at GGH	Admin at GGH	Outpatients Clinic at WGH
15:00 – 16:00	TRAVEL Between Hospitals	Outpatient Clinic at GGH	Research or admin at GGH	Admin at GGH	Outpatients Clinic at WGH
16:00 – 17:00	Admin at GGH	Outpatient Clinic at GGH	Telelink to ABMU Multidisc. Team Meeting		Outpatients Clinic at WGH
17:00 – 18:00	Outpatient Clinic at GGH				Outpatients Clinic at WGH
18:00 – 19:00	Outpatient Clinic at GGH				
19:00 – 20:00	Outpatient Clinic at GGH				

**The Role of the GP with specialist interest in dermatology**

In 2005-06 there were no dermatology consultants in Hywel Dda LHB so all patients were referred to Singleton Hospital in Swansea. This also meant that GPs were unable to pursue a special interest in dermatology since GPs are required to have a certain amount of patient contact, under the supervision of a consultant, to pursue a specialism.

---

<sup>5</sup> Clinic on Thursday refers to one of the following clinics: Paediatric, teledermatology videoconference, rheum or admin

The GP with a specialist interest for dermatology in Hywel Dda is based at Bronglais Hospital in Aberystwyth. As well as being involved in teledermatology, she is the Medical Director of Hywel Dda LHB and a Locum GP at Borth Surgery.

Her role in teledermatology is:

- To attend videoconference clinics (one morning each month) where she supports patients during their appointments with the consultant dermatologist.
- To supervise treatment plans and ensure the continuation of patient care.
- To discuss with the consultant which patients can be seen remotely at the videoconference clinics.
- To help the specialist dermatology nurse decide which patients can attend remote “store and forward” clinics in Aberystwyth, Aberaeron and Borth.
- To maintain continuing professional development (CPD) through contributing to the treatment of patients via video-conference.

In addition to her role in teledermatology, the specialist GP ran minor surgery clinics and non-dermatology GP surgeries. In the minor surgery clinics she had help from a specialist nurse to remove moles etc. and saw 6 patients per clinic. This contrasts with seeing approximately 16 patients in a non-dermatology GP clinic (each patient has a 10 minute appointment).

### **The Role of the Dermatology Specialist Nurse (DSN)**

The official job title for this post is ‘Community Dermatology Liaison Nurse’ and the responsibilities are:

- Liaising with the consultant dermatologist for the “store and forward” and videoconference clinics.
- Running nurse-led dermatology clinics.
- Assisting GPs with dermatology clinics.

The incumbent during the study period had been based at Borth Surgery since May 2011 and had been involved in the “store and forward” and videoconference clinics since October 2011.

Although the DSN mainly worked at the Borth surgery, she explained that she could deliver teledermatology clinics at other locations if she worked full-time rather than part-time. The specialist dermatology nurse had a term-time contract and worked 18 hours per week. Teledermatology is one part of her job and she spent 6 hours per day on Teledermatology “store and forward” activities.

## **7 The Simulation Models**

The purpose of the simulation modelling component of the Project is to represent the 'patient journey' for dermatology patients in Hywel Dda from their first GP consultation through to their discharge from the system. Two models were created, the first simulating the journey if patients choose to attend a "store and forward" clinic and the second if they choose to attend an outpatient appointment. The models were developed in Simul8, a well-known computer package for building simulation models. The 'patient journey' for patients attending videoconference clinics was not modelled as the clinics have only been in operation a short time so data was available on too few patients.

### **Background**

The simulation model seeks to compare the estimated 'time in system' or 'elapsed time' for the patients who attended teledermatology clinics in Hywel Dda LHB between 2010 and 2012.

As noted above, two teledermatology clinics were being run in Hywel Dda LHB – these were in Aberystwyth and Aberaeron and saw 123 patients in 2010 and early 2011.

At the beginning of 2011, the specialist nurse left. A new specialist nurse was appointed in late 2011. This resulted in the closure of the Aberystwyth clinic and, when a new nurse was appointed, the opening of a new, replacement clinic in Borth.

### **Developing the Simulation Model**

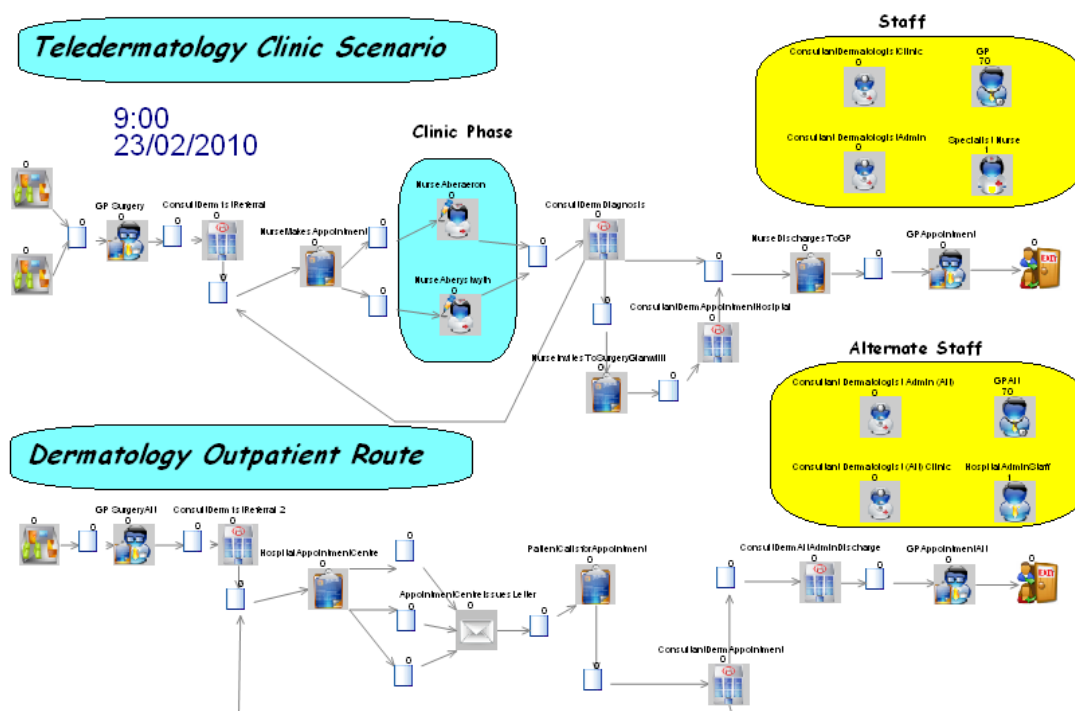
The Teledermatology Clinic Scenario model uses data for 123 patients who attended either Aberystwyth or Aberaeron Clinic for their "store and forward" clinic appointment. The Dermatology Outpatient Route model simulates the 'patient journey' for the same 123 patients had they chosen to attend outpatients instead. The timings captured in the model are based on the data provided by Hywel Dda LHB and shown above in Table 4.1. For example, an estimate was provided of the time it took for a referral letter to get from the GP to the consultant. For the outpatient model, information was provided about the length of the Dermatology Outpatient waiting list (it varied between 2-3 weeks for high priority patients and 6 months for routine patients) and the percentage of patients categorised at each level of priority; approximately 30% of patients experienced a six month wait.

Based on the information provided, the average time that elapsed between the patient seeing their GP and attending the “store and forward” appointment was set at 41 days for each patient. The date of the patient’s GP appointment was calculated by subtracting 41 days from the patient’s clinic date. This date was imported into the model on an Excel spreadsheet. The simulation clock was set at the date of the earliest GP appointment, the 23<sup>rd</sup> February 2010. The model was set to run in days, incorporating the calculations mentioned above.

Staff resources were also incorporated into the model. The consultant dermatologist was modelled as performing two separate tasks: clinic and administration.

A screenshot of the Simul8 models is given in Figure 7.1. The top half describes the teledermatology “store and forward” clinic system. The bottom half of the screenshot shows the traditional outpatient system.

**Figure 7.1: Screenshot of the Teledermatology Clinic Scenario and Dermatology Outpatient Route Simulation Models**



There are some elements that are the same in both systems e.g. visiting the GP surgery, letter being sent to the consultant, final discharge from the system. However, for the teledermatology model two clinics are available -Aberaeron and Aberystwyth - whilst the outpatient model only includes the clinic at Glangwili Hospital.



Full technical specifications for the models were documented in a separate Technical Report to WG, which can be made available on request to approved researchers undertaking similar modelling projects.

The simulation models were run using a limit of 600 days. This was assumed to be enough time for all patients to have passed through the system. Each simulation model was run using 123 patients. The results from the simulations are summarised in the Table 7.1, below.

**Table 7.1 Simulation Model Results for 123 patients attending Aberaeron and Aberystwyth teledermatology clinics between 2010 and 2011**

Type of clinic	Minimum (days)	Average (days)	Maximum (days)	Percentage cleared system (%)
Teledermatology	80	92	181	100
Outpatient Dermatology	73	208	493	80

Source: Simulation model run for 600 days

From the above table it can be seen that, after 600 days, all 123 patients passed through the teledermatology model and had been discharged to their GP (100% cleared system) with an average of 92 days. In contrast, only 98 patients (80 per cent) had cleared the outpatient model, with those clearing the system taking on average 208 days. The maximum time for a patient to pass through the two systems was also very different, at 181 days for teledermatology compared with 493 days for the outpatient system.

*“What if” Scenario 1 – scheduling electronic referrals*

As noted above, one of the objectives of the Study was to determine the effect of reducing the elapsed time (currently 15 days) between the patient attending the “store and forward” clinic and the electronic referral being reviewed by the consultant. The telemedicine manager and the DSN wanted to see the effect of reducing the consultant’s turn-around time for the electronic referrals. A specific time reduction was not proposed by the health board so we chose to reduce the elapsed time from 15 days to 10 days. The simulation model run shows that when this reduction is made, the average time a patient spends in the system overall is reduced from 92 days to 84 days.

*“What if” Scenario 2 – hospital waiting list*

The main assumption that affected the comparison between the models was the waiting time associated with the outpatient appointment system. The six month wait

for 30% of patients in the dermatology outpatient appointment queue (as noted above) was the main barrier preventing patients from passing through the outpatient model to a similar timescale to the teledermatology system.

To test the sensitivity of the estimated time in the system to the six-month waiting list assumption, the outpatient model was adapted slightly so that the hospital waiting time was reduced to the 21 days observed in the Teledermatology model.

**Figure 7.2 Outpatient Route with amended Hospital appointment centre queue**

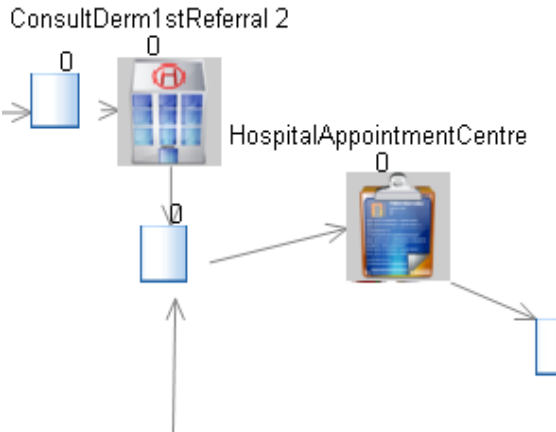


Figure 7.2, above, shows that the three routes (very urgent, urgent and routine) in the outpatient model have been reduced to one route with a minimum wait of 21 days. The results of this amended simulation are displayed in Table 7.2, below

**Table 7.2 Results with amended Outpatient Route Queue**

Type of Clinic	Minimum (days)	Average (days)	Maximum (days)	Percentage cleared system (%)
Teledermatology	80	92	181	100
Outpatient Dermatology	80	115	277	100

Source: Simulation model amended to reduce waiting time to 21 days

The results from the simulation show that if all the patients in the outpatient clinic only had to wait 21 days for their appointment compared with a longer wait time, all of the patients would clear the system within the 600 days, albeit with a longer average time in the system than is estimated for the Teledermatology route. This highlights the potential to improve the outpatient Dermatology route to almost the same efficiencies as the Teledermatology route through improvements to one aspect of the process. However, it should be highlighted that the efficiencies wouldn't be immediate as the new process would need time to be introduced and embedded and extra clinicians would be needed to clear the backlog and maintain the process. However, the above

equally highlights the sensitivity of the model to changes in this single aspect of the process.

### *Staff Resource*

One other potential service optimisation that could be explored in the future is staff resource. It would be sensible to assume that by increasing staff resource you would expect to see reductions for the average time patients spend in either dermatology pathway. However, to do this we would need to know the effect of increasing staff resource on the hospital waiting lists in the outpatient approach and on the time the consultant spends looking at GP and electronic referrals.

If the study were to be revisited in the future, the effect of staff skills and preferences on each treatment route could be considered. For example, the consultant dermatologist explained that in some areas the clinics are run differently and consultants may prefer to send their patients to the outpatient clinic without using 'store and forward' (source: discussions with the consultant dermatologist, 2013).

### **How the model could be improved**

Whilst it is possible to conclude that the elapsed time for the teledermatology pathway is shorter, it could be argued that there are elements of both approaches that need further investigation. In particular, the waiting times in the outpatient pathway would need to be better understood and mapped in the model. For example, having better data on when the referral arrives at the medical records centre and when the appointment date is sent to the patient would give a better approximation of what happens with the hospital waiting lists and this could be included in an improved simulation model. Similarly, having access to data on when the specialist nurse contacted the patient to book the "store and forward" appointments would give a better approximation of the waiting time in the teledermatology clinic system.

The models indicate some areas where improvements could be made in both the teledermatology and outpatient dermatology pathways, regarding staffing levels or optimisation of staff time. In initial discussions with the telemedicine manager and the specialist dermatology nurse, they asked whether the model could explore the impact on the "store and forward" pathway of reducing the elapsed time taken for the consultant dermatologist to look at the electronic referrals received. As noted above, the simulation models were adapted to examine the effect a 5-day reduction in the time taken by the consultant to make their assessment would have on the overall

time a patient spends in the system. Future model improvements could be to look at different reductions or to adjust the consultant's working pattern in the simulation model and rerun the simulation models to consider the effect.

### **Model Validation and Quality Assurance**

The key assumptions behind the simulation model were checked in discussion with the clinicians involved in the study and with analysts from the WG KAS OR Working Group. A 'sense check' of the emerging findings from the simulation models was achieved by presenting at the Rural Health Implementation Group and at the Welsh Health Area Network meetings in 2012.

### **Conclusions**

From the simulation models, the following conclusions can be drawn regarding the two pathways;

- Teledermatology allowed all of the patients in the two 'store and forward' clinics to clear the system within 600 days compared with 80% in the outpatient system.
- Patients using teledermatology spent a shorter time in the system than those using the outpatient appointment system. On average, patients spent 92 days (3 months) in the teledermatology system compared with 208 days (approximately 7 months) in the outpatient system.
- The waiting time associated with the "store and forward" clinics was much shorter than for the hospital outpatient clinic; three weeks compared with up to six months.
- As mentioned above, the waiting time of six months for 30 per cent of cases is a large factor in the elapsed time for the outpatient pathway. If this time could be reduced, this would have a knock-on effect of reducing the elapsed time for the outpatient pathway.

## 8 Cost Analysis

A cost analysis was carried out to see how the two patient pathways differed. The cost analysis focussed on staff costs for the three key clinicians involved, the cost of the camera equipment used in the “store and forward” clinics and patient travel costs.

As noted above, no data was available on how the patient got to their appointment, whether they used patient transport or whether anyone accompanied them. The assumption was therefore made that the patient travelled by private transport to and from their own home. No additional costs were assumed for patients’ relatives e.g. those required to accompany a child, a disabled or an elderly patient to an appointment. The telemedicine project manager highlighted, for example, that elderly patients from nursing or residential care homes, are normally escorted to appointments by a member of care staff. The cost implications of this have not been factored into the cost comparison presented in this paper. For longer journeys, the telemedicine project manager explained that residential care providers may be less able to release staff to take patients to appointments, and therefore other means, such as an ambulance or patient transport, tend to be used. Again, due to a lack of available data, none of these cost implications have been incorporated.

It should be noted that the cost analysis is partial, since no information was captured on the time spent by GPs or administrative staff in referring patients to the dermatology service or the cost of the buildings used to deliver the services. In the absence of this information, it has been assumed that these costs would be broadly similar for both pathways. Table 8.1 provides an overview of the data used in the cost analysis.

### Data

Hywel Dda LHB provided a rough estimate of the time involved in each member of staff’s involvement in the patient’s treatment, the hourly wages of the medical staff involved in each of the two pathways, and the cost of the digital camera. As noted above, the “store and forward” clinics benefited from free use of a secure NHS server in order to transfer images securely.

Table 8.1, below, shows the time spent by each of the key clinicians in the study under each approach and the associated cost. It can be seen that the cost of staff time per patient is lower for the outpatient service because there is no need to employ a Specialist Dermatology Nurse. The cost of the GP’s time has not been

included, as the specialist nurse is responsible for the patient’s care in the “store and forward” clinic. The cost of other clinicians, such as nurses has not been included.

**Table 8.1: Data used in the Cost Analysis**

Item	Value	Unit	Source
Number of Patients	143	Individuals	Hywel Dda LHB
Average Age of Patient	51	Years	Hywel Dda LHB
Specialist Dermatology Nurse (plus on costs)	16.46	£ per hour	Hywel Dda LHB
Consultant Dermatologist (plus on costs)	56.38	£ per hour	Hywel Dda LHB
Administrative Staff (plus on costs)*	10.62	£ per hour	Hywel Dda LHB
Digital Camera	2,104	£	Hywel Dda LHB
Medical Staff Time (Teledermatology)		per patient	
Specialist Dermatology Nurse	80	Minutes	Hywel Dda LHB
Consultant Dermatologist	20	Minutes	Hywel Dda LHB
Medical Staff Time (Outpatient Dermatology)		per patient	
Consultant Dermatologist	15	Minutes	Estimated
Average Round Trip Travel Time			
Teledermatology	26	Minutes	Patient Travel Analysis
Outpatient Dermatology	123	Minutes	Patient Travel Analysis

**Table 8.2: Medical Staff Time and Cost per Patient**

	Time per patient (Minutes)		Cost (£)*	
	Teledermatology	Outpatient	Teledermatology	Outpatient
Specialist Dermatology Nurse	80	0	22	N/A
Consultant Dermatologist	20	15	19	14
Total	100	15	41	14

\* Figures have been rounded to the nearest £.

The monetary value of patient travel time was estimated using the UK Department for Transport’s ‘Transport Analysis Guidance’ (Transport, (2011)). There are two estimates for a person’s travel time depending on whether the person travelling is employed. The estimated average value of a person’s travel time if they are not employed is £4.76 per hour per person. The corresponding estimate for an employed person is £28.69 per hour. No data on the patient’s employment status was available for this study so the assumption was made that patients were not employed. A future study might attempt to estimate, based on the age distribution of the patients, the proportion who would be expected to be employed but this was not done within the limited scope of the demonstration project.

It should be noted that ‘journey time to a “store and forward” clinic’ has been calculated as the average of the average journey times to each of the three clinics (Aberaeron, Aberystwyth or Borth).

Vehicle costs - fuel and ‘non-fuel operating’ costs - and the costs of carbon emissions have also been included in the cost analysis, cost comparison and the sensitivity analysis (see Tables 8.3, 8.4 and 8.5 respectively). According to the UK Department for Transport’s ‘Transport Analysis Guidance’ (Transport, (2011)), the ‘non-fuel operating’ costs refer to the costs of running a car such as oil, tyres, maintenance and depreciation. As we would expect, given the greater distance, there is a marked difference between the average cost of attending an outpatient appointment and the average cost of attending a teledermatology “store and forward” clinic (£26 compared with £5).

**Table 8.3: Estimated Average Travel Costs \*\***

	Teledermatology	Outpatient	Difference in cost
Time	£2.00	£10.00	-£8.00
Fuel Cost	£2.00	£10.00	-£8.00
Non-Fuel Operating Cost	£1.00	£6.00	-£5.00
Carbon Emissions	£0.20	£1.00	-£0.80
Total	£5.00	£26.00	-£21.80

Table 8.4, below, summarises the comparative costs of providing “store and forward” and outpatient clinics for dermatology in Hywel Dda LHB. The saving achieved by moving the average patient from the teledermatology pathway to the outpatient pathway is not sufficient to fully offset the additional staff and equipment cost of the teledermatology service. For example, on the basis of this partial comparison of costs, the average cost per patient appointment is £20 greater for the teledermatology pathway than for the outpatient pathway.

However, the estimated cost is based on a relatively small sample of 143 patients and the cost of the camera is a one-off cost. So, for example, the cost of the camera per patient would decrease as the number of patients routed through the pathway increased.

It should be noted that the cost analysis is very sensitive to the value placed on a patient’s time. If the calculations were redone valuing some proportion of patients’ travel time at the higher cost, £28.69 per hour, this would have a significant effect on the outcome. If all travel time was valued as working time, this would result in the teledermatology pathway being £19 cheaper than the outpatient pathway as shown in the sensitivity analysis (see Table 8.5).

**Table 8.4: Cost Comparison (per patient consultation)\***

Item	Teledermatology	Dermatology	Difference in cost
Camera Cost per patient	£15.00	N/A	£15.00
Specialist Dermatology Nurse	£22.00	N/A	£22.00
Consultant Dermatologist	£19.00	£14.00	£5.00
Value of Patient Travel Time (Non-Working Time)	£2.00	£10.00	£-8.00
Fuel Cost	£2.00	£10.00	£-8.00
Non-Fuel Operating Cost	£1.00	£6.00	£-5.00
Carbon Emissions	£0.00	£1.00	£-1.00
Total	£61.00	£41.00	£20.00

Source: Knowledge and Analytical Services estimate

\* Figures have been rounded to the nearest pound and therefore may not sum exactly.

**Table 8.5: Sensitivity Test - Cost Comparison (per patient) using Higher Value of Working Time**

Item	Service		Difference in cost
	Teledermatology	Dermatology	
Camera Cost per patient	£15.00	N/A	£15.00
Specialist Dermatology Nurse	£22.00	£0.00	£22.00
Consultant Dermatologist	£19.00	£14.00	£5.00
Value of Patient Travel Time (Working Time)	£12.00	£59.00	£-46.00
Fuel Cost	£2.00	£10.00	£-8.00
Non-Fuel Operating Cost	£1.00	£6.00	£-5.00
Carbon Emissions	£0.00	£1.00	£-1.00
Total	£71.00	£90.00	£-19.00

\* Figures have been rounded to the nearest pound

## Benefits

In terms of the benefits, the teledermatology system can result in both cost-related and non-cost related benefits.

The non-cost related benefits include the transfer of skills between the Consultant Dermatologist, the Specialist GP and the Specialist Dermatology Nurse. For example, the increased knowledge and experience of the GP and SDN could potentially decrease service costs in future, and improve the efficiency of the service. Telemedicine also allows the dermatologist and other clinicians to keep up to date with e.g. the latest medical advances, consult online resources and have clinical discussions with other experts (source: discussions with consultant dermatologist, specialist dermatology nurse and specialist GP, April 2012). This 'learning effect' cannot be costed but represents a significant benefit to patients, clinicians and society.



In addition, the consultant dermatologist reported that telemedicine would allow patients to be directed to online information about their illness and to relevant support groups as well as creating a large collection of digital images of different skin conditions which would help with training (source: discussion with consultant dermatologist, specialist nurse and specialist GP, April 2012).

In terms of cost-related benefits, teledermatology can provide a cheaper and less time-consuming solution for patients, particularly in rural areas of Wales.

As noted above, the challenges that emerged during the demonstration process and the benefits of using OR methods to inform service optimisation will be explored in more detail in a Lessons Learned report, publication of which is to follow.

## 9 Conclusions

Emerging UK and well-established international evidence suggests that "store-and-forward" teledermatology can provide a more cost effective alternative to outpatient dermatology services if the patient lives beyond a certain distance from their dermatologist outpatient appointment and if the service already has a communication network in place. Evidence suggests that this critical threshold may be 75km (Moreno-Ramirez, et al., 2009, Van der Heijden, de Keizer, Bos, Spuls, & Witkamp, 2011 and Eminovic, Dijkgraaf, Berghout, Prins, Bindels, & de Keizer, 2010).

The Project demonstrated that, even where some data was available about the system, expert opinion was essential to developing and refining the simulation models. Engaging with practitioners throughout the Project was therefore essential and lessons were learned about working with practitioners and about data availability and quality (as noted above, publication of a lessons learned report is to follow). In the early part of the Project, the knowledge and experience of practitioners was vital in enabling the academic researcher and analysts within WG to understand the dermatology systems, available data and any assumptions that would need to be made before the models were developed. As the project progressed, input from practitioners was essential in validating the model and identifying additional data sources. Later in the study, a valuable 'sense check' was provided when the emerging simulation models were presented at a meeting of the Rural Health Implementation Group (2012), which included both clinicians and policymakers.

A key strength of the simulation models was that they provided an easy to follow representation of the Teledermatology and outpatient systems. Feedback from the Rural Health Implementation Group meeting demonstrated that both clinicians and policymakers found the visual way in which the evidence was presented engaging as well as allowing them to easily identify and challenge any aspects of the models that did not accurately represent the systems.

The challenges that emerged during the demonstration process and the benefits of using OR methods to inform service optimisation will be explored in more detail in a Lessons Learned report, publication of which is to follow.

The project has shown that teledermatology can offer improvements compared with the traditional outpatient model. In terms of costs, it is evident that the 'cost effectiveness' of teledermatology is very sensitive to the assumptions made with

regard to the value of patient travel time and the way the equipment costs are allocated. As discussed in more detail in Chapter 3, some of the possible costs involved e.g. to relatives accompanying patients, were not captured. However, given these limitations, the cost analysis demonstrated that teledermatology 'store and forward' can save up to an estimated £19 per patient consultation. The maximum cost assumes that all patients are employed so their travel time is valued at £28.69 per hour and not £4.76, when in reality, it is likely that the real average saving to patients will fall somewhere in between the 'working' and 'non-working' valuations. For working people in Hywel Dda LHB, then, we are able to conclude that teledermatology does provide a more cost-effective means of receiving treatment than the outpatient system. For non-working people, while there remains some uncertainty about whether the overall costs would be reduced, we can nevertheless conclude that teledermatology can provide a significant reduction in both travel costs and travelling time.

Overall, we are able to conclude that teledermatology offers significant advantages, some of which would be particularly valuable to patients living in rural areas, since it offers patients:

- Reduced travel time and distance and therefore cost, with some patients saving as much as 85 miles per appointment and anything up to two hours of travelling time;
- A shorter waiting time for an appointment; and
- A shorter elapsed time in the system - on average a patient in this study spent three months in the system under teledermatology compared with approximately seven months using the outpatient approach.

In addition to the advantages to the patient, reduced patient travel may have a benefit to the environment and thereby support the WG's Sustainable Development objectives.

The Project has illustrated that the use of Operational Research methods such as simulation modelling, alongside established methods like cost-benefit analysis, can provide evidence to inform the optimisation of telemedicine services. These approaches could potentially be used to inform the optimisation of other telemedicine services and of a broader range of services both within the NHS and in the public sector more widely. For example, a similar analysis has been proposed to examine the effect of using videoconferencing in the treatment of neurology patients on the consultant's travel time and the length of the waiting list. A further study has been

proposed to examine how using telemedicine to transmit paediatric cardiac images affects the travel times for the families of babies with heart conditions in Wales.

What remains is to assess whether benefits may result from introducing teledermatology across Wales.

As noted above, discussions with consultant dermatologists suggested that there is potential for Teledermatology clinics to benefit other dermatology patients across Wales. One of the experts involved suggested that the approach is one way of trying to relieve some of the pressure on a stretched service.

For the teledermatology clinic studied in this project, 'store and forward' was essentially being used as a triage mechanism to evaluate new dermatology referrals. In terms of rolling out teledermatology more widely across Wales, the proportion of new referrals that could be evaluated using 'store and forward' is likely to vary as some dermatologists have a strong preference for examining their patients in a clinic setting rather than using electronic referrals as a means of triage. In Hywel Dda LHB, there are approximately 8,000 new dermatology referrals per year. The consultant dermatologist involved in the Teledermatology Demonstration Project suggested that approximately 75% of these 8,000 referrals would be likely to be suitable to be triaged through "store and forward" clinics<sup>6</sup>. It should also be kept in mind that a proportion of the patients triaged through 'store and forward' would still need to be seen in an outpatient clinic at a later date.

The number and type of clinicians currently involved in triaging new dermatology patients, and therefore the amount of change that would be required in order to move to 'store and forward', would also be likely to vary across different parts of Wales, and would therefore need to be considered separately for each health board before the results from this demonstration project could be applied throughout Wales.

In rolling out teledermatology across Wales and the accompanying awareness raising, there is a risk that referrals to the dermatology service could increase, which in turn may clog the system<sup>7</sup>. However, this wasn't the effect in the Cardiff and Vale University Health Board when they introduced a Teledermatology Service in 2006, where the consultant dermatologist reported no disadvantages to its introduction (for

---

<sup>6</sup> Source: Discussion with consultant dermatologist, Hywel Dda LHB

<sup>7</sup> Source: Discussions with expert in Aneurin Bevan LHB

further information, see Chapter 2)<sup>8</sup>. However, it should be noted that the expansion of the original Cardiff and Vale Teledermatology Service was achieved at least partly through the provision of some grant funding, which provided both digital cameras and media support, which helped to achieve a painless implementation.

The Teledermatology Demonstration Project in Hywel Dda LHB highlights that 'store and forward' as a triage mechanism has benefits when the setting is mainly rural; as patients travel to local clinics rather than travelling to hospitals that are further away. Teledermatology clinics using 'store and forward' have run in both North and West Wales for approximately 10 years and anecdotal evidence from both GPs and consultants suggests that it works well. In North Wales, the patients referred to the teledermatology service have photographs taken of their skin condition and the consultant then decides whether the patient should be seen urgently or routinely but every patient is still seen in an outpatient clinic<sup>9</sup>. Teledermatology clinics using 'store and forward' have run in both North and West Wales for approximately 10 years and anecdotal evidence from both GPs and consultants suggests that it works well.

As discussed above, there is clear evidence of the benefits of using 'store and forward' clinics in Hywel Dda. It should, however, be noted that the uptake and success of any service expansion to include Teledermatology depends on the level of investment (personnel, equipment) and how it works with the existing primary and secondary care services. When considering whether to adopt the service throughout Wales, further thought should be given to:

- The workforce mix that would be required for 'store and forward' compared with outpatient clinics;
- The extent to which dermatologists would wish to use the 'store and forward' approach, including whether they may wish to use it as a method of triage or for both triage and diagnosis;
- The potential time savings that would result to dermatology services through using 'store and forward' as a triage mechanism;
- The potential time savings to GP practices that could be achieved by using teledermatology clinics as a way of triage and / or diagnosis;
- GP referral rates to outpatient clinics; and
- The technical requirements around creating an interface with primary care.

---

<sup>8</sup> Discussion with expert from Cardiff and Vale Teledermatology Service

<sup>9</sup> Source: Discussions with expert from Cardiff and Vale Teledermatology Service

The cost analysis highlighted that there are definite savings for patients in Hywel Dda LHB in terms of travel. However, the cost analysis gives only a partial picture of the costs and savings that could be achieved in Hywel Dda and therefore of what could be achieved when scaled to an All Wales level. In order to complete the picture, it would be recommended that further analysis should be done to examine the other costs mentioned in Chapter 3 of the report (e.g. staff training, relatives' use of time, patient medication).

This study has focussed on a mainly rural area of Wales. Future work could also examine the possible cost savings associated within the Cardiff and Vale Teledermatology Service in order to illustrate the potential benefit to patients and clinicians in an urban setting.

## Appendix 1: Patient Travel Analysis – Aberaeron and Borth

This appendix contains the patient travel analysis for the 21 patients that attended Aberaeron Clinic and the 20 patients that attended Borth Clinic.

### Aberaeron Clinic

Table A1, below, demonstrates that the round trip distances ranged from 1.7 to 46 miles. The overall distance travelled associated with these 21 patients was 268 miles.

**Table A1: The Patient Travel Distance (Shortest Route) from Patient Postcode to Aberaeron Clinic.**

Patient Postcode	Round Trip Distance (miles)	Number of Patients (n)	Total Group Distance (miles)
SA19 8	46	1	46
SA45 9	15	2	30
SA46 0	1.7	9	15
SA47 0	9	1	9
SA48 7	17	3	51
SA48 8	23	5	117
TOTAL	112	21	268

Table A2, below, demonstrates that the round trip travel time varied from 3.6 to 69 minutes. The overall combined journey time for the 21 patient records attributed to the Aberaeron Clinic was 395 minutes (6 and a half hours).

**Table A2: The Patient Travel Time (Shortest Route) from Patient Postcode to Aberaeron Clinic.**

Patient Postcode	Round Trip Travel Time (minutes)	Number of Patients (n)	Total Group Time (minutes)
SA19 8	69	1	69
SA45 9	25	2	50
SA46 0	3.6	9	33
SA47 0	14	1	14
SA48 7	30	3	90
SA48 8	28	5	140
TOTAL		21	395

### *Distance and Time Savings to the Patients of Aberaeron Clinic*

Table A3, below, demonstrates the distance savings for the patients that attended Aberaeron Clinic, rather than travelling to Glangwili Hospital. For example, the patient

can save between 0.3 miles and 57 miles each appointment. The overall combined distance savings associated with these 21 patients was 849 miles. Table A4, below, demonstrates the corresponding savings in journey time. The overall, combined saving for the 21 patient records attributed to the Aberaeron Clinic was 1,335 minutes (22 hours).

**Table A3: Distance Savings (Attending Aberaeron Clinic vs. Glangwili Hospital)**

Patient Postcode	Patients (n)	Round Trip Distance to Aberaeron (miles)	Round Trip Distance to Glangwili (miles)	Distance Savings (miles)	Group Round Trip Distance to Glangwili (miles)	Total Distance Savings (miles)
SA19 8	1	46.0	46.3	0.3	46.3	0.3
SA45 9	2	15.0	52.0	37.0	105.0	75.0
SA46 0	9	1.7	59.0	57.0	529.0	514.0
SA47 0	1	9.0	50.0	41.0	50.0	41.0
SA48 7	3	17.0	47.0	30.0	141.0	90.0
SA48 8	5	23.0	49.0	26.0	246.0	129.0
TOTAL					1,117.0	849.0

**Table A4: Time Savings (Attending Aberaeron Clinic vs. Glangwili Hospital)**

Patient Postcode	No. of Patients (n)	Round Trip Time to Aberaeron Clinic (minutes)	Round Trip Time to Glangwili (minutes)	Time Savings (minutes)	Total Group Time Savings (minutes)
SA19 8	1	68	92	23	23
SA45 9	2	24	83	59	117
SA46 0	9	3.6	97	94	844
SA47 0	1	14	84	70	70
SA48 7	3	30	61	31	94
SA48 8	5	28	65	37	186
TOTAL (mins)					1,335
Total (hours)					22

Table A5, below, demonstrates the comparative, round trip distance savings for the patients attending Aberaeron Clinic rather than travelling to Singleton Hospital. In total, the patients attending Aberaeron Clinic saved a combined travel distance of 1,838 miles.



**Table A5: Distance Savings (Attending Aberaeron Clinic vs. Singleton Hospital)**

Patient Postcode	Number of Patients (n)	Round Trip Distance to Aberaeron Clinic (miles)	Round Trip Distance to Singleton (miles)	Distance Savings (miles)	Group Round Trip Distance to Singleton (miles)	Total Distance Savings (miles)
SA19 8	1	46	73	27	73	27
SA45 9	2	15	105	90	209	179
SA46 0	9	1.7	110	108	988	973
SA47 0	1	9	102	93	102	93
SA48 7	3	17	95	78	286	235
SA48 8	5	23	90	66	448	331
TOTAL						1,838

**Borth Clinic**

Table A6, below, demonstrates that the round trip distances for the 20 patients that attended Borth Clinic range from 12 miles to 35miles. The overall distance travelled associated with these 20 patients was 435 miles.

**Table A6: The Patient Travel Distance (Shortest Route) from Patient Postcode to Borth Clinic.**

Patient Postcode	Round Trip Distance (miles)	Number of Patients (n)	Total Group Distance (miles)
SY20 8	27	2	55
SY23 1	15	1	15
SY23 2	13	2	26
SY23 3	21	5	104
SY23 4	29	4	117
SY23 5	35	2	70
SY24 5	12	4	48
TOTAL		20	435

Table A7, below, demonstrates that the corresponding round trip travel time varied from 22 to 54 minutes. The overall combined travel time associated with the 21 patient records attributed to Borth Clinic was 765 minutes (approximately 13hours).

**Table A7: The Patient Travel Time (Shortest Route) from Patient Postcode to Borth Clinic.**

Patient Postcode	Round Trip Travel Time (minutes)	Number of Patients (n)	Combined Group Travel Time (minutes)
SY20 8	43	2	86
SY23 1	28	1	28
SY23 2	24	2	48
SY23 3	41	5	207
SY23 4	50	4	201
SY23 5	54	2	109
SY24 5	22	4	88
TOTAL		20	765

*Distance and Travel Time Savings to the Patients of Borth Clinic*

Table A8, below, demonstrates the comparative, round trip distance savings for the patients that attended Borth Clinic, rather than travelling to Glangwili Hospital. The overall combined distance saving associated with the 20 patient records for Borth Clinic was approximately 1,400 miles.

**Table A8: Distance Savings (Attending Borth Clinic vs. Glangwili Hospital)**

Patient Postcode	Patients (n)	Round Trip Distance to Borth Clinic (miles)	Round Trip Distance to Glangwili (miles)	Group Round Trip Distance (miles)	Total Distance Savings (miles)
SY20 8	2	27	120	240	186
SY23 1	1	15	86	85	71
SY23 2	2	13	89	177	152
SY23 3	5	21	101	505	401
SY23 4	4	29	80	318	201
SY23 5	2	35	66	132	62
SY24 5	4	12	103	410	362
TOTAL	20				1,435

Table A9, below, demonstrates the corresponding savings in travel time. The patients save between 45 and 124 minutes travelling. The overall, combined saving in travel time for the 20 patient records attributed to Borth Clinic was 1,902 minutes (approximately 32 hours).

**Table A9: Travel Time Savings (Attending Borth Clinic vs. Glangwili Hospital)**

Patient Postcode	Patients (n)	Round Trip Travel Time to Borth (minutes)	Round Trip Travel Time to Glangwili (minutes)	Travel Time Savings (minutes)	Total Group Travel Time Savings (minutes)
SY20 8	2	42	167	124	248
SY23 1	1	28	123	96	96
SY23 2	2	24	127	103	207
SY23 3	5	42	153	112	559
SY23 4	4	50	101	51	205
SY23 5	2	54	100	45	91
SY24 5	4	22	146	124	497
TOTAL	20				1,902

Once again, in a similar analysis, there are round trip distance savings for the patients attending Borth Clinic rather than traveling to Singleton Hospital. The round trip distance savings for an individual patient are between 75miles and 137 miles. Overall, the patients that attended Borth Clinic saved a combined travel distance of 2,284 miles.

In summary, the patients save time and mileage when they travel to their local “store and forward” clinic rather than an outpatient appointment in Glangwili Hospital.

## **Appendix 2: Acknowledgements**

We would like to thank everyone that has been involved in this project. We would like to thank the Welsh Government (WG) and the Economic and Social Research Council (ESRC) for funding the Knowledge Transfer Research Fellow. We would like to thank the School of Mathematics, Cardiff University for seconding the Fellow for 2011 – 2013. We would like to thank all the practitioners from Hywel Dda Local Health Board for all their assistance and advice during this project. We would also like to thank everyone who has reviewed the project and provided feedback which has been extremely useful.

### **Organisations**

Economic and Social Research Council

Welsh Government

Rural Health Implementation Group

Hywel Dda Local Health Board

Aneurin Bevan Local Health Board

Cardiff and Vale University Local Health Board

Cardiff University (Mathematics)

## Bibliography

- Armstrong, A., Kovarik, C., Goldehn, M., McKoy, K., Shippy, A., & Pak, H. (2012). State of teledermatology programs in the United States. *Journal of the American Academy of Dermatologists*.
- Bergmo, S. (2009). Can Economic Evaluation in Telemedicine be Trusted? A Systematic Review of the Literature. *Cost Effectiveness and Resource Allocation*, 7-18.
- Commission, E. (2010). *MethoTelemed Final Study Report, Version 2*.
- Eminovic, N., de Keizer, N., Bindels, P., & Hasman, A. (2007). Maturity of teledermatology evaluation research: a systematic literature review. *British Journal of Dermatology*, 412-419.
- Eminovic, N., Dijkgraaf, M., Berghout, R., Prins, A., Bindels, P., & de Keizer, N. (2010). A cost minimisation analysis in teledermatology: model based approach. *BMC Health Services Research*, 251.
- Group, R. H. (2011). *Rural Health Telemedicine*. Cardiff: Welsh Government.
- Hampshire, N. (2009). *Evaluation of Vantage Teledermatology Pilot in Hampshire*. Price Waterhouse Coopers.
- Moreno-Ramirez, D., Ferrandiz, L., Ruiz-de-Casas, A., Nieto-Garcia, A., Moreno-Alvarez, P., Galdeano, R., et al. (2009). Economic evaluation of a store and forward teledermatology system for skin cancer patients. *Journal of Telemedicine and Telecare*, 40-45.
- Perednia, D., & Brown, N. (1995). Teledermatology: one application of telemedicine. *Bulletin of the Medical Library Association*, 42-47.
- Tran, K., Ayad, M., Weinberg, J., & Cherng, A. (2010). Mobile teledermatology in the developing world: Implications of a feasibility study on 30 Egyptian patients with common skin diseases. *Journal of American Academy of Dermatology*, 1-8.
- Transport, D. f. (2011). *Tag Unit 3.5.4 Cost Benefit Analysis, TAG Unit 3.5.6 - Values of Time and Operating Costs; and TAG Unit 3.3.5 - The Greenhouse Gases Sub-Objective*.
- Treasury, HM. (2003). *The HM Treasury Green Book: Appraisal and Evaluation in Central Government*.
- Van der Heijden, J., de Keizer, N., Bos, J., Spuls, P., & Witkamp, L. (2011). Teledermatology applied following patient selection by practitioners in daily

practice improves efficiency and quality of care at lower cost. *British Journal of Dermatology*, 1058-1065.

Whitten, P., Mair, S., Haycox, A., May, C., Williams, T., & Hellmich, S. (2002). Systematic Review of Cost Effectiveness Studies of Telemedicine Interventions. *British Medical Journal*, 324: 1434.

Wootton, R., & Oakley, A. M. (2002). *Teledermatology*. London: Royal Society of Medicine Press Ltd.