



Remote Telemonitoring

A Preliminary Review of Current Evidence

Draft

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Glossary

HbA_{1c}

Glycosylated haemoglobin. It is used as an indicator of average blood glucose levels over a prolonged period of time. A target level for HbA_{1c} is usually between 6.5% and 7.5%. It is frequently used in the management of diabetic patients.

Remote Telemonitoring

A clinical practice that involves remotely monitoring patients who are not at the same location as the healthcare provider. In general, a patient will have a number of monitoring devices at home, and these devices will transmit information on people's vital signs via telephone to the remote monitoring service provider and if necessary to their healthcare provider.

Telemedicine

Telemedicine is a broader concept than telemonitoring and also includes patient consultations using telecommunications, and provider to provider services.

Introduction

This report is a high level preliminary review of current evidence in relation to the use of remote monitoring in support of the management of chronic disease. The assessment of the evidence base will be an ongoing task for the European Centre for Connected Health (ECCH). This review is focussed on the three chronic disease areas that have been identified as a first priority for ECCH. The three conditions are diabetes mellitus, chronic heart failure and chronic obstructive pulmonary disease (COPD).

The Remote Telemonitoring service target is to secure access for 5000 patients with the aforementioned conditions by 2011. Remote telemonitoring is one element of telemedicine. It involves the remote recording of data about a patient without the presence of a healthcare professional, often in the patient's own home. Typically a remote telemonitoring service will record the vital signs of the patient such as blood pressure, pO₂, weight and heart rate etc. However the same technology can also be used for recording other data items such as a patient's response to preset questions of clinical interest. The remotely captured data is then transmitted using telecommunication systems to the remote monitoring service provider.

This first assessment of current evidence is time limited and therefore the emphasis has been on identifying key research from the top levels of the evidence hierarchy as defined by the School of Health and Related Research at the University of Sheffield. "The higher up a methodology is ranked, the more robust and closer to objective truth it is assumed to be" (SchARR). The aim of the literature search was to identify relevant systematic reviews and randomised controlled trials.

Rank	Methodology
1	Systematic reviews and meta-analyses
2	Randomised controlled trials
3	Cohort studies
4	Case-control studies
5	Cross sectional surveys
6	Case reports
7	Expert opinion
8	Anecdotal

Table 1: Hierarchy of Evidence (SchARR)

The Department of Health, Social Services and Public Safety's twenty year strategy anticipates that telemedicine will "...provide greater opportunities to deliver services locally" playing a role in reducing length of stay in hospital (DHSSPS 2004).

Background

The health service in Northern Ireland faces a major challenge in the first half of the 21st century. Demographic and social changes along with an increased illness burden due to the increasing prevalence of chronic disease mean that existing models of care are not sustainable in the medium to longer term.

In Northern Ireland, as in other developed countries we have an ageing population. The extent of the changes in our demographic profile is obvious when displayed visually. Figure 1 and figure 2 illustrate two population pyramids for Northern Ireland. Figure 1 for 2006, and figure 2 for 2056. The data for the charts comes from the Office for National Statistics and was accessed via the website of the Northern Ireland Statistics & Research Agency.

The average age of the population will have increased from 37.3 years in 2006 to 41.1 years by 2026 and to 45.1 years by 2056.

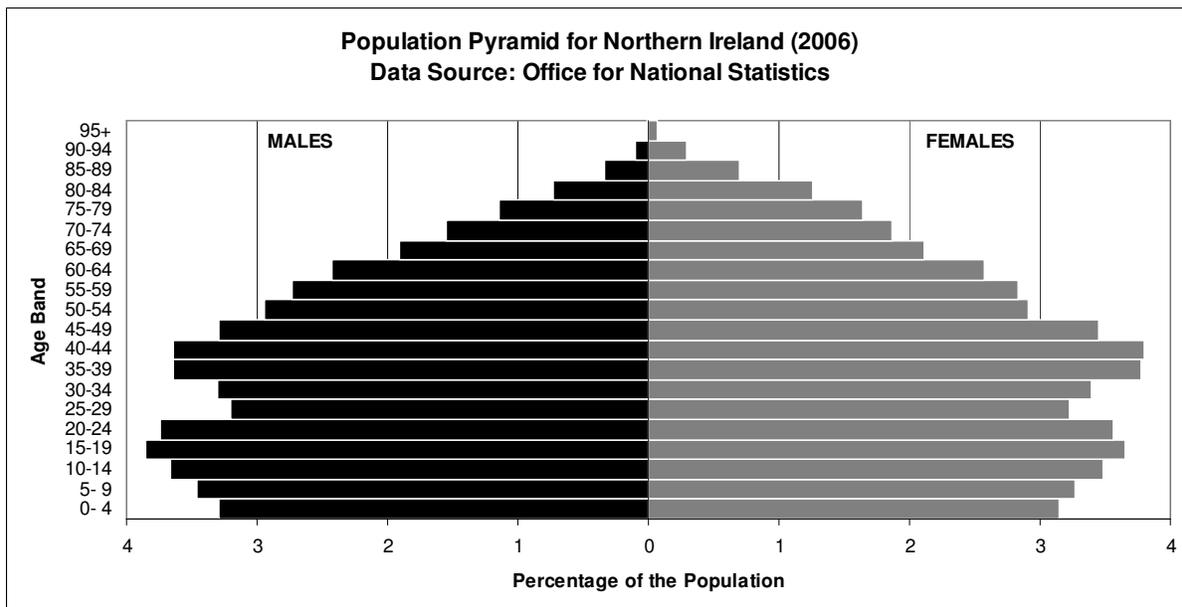


Figure 1: Population Pyramid for NI (2006)

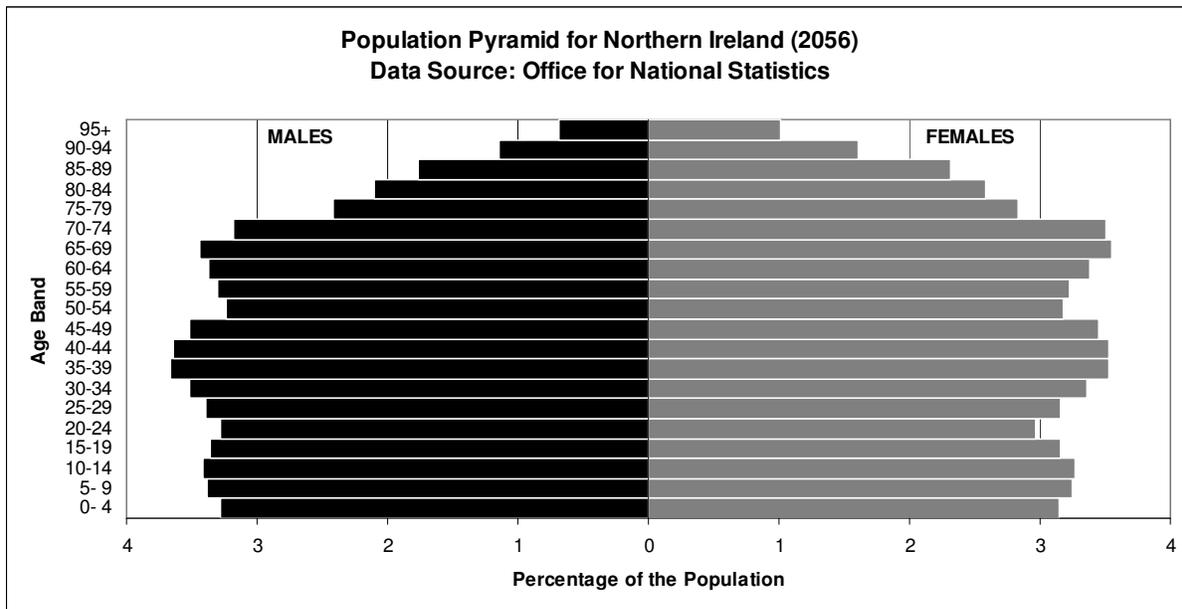


Figure 2: Population Pyramid for NI (2056)

In addition to the ageing of the population the Kings Fund has identified "...increased exposure to risk factors resulting from social and environmental changes" as a factor in the increasing prevalence of chronic disease (Rosen, Asaria et al. 2007). The Institute of Public Health in Ireland has modelled the changing prevalence of diabetes mellitus for Northern Ireland taking into account the changing population and increasing rates of obesity. They have predicted that population prevalence of diabetes mellitus will increase from 5.4% in 2005 to 6.3% in 2015. This represents an increase in the population prevalence of diabetes mellitus in Northern Ireland of 26% (Jordan, Graham et al. 2007).

The World Health Organisation has recognised the burden of chronic disease globally and in the United Kingdom. They have estimated that chronic disease accounts for 85% of all deaths in the United Kingdom.

Social changes also have to be considered in terms of their impact on the type of services that will be required. The trend is for smaller families and increasing numbers of people who live alone.

Our health service is funded by taxation. Figure 3 shows the predicted growth in pensionable age population between 2006 and 2056. This presents a dual challenge for our health service. It predicts an increase in health service utilisation as a result of more people living with chronic disease and increasing strain on the ability of taxation to fund the health service as the working age population does not show a similar expansion in size. For this reason we need to investigate new ways of delivering healthcare that take onboard the desire to have a more patient centred service while recognising potential shortages that are predicted in the pool of skilled healthcare professionals in a global marketplace and the need for greater efficiency.

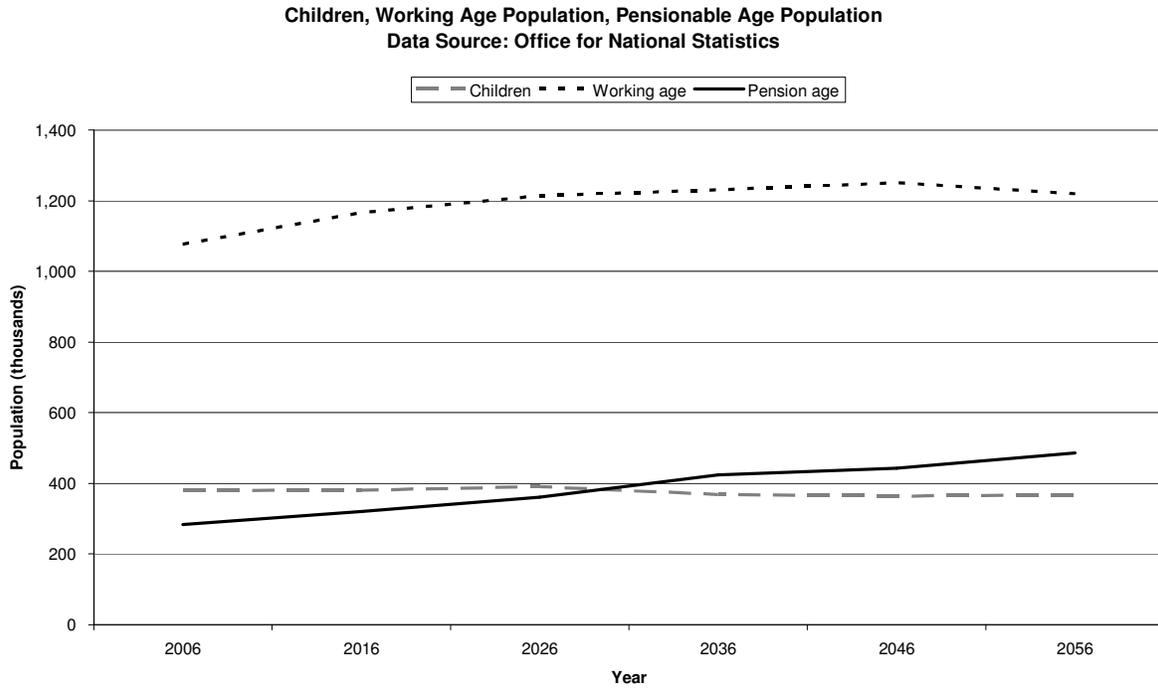


Figure 3: Changing Population Profile for NI 2006 to 2056

* Children under 16. Working age and pensionable age populations based on state pension age for given year. Between 2010 and 2020, state pension age will change from 65 years for men and 60 years for women, to 65 years for both sexes. Between 2024 and 2046, state pension age will increase in three stages from 65 years to 68 years for both sexes.

Methodology

In the context of an ageing population and increasing prevalence of chronic disease the objective of this review is to ascertain if the current evidence base supports the use of remote telemonitoring in the management of diabetes mellitus, chronic heart failure and chronic obstructive pulmonary disease.

A literature search was undertaken using the PubMed database. The aim of the literature search was to identify articles that addressed the concept of remote telemonitoring rather than the broader concept of telemedicine. However to avoid a prematurely narrow focus the search criteria included the terms telemedicine, telecare, telehealth, telemonitoring and remote monitoring. Similarly the search terms for the chronic conditions of interest were also aimed at capturing all relevant articles.

The complete search expression used was (telemedicine OR telecare OR telehealth OR telemonitoring OR "home monitoring" OR "remote monitoring") AND (COPD OR COAD OR "heart failure" OR "cardiac failure" OR "diabetes mellitus" OR "chronic disease" OR "chronic condition" OR "chronic illness").

The initial search returned 733 articles of potential interest. The initial dataset was reduced to 547 articles by limiting to publications covering human subjects, in the English language and with available abstracts.

By restricting the result set to clinical trials, meta-analyses and randomised controlled trials and reviews a further 347 articles were excluded, leaving 200 articles requiring a more detailed review.

Two of the references from the PubMed database were erroneous, pointing to non existing articles.

Reviewing the titles and abstracts of the remaining 198 articles led to the exclusion of 94 articles. Articles were excluded if remote monitoring was not the main focus of the article or if the primary focus was on conditions other than chronic heart failure, diabetes mellitus or COPD. Articles in which the remote monitoring consisted of telephone support only were also excluded.

Manual searching of several key journals (International Journal of Medical Informatics, Journal of Telemedicine and Telecare, Diabetes Care, Implementation Science and Telemedicine Journal and e-Health) identified 17 additional papers. In total 121 articles were identified for detailed examination.

Due to the very limited time available for this preliminary review of the evidence this review has examined in detail only the 21 systematic reviews identified. The other 100 articles including RCTs will be examined in detail over the coming months. The rationale being that the initial effort should be concentrated on examining the literature offering the best weight of evidence in order to guide initial decision making.

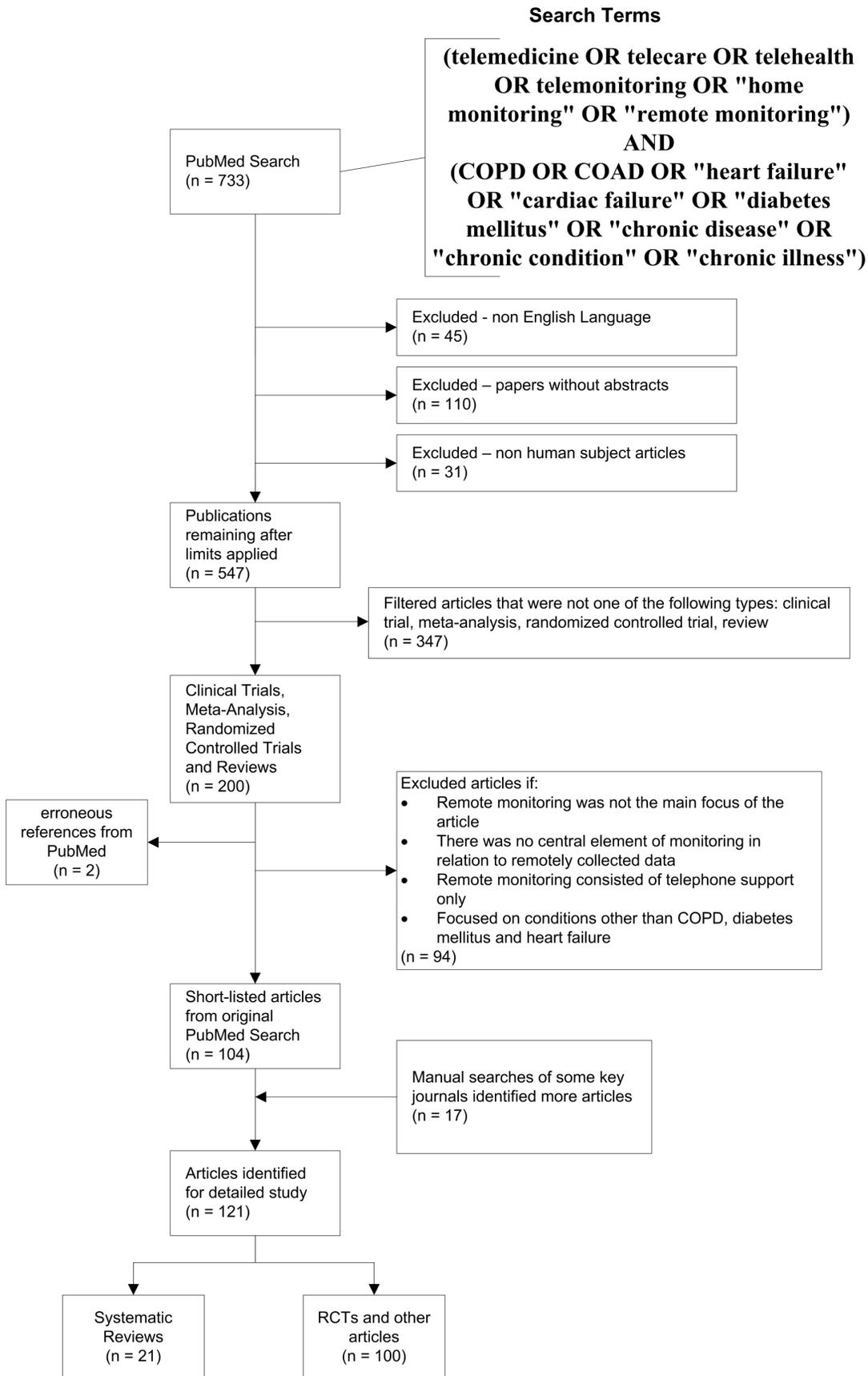


Figure 4: Search Methodology

Discussion

The infrastructural requirements for delivering a remote telemonitoring service, such as that proposed by ECCH, are still relatively novel. For example widespread availability of broadband has only become a reality in the past few years. Therefore some caution must be applied to interpreting evidence that is more than five years old. Unsurprisingly the growth in the availability of the technological advances that make a remote monitoring service possible is mirrored by a growth in the literature, with a doubling in the number of systematic reviews each year since 2004.

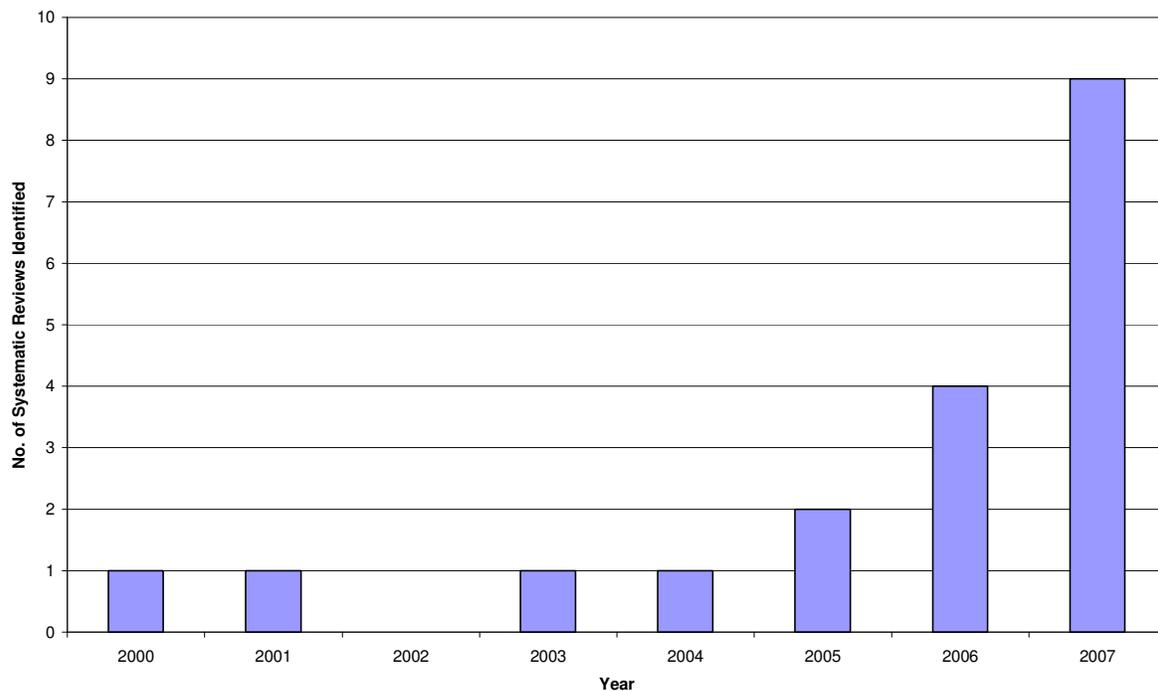


Figure 5: Number of Systematic Reviews Identified in the Literature

In total 21 systematic reviews were identified that addressed remote telemonitoring or at least included the concept within the scope of the review.

Each of the identified reviews will be considered individually detailing the objective for undertaking the review, the methods used and key findings. A brief comment is made on each review in terms of the relevance of its findings to the issue of remote telemonitoring for chronic heart failure, diabetes mellitus or COPD.

1	
Author	Currell, R., C. Urquhart, et al. (2000).
Title	"Telemedicine versus face to face patient care: effects on professional practice and health care outcomes."
Reference	Cochrane Database Syst Rev(2): CD002098.
Objective	To assess the effects of telemedicine as an alternative to face-to-face patient care.
Method	Searched the Effective Practice and Organisation of Care Group's specialised register, The Cochrane Library, MEDLINE (1966-August 1999), EMBASE (to 1996), Cinahl (to August 1999), Inspec (to August 1996), Healthstar (1983-1996), OCLC, Sigle (to 1999), Assia, SCI (1981-1997), SSCI (1981-1997), DHSS-Data. Hand searched the Journal of Telemedicine and Telecare (1995-1999), Telemedicine Journal (1995-1999) and reference lists of articles. Also hand searched conference proceedings and contacted experts in countries identified as having an interest in telemedicine.
Findings	Establishing systems for patient care using telecommunications technologies is feasible, but there is little evidence of clinical benefits. The studies provided variable and inconclusive results for other outcomes such as psychological measures, and no analysable data about the cost effectiveness of telemedicine systems. The review demonstrates the need for further research and the fact that it is feasible to carry out randomised trials of telemedicine applications. Policy makers should be cautious about recommending increased use and investment in unevaluated technologies.
Comment	This review is now somewhat dated. It covered the full scope of telemedicine rather than the more restricted area of remote telemonitoring. It found that telemedicine interventions were a feasible system option for patient care and did not find any detrimental effects resulting from the use of telemedicine.

2	
Author	Hersh, W. R., M. Helfand, et al. (2001).
Title	"Clinical outcomes resulting from telemedicine interventions: a systematic review."
Reference	BMC Med Inform Decis Mak 1: 5.

Objective	The objective of this systematic review was to evaluate the efficacy of telemedicine interventions for health outcomes in two classes of application: home-based and office/hospital-based.
Method	Data sources for the study included reports of studies from the MEDLINE, EMBASE, CINAHL, and HealthSTAR databases; searching of bibliographies of review and other articles; and consultation of printed resources as well as investigators in the field. We included studies that were relevant to at least one of the two classes of telemedicine and addressed the assessment of efficacy for clinical outcomes with data of reported results. We excluded studies where the service did not historically require face-to-face encounters (e.g., radiology or pathology diagnosis). All included articles were abstracted and graded for quality and direction of the evidence.
Findings	A total of 25 articles met inclusion criteria and were assessed. The strongest evidence for the efficacy of telemedicine in clinical outcomes comes from home-based telemedicine in the areas of chronic disease management, hypertension, and AIDS. The value of home glucose monitoring in diabetes mellitus is conflicting. There is also reasonable evidence that telemedicine is comparable to face-to-face care in emergency medicine and is beneficial in surgical and neonatal intensive care units as well as patient transfer in neurosurgery. Despite the widespread use of telemedicine in virtually all major areas of health care, evidence concerning the benefits of its use exists in only a small number of them. Further randomized controlled trials must be done to determine where its use is most effective.

Comment	Not all of the articles considered in this review are of relevance to the remit of our current work. Several of the papers addressed clinical areas such as neurosurgery, neonatology, dermatology, AIDS, intensive care and hypertension. Furthermore some of the articles dealing with diabetes related solely to gestational diabetes or paediatrics which is outside the scope of the initial ECCH proposals. However they found that the strongest evidence for the use of telemedicine was concerned with home-based telemedicine in the area of chronic disease management.
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3	
Author	Louis, A. A., T. Turner, et al. (2003).
Title	"A systematic review of telemonitoring for the management of heart failure."
Reference	Eur J Heart Fail 5(5): 583-90.

Objective	To review the literature on the application of telemedicine in the management of heart failure.
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Method	A literature search was conducted on studies involving telemonitoring and heart failure between 1966 and 2002 using Medline, Embase, Cochrane Library and Journal of Telemedicine and Telecare.
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Findings	Eighteen observational studies and six randomised controlled trials involving telemonitoring and heart failure were identified. Observational studies suggest that telemonitoring; used either alone or as part of a multidisciplinary care program, reduce hospital bed-days occupancy. Patient acceptance of and compliance with telemonitoring was high. Two randomised controlled trials suggest that telemonitoring of vital signs and symptoms facilitate early detection of deterioration and reduce readmission rates and length of hospital stay in patients with heart failure. One study also showed a reduction in readmission charges. One substantial randomised controlled study showed a significant reduction in mortality at 6 months by monitoring weight and symptoms in patients with heart failure; however, no difference was observed in readmission rates. Another randomised study comparing video-consultation performed as part of a home health care programme for patients with a variety of diagnoses, suggested a reduction in the costs of hospital care, which offset the cost of video-consultation. Patients with heart failure were not reported separately. One randomised study showed no difference in outcomes between the telemonitoring group and the standard care group. Telemonitoring might have an important role as part of a strategy for the delivery of effective health care for patients with heart failure. Adequately powered multicentre, randomised controlled trials are required to further evaluate the potential benefits and cost-effectiveness of this intervention.
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Comment	This review examined several randomised controlled trials of telemonitoring in heart failure. A number of these studies reported positive findings for the use of telemonitoring in heart failure. Positive outcomes included improvement in quality of life, reduction in mortality and reduction in readmission rates and length of stay in hospital.
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4	
Author	Hailey, D., A. Ohinmaa, et al. (2004).
Title	"Published evidence on the success of telecardiology: a mixed record."
Reference	J Telemed Telecare 10 Suppl 1: 36-8.
Objective	To carry out a systematic review of the literature on telecardiology assessment from 1992 to September 2003.
Method	Articles reporting clinical, economic or administrative outcomes were selected. Quality of evidence was assessed using an approach that considered both study design and study performance. Forty-four studies met the selection criteria.
Findings	Studies of home care applications, particularly management of congestive heart failure, were of highest quality, giving a high degree of confidence in their findings. Studies on paediatric and non-emergency adult hospital applications were of poorer quality; they were mostly reports of case series and gave relatively little detail. Economic analysis was limited to cost studies and in most cases was judged to be of poor to fair quality. While telecardiology has been widely applied, there is still limited good quality evidence of its benefits to health-care. Success in establishing the feasibility of telecardiology applications is offset by a failure to obtain convincing data on their influence on health outcomes and on their cost-effectiveness.
Comment	Although this review did include studies that considered the management of heart failure the review itself does not list the individual articles and given the time frame of the search criteria some caution is warranted in considering the applicability of the findings to interventions today.

5	
Author	Farmer, A., O. J. Gibson, et al. (2005).
Title	"A systematic review of telemedicine interventions to support blood glucose self-monitoring in diabetes."
Reference	Diabet Med 22(10): 1372-8.
Objective	To evaluate evidence for feasibility, acceptability and cost-effectiveness of diabetes telemedicine applications.
Method	MEDLINE, EMBASE, PSYCHINFO, CINAHL, Cochrane, and INSPEC were searched using the terms diabetes and telemedicine for clinical studies using electronic transfer of blood glucose results in people with diabetes. The technology used, trial design and clinical outcome measures used were extracted for trials and prospective cohort studies. Randomized controlled trials with HbA1c as an outcome were pooled using standard meta-analytical methods.
Findings	Telemedicine solutions for diabetes care are feasible and acceptable, but evidence for their effectiveness in improving HbA1c or reducing costs while maintaining HbA1c levels, or improving other aspects of diabetes management is not strong. Further research should seek to understand how telemedicine might enhance educational and self-management interventions and RCTs are required to examine cost-effectiveness.
Comment	The authors of this review have included 16 trials and 10 cohort studies in their analysis. They have described quality assessing the RCTs using the Jadad scale. The authors describe that evidence from cohort studies as well as the RCT's strengthens the conclusion that the use of telemedicine in a clinical setting is feasible.

6	
Author	Meystre, S. (2005).
Title	"The current state of telemonitoring: a comment on the literature."
Reference	Telemed J E Health 11(1): 63-9.
Objective	Not clearly defined.
Method	An extensive literature search was conducted during the years 2001 and 2002, using the following terms: telemonitoring, telemedicine and monitoring, remote sensing, remote monitoring, distant monitoring, and biotelemetry. Documents that were retrieved came from academic literature, MEDLINE, library databases, conference proceedings, and Internet websites. This collection of literature was then reviewed for its value and for the development of a global view of telemonitoring.
Findings	This literature review suggests that the most promising applications for telemonitoring is for chronic illnesses such as cardiopulmonary disease, asthma, and heart failure in the home. Telemonitoring allows reduction of chronic disease complications thanks to a better follow up; provides health care services without using hospital beds; and reduces patient travel, time off from work, and overall costs. Several systems have proven to be cost effective. Telemonitoring is also a way of responding to the new needs of home care in an ageing population.
Comment	Although published in 2005 the actual literature search for this review was conducted between 2001 and 2002. Therefore the articles it references date from the mid to late 1990s for the most part. The focus of the review was telemonitoring but it did include conditions other than those of interest. However it did find that the possibilities for the future use of telemonitoring in chronic illness was promising.

7	
Author	Bensink, M., D. Hailey, et al. (2006).
Title	"A systematic review of successess and failures in home telehealth: preliminary results."
Reference	J Telemed Telecare 12 Suppl 3: 8-16.
Objective	To identify studies in home telehealth that compared a home telehealth intervention with a non-telehealth standard/usual care alternative in terms of administrative changes, patient management decisions, patient outcomes, caregiver outcomes, economic impact or social impact on patients.
Method	A search of various databases produced 6643 references. Of these 769 papers were selected for more detailed investigation. These papers, combined with hand searching of relevant telehealth journals and cross-referencing of citations in identified publications, resulted in 138 papers referring to 130 projects for review.
Findings	In this preliminary analysis we used a quality appraisal approach that took into account the study design. An additional analysis of patient numbers was then used to calculate a net evidence score. A large proportion of studies (80%) were randomised controlled trials. Only 22 projects (17%) reported economic data deemed to be sufficient for appraisal. Evidence exists for the clinical effectiveness of home telehealth in diabetes, the general area of mental health, high risk pregnancy monitoring, heart failure and cardiac disease.
Comment	This is the preliminary findings of the group. Article 12 represents their final findings.

8	
Author	Hersh, W. R., D. H. Hickam, et al. (2006).
Title	"Diagnosis, access and outcomes: Update of a systematic review of telemedicine services."
Reference	J Telemed Telecare 12 Suppl 2: S3-31.

Objective	To review the literature for telemedicine services that substitute for face-to-face medical diagnosis and treatment.
Method	Three types of telemedicine services: store-and-forward, home-based and office/hospital-based services. Studies were included if they were relevant to at least one of the three study areas, addressed at least one key question and contained reported results. Excluded articles that did not study a service requiring face-to-face encounters (i.e. teleradiology was excluded).
Findings	Following a full-text review, 106 studies were included. Store-and-forward services have been studied in many specialties, the most common being dermatology, wound care and ophthalmology. The evidence for their efficacy is mixed. Several limited studies showed the benefits of home-based telemedicine interventions in chronic diseases. Studies of office/hospital-based telemedicine suggest that telemedicine is most effective for verbal interactions, e.g. videoconferencing for diagnosis and treatment in specialties like neurology and psychiatry. There are still significant gaps in the evidence base between where telemedicine is used and where its use is supported by high-quality evidence. Further well-designed research is necessary to understand how best to deploy telemedicine services in health care.

Comment	<p>This review is an update of the authors' earlier work (Article 2). The literature searches cover up until June 2004. Of the three types of telemedicine service studied the home-based type is of most relevance to the initial focus of ECCH. The nature of the home-based intervention was generally dedicated staff (usually nursing) monitoring the data recorded in the home and developing clinical management plans.</p> <p>The authors concluded that these studies lead to improved outcomes but the design of the studies made it difficult to separate the effect of the telemedicine intervention from the effect of dedicated staff.</p>
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9	
Author	Koch, S. (2006).
Title	"Home telehealth--current state and future trends."
Reference	Int J Med Inform 75(8): 565-76.

Objective	The purpose of this paper is to give an overview about the state of the art in research on home telehealth in an international perspective.
Method	The study is based on a review of the scientific literature published between 1990 and 2003 and retrieved via Medline in January/February 2004. All together, the abstracts of 578 publications have been analyzed.
Findings	<p>The majority of publications (44%) comes from the United States, followed by UK and Japan. Most publications deal with vital sign parameter (VSP) measurement and audio/video consultations ("virtual visits"). Publications about IT tools for improved information access and communication as well as decision support for staff, patients and relatives are relatively sparse. Clinical application domains are mainly chronic diseases, the elderly population and paediatrics.</p> <p>Internationally, we observe a trend towards tools and services not only for professionals but also for patients and citizens. However, their impact on the patient-provider relationship and their design for special user groups, such as elderly and/or disabled needs to be further explored.</p>
Comment	This review includes articles that date back as far as 1990. It did not place any restrictions on the conditions for which the home telehealth was used. Unusually it also included a number of vision papers in an attempt to identify future trends.

10	
Author	Martinez, A., E. Everss, et al. (2006).
Title	"A systematic review of the literature on home monitoring for patients with heart failure."
Reference	J Telemed Telecare 12(5): 234-41.

Objective	To assess the value of home monitoring for heart failure (HF) patients.
Method	The abstracts of 383 articles were read. We excluded those in which either no home monitoring was done or only the technical aspects of the telemedicine application were described. Forty-two studies met the selection criteria. We classified the results into feasibility (technical and institutional) and impact (on the clinical process, on patient health, on accessibility and acceptability of the health system, and on the economy).
Findings	Evaluating the articles showed that home monitoring in HF patients is viable, given that: (1) it appears to be technically effective for following the patient remotely; (2) it appears to be easy to use, and it is widely accepted by patients and health professionals; and (3) it appears to be economically viable. Furthermore, home monitoring of HF patients has been shown to have a positive impact on: (1) the clinical process, supported by a significant improvement of patient follow-up by adjustment of treatment, diet or behaviour, as well as hospital readmissions and emergency visits reduction; (2) the patient's health, supported by a relevant improvement in quality of life, a reduction of days in hospital, and a decrease in mortality; and (3) costs resulting from the use of health resources.

Comment	The authors conclude that there is evidence to show that home monitoring is reliable and has several advantages. They consider home monitoring to be a proven intervention that is ready for wide scale rollout. They anticipate role out would lead to better quality of life for patients.
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11	
Author	Barlow, J., D. Singh, et al. (2007).
Title	"A systematic review of the benefits of home telecare for frail elderly people and those with long-term conditions."
Reference	J Telemed Telecare 13(4): 172-9.

Objective	To review the benefits of home telecare for frail elderly people and for patients with chronic conditions.
Method	We searched 17 electronic databases, the reference lists of identified studies, conference proceedings and Websites for studies available in January 2006. We identified summaries of 8666 studies, which were assessed independently for relevance by two reviewers. Randomized controlled trials of any size and observational studies with 80 or more participants were eligible for inclusion if they examined the effects of using telecommunications technology to (a) monitor vital signs or safety and security in the home, or (b) provide information and support. The review included 68 randomized controlled trials (69%) and 30 observational studies with 80 or more participants (31%).
Findings	Most studies focused on people with diabetes (31%) or heart failure (29%). Almost two thirds (64%) of the studies originated in the US; more than half (55%) had been published within the previous three years. Based on the evidence reviewed, the most effective telecare interventions appear to be automated vital signs monitoring (for reducing health service use) and telephone follow-up by nurses (for improving clinical indicators and reducing health service use). The cost-effectiveness of these interventions was less certain. There is insufficient evidence about the effects of home safety and security alert systems. It is important to note that just because there is insufficient evidence about some interventions, this does not mean that those interventions have no effect.

Comment	Vital signs monitoring with telephone follow up by nurses was identified as the most effective intervention in terms of improving clinical indicators and reducing health service use. But the authors highlighted the effectiveness of the intervention depended on the condition. Most of the identified research was on diabetes, heart failure, asthma and chronic obstructive pulmonary disease.
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12	
Author	Bensink, M., D. Hailey, et al. (2007).
Title	"A systematic review of successes and failures in home telehealth. Part 2: Final quality rating results."
Reference	J Telemed Telecare 13 Suppl 3: 10-14.
Objective	Follow on Systematic Review (see Bensink article 7)
Method	Each of 130 studies about home telehealth was independently rated by three reviewers in terms of patient selection, specification of interventions, specification of analysis, patient disposal and outcomes reported. The mean ratings of study quality were used to calculate an overall decision-making score. From the decision-making score, a net evidence score was derived for each of the 26 diseases/conditions identified. The mean decision-making score, combining study design and quality ratings, was used for comparison with a preliminary report prepared in 2006. The inclusion of ratings of study quality strengthened and confirmed the original findings.
Findings	There are good to high quality studies supporting the use of home telehealth in the areas of diabetes, the general area of mental health, high-risk pregnancy monitoring, heart failure, other cardiac conditions and smoking cessation. Incorporating the rating of study quality in systematic reviews is an important step which provides additional information about the strength of evidence available.
Comment	This review is a follow up to the authors' earlier work. In this review they applied a scoring system to rate the evidence base for home telehealth for 25 diseases/conditions. Heart failure was ranked 2 nd , while diabetes was ranked 4 th , chronic disease management 7 th and chronic lung disease 16 th . The high ranking of heart failure and diabetes shows a high quality of evidence in favour of the use of home telehealth in these conditions.

13	
Author	Bowles, K. H. and A. C. Baugh (2007).
Title	"Applying research evidence to optimize telehomecare."
Reference	J Cardiovasc Nurs 22(1): 5-15.

Objective	To present a summary and critique of the published empirical evidence about the effects of telehomecare on older adult patients with chronic illness.
Method	The referenced literature in PubMed, MEDLINE, CDSR, ACP Journal Club, DARE, CCTR, and CINAHL databases was searched for the years 1995-2005 using the keywords "telehomecare" and "telemedicine," and limited to primary research and studies in English. Approximately 40 articles were reviewed. Articles were selected if telehealth technology with peripheral medical devices was used to deliver home care for adult patients with chronic illness. Studies where the intervention consisted of only telephone calls or did not involve video or in-person nurse contact in the home were excluded.
Findings	Nineteen studies described the effects of telehomecare on adult patients, chronic illness outcomes, providers, and costs of care. Patients and providers were accepting of the technology and it appears to have positive effects on chronic illness outcomes such as self-management, rehospitalizations, and length of stay. Overall, due to savings from healthcare utilization and travel, telehomecare appears to reduce healthcare costs. Generally, studies have small sample sizes with diverse types and doses of telehomecare intervention for a select few chronic illnesses; most commonly heart failure. Very few published studies have explored the cost or quality implications since the change in home care reimbursement to prospective payment. Further research is needed to clarify how telehomecare can be used to maximize its benefits among diverse adult chronic illness populations.
Comment	The authors comment that some research shows decreased re-hospitalisation rates for heart failure and diabetes with telehomecare. They also discuss better diabetic management as a result of telehomecare. They comment that generalisations are difficult due to a number of differences in the underlying studies.

14	
Author	Chaudhry, S. I., C. O. Phillips, et al. (2007).
Title	"Telemonitoring for patients with chronic heart failure: a systematic review."
Reference	J Card Fail 13(1): 56-62.

Objective	To extend the results of prior reviews of telemonitoring in heart failure by performing an in-depth examination of a wide range of telemonitoring interventions with the addition of several recently published studies not previously analyzed.
Method	Searched Medline databases, bibliographies, and spoke with experts to review the evidence on telemonitoring in heart failure patients. Interventions included: telephone-based symptom monitoring (n = 5), automated monitoring of signs and symptoms (n = 1), and automated physiologic monitoring (n = 1). Two studies directly compared effectiveness of 2 or more forms of telemonitoring. Study quality and intervention type varied considerably. Six studies suggested reduction in all-cause and heart failure hospitalizations (14% to 55% and 29% to 43%, respectively) or mortality (40% to 56%) with telemonitoring. Of the 3 negative studies, 2 enrolled low-risk patients and patients with access to high quality care, whereas 1 enrolled a very high-risk Hispanic population. Studies comparing forms of telemonitoring demonstrated similar effectiveness. However, intervention costs were higher with more complex programs (\$8383 per patient per year) versus less complex programs (\$1695 per patient per year).
Findings	The evidence base for telemonitoring in heart failure is currently quite limited. Based on the available data, telemonitoring may be an effective strategy for disease management in high-risk heart failure patients.

Comment	The authors reviewed a small number of RCTs of telemonitoring for patients with chronic heart failure. One of the papers showed a significant reduction in mortality despite not showing any difference in re-hospitalisation rates. Another paper demonstrated a reduction in hospital admissions due to heart failure. The same paper also indicated that telemonitoring could be cost beneficial.
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15	
Author	Clark, R. A., S. C. Inglis, et al. (2007).
Title	"Telemonitoring or structured telephone support programmes for patients with chronic heart failure: systematic review and meta-analysis."
Reference	BMJ 334(7600): 942.

Objective	To determine whether remote monitoring (structured telephone support or telemonitoring) without regular clinic or home visits improves outcomes for patients with chronic heart failure.
Method	Searched 15 electronic databases, conducted hand searches of previous studies, and contacted authors and experts. Two investigators independently screened the results of published randomised controlled trials comparing remote monitoring programmes with usual care in patients with chronic heart failure managed within the community.
Findings	14 randomised controlled trials (4264 patients) of remote monitoring met the inclusion criteria: four evaluated telemonitoring, nine evaluated structured telephone support, and one evaluated both. Remote monitoring programmes reduced the rates of admission to hospital for chronic heart failure by 21% (95% confidence interval 11% to 31%) and all cause mortality by 20% (8% to 31%); of the six trials evaluating health related quality of life three reported significant benefits with remote monitoring, and of the four studies examining healthcare costs with structured telephone support three reported reduced cost and one no effect. Programmes for chronic heart failure that include remote monitoring have a positive effect on clinical outcomes in community dwelling patients with chronic heart failure.

Comment	The authors concluded that although they had shown substantial and statistically significant benefits with remote monitoring for patients with chronic heart failure they considered it to be a different way of systematically organising effective care rather than a treatment. They further concluded that remote monitoring may be of particular benefit to patients who have difficulty accessing specialised care because of geography, transport, or infirmity.
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16	
Author	Garcia-Lizana, F. and A. Sarria-Santamera (2007).
Title	"New technologies for chronic disease management and control: a systematic review."
Reference	J Telemed Telecare 13(2): 62-8.

Objective	To review the clinical effectiveness of interventions using ICTs for managing and controlling chronic diseases.
Method	Electronic databases were searched for randomized clinical trials that assessed the effectiveness of ICTs (except for those that included only telephone communication) and measured some clinical indicator. Information was reviewed and assessed independently by two researchers. Of the 950 clinical trials identified, 56 studies were identified for potential inclusion. Of those, 24 were finally included: 5 studies in asthma, 3 in hypertension, 1 in home telecare, 7 in diabetes, 6 in heart failure and 2 in prevention heart disease.
Findings	Overall, ICT applications did not show an improvement in clinical outcomes, although no adverse effects were identified. However, ICTs used in the detection and follow up of cardiovascular diseases provided better clinical outcomes, mortality reduction and lower health services utilization. Systems used for improving education and social support were also shown to be effective. At present the evidence about the clinical benefits of ICTs for managing chronic disease is limited.

Comment	<p>This review considered a number of different conditions. It included 6 papers looking at heart failure dating between 2001 and 2005. The authors concluded that the earlier of these studies showed no improvement in quality of life but did show an improvement in self control of their condition. They comment that later papers reported better outcomes with a reduction in mortality.</p> <p>The authors reviewed 7 papers that looked at diabetes dating between 1995 and 2004. Although some of these looked solely at issues other than remote telemonitoring such as patient education. They concluded that some of these papers did not show an improvement in clinical status even though the biochemical indicators were slightly improved compared to with usual care. Some of the more complex interventions such as web based health record with feedback from multidisciplinary professionals showed significant benefits in HbA_{1c} levels.</p>
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17	
Author	Jaana, M. and G. Pare (2007).
Title	"Home telemonitoring of patients with diabetes: a systematic assessment of observed effects."
Reference	J Eval Clin Pract 13(2): 242-53.

Objective	To provide a systematic review of diabetes 'home telemonitoring' and its effect at the informational, clinical, behavioural, structural and economical levels.
Method	A comprehensive literature review was conducted on Medline and Cochrane Library to identify relevant articles. The keywords used include diabetes, telemonitoring, home monitoring, telecare and telemedicine.
Findings	<p>Seventeen studies using diverse technologies and transmitting different clinical, medical and behavioural data were found. Significant impacts were observed namely at the behavioural, clinical and structural levels. Minimal technical problems and no cost-benefit and cost-effectiveness analyses were reported.</p> <p>Close management of diabetic patients through telemonitoring showed significant reduction in HbA_{1c} and complications, good receptiveness by patients and patient empowerment and education. Yet, the magnitude of its effects remains debatable, especially with the variation in patients' characteristics (e.g. background, ability for self-management, medical condition), samples selection and approach for treatment of control groups. Further investigation of telemonitoring efficacy and cost-effectiveness over longer periods of time, and larger samples is needed. Assessment of the attitude of providers is also important in light of their heavy workload and issues of reimbursement.</p>

Comment	<p>The authors comment that close management and monitoring of diabetes in several studies have resulted in significant decrease in HbA_{1c}. They also comment that the close management approach seems to have significant positive impact on patients' attitudes towards their illness.</p> <p>They state that the economic and structural impacts of telemonitoring are still at an early stage.</p> <p>The authors believe that larger studies over longer time frames are required to further assess this promising patient management approach with regard to efficacy and cost-effectiveness.</p>
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18	
Author	Pare, G., M. Jaana, et al. (2007).
Title	"Systematic review of home telemonitoring for chronic diseases: the evidence base."
Reference	J Am Med Inform Assoc 14(3): 269-77.

Objective	To provide a systematic review of experimental and quasi-experimental studies involving home telemonitoring of chronic patients with pulmonary conditions, diabetes, hypertension, and cardiovascular diseases.
Method	A comprehensive literature search was conducted on Medline and the Cochrane Library to identify relevant articles published between 1990 and 2006. A total of 65 empirical studies were obtained (18 pulmonary conditions, 17 diabetes, 16 cardiac diseases, 14 hypertension) mostly conducted in the United States and Europe.
Findings	<p>The magnitude and significance of the telemonitoring effects on patients' conditions (e.g., early detection of symptoms, decrease in blood pressure, adequate medication, reduced mortality) still remain inconclusive for all four chronic illnesses. However, the results of this study suggest that regardless of their nationality, socioeconomic status, or age, patients comply with telemonitoring programs and the use of technologies. Importantly, the telemonitoring effects on clinical effectiveness outcomes (e.g., decrease in the emergency visits, hospital admissions, average hospital length of stay) are more consistent in pulmonary and cardiac studies than diabetes and hypertension. Lastly, economic viability of telemonitoring was observed in very few studies and, in most cases, no in-depth cost-minimization analyses were performed.</p> <p>Home telemonitoring of chronic diseases seems to be a promising patient management approach that produces accurate and reliable data, empowers patients, influences their attitudes and behaviors, and potentially improves their medical conditions. Future studies need to build evidence related to its clinical effects, cost effectiveness, impacts on services utilization, and acceptance by health care providers.</p>

Comment	In this review the authors considered a wider range of chronic conditions than in their other review (Article 17). Here they also included hypertension, blood pressure, pulmonary diseases/conditions, asthma, respiratory diseases/conditions, cardiac diseases/conditions, and heart failure. In total they reviewed 65 studies that examined the outcomes of home telemonitoring programs. Their findings were positive but they did comment that further studies were required to further build the evidence base.
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19	
Author	Verhoeven, F., L. van Gemert-Pijnen, et al. (2007).
Title	"The contribution of teleconsultation and videoconferencing to diabetes care: a systematic literature review."
Reference	J Med Internet Res 9(5): e37.
Objective	To determine the benefits and deficiencies of teleconsultation and videoconferencing regarding clinical, behavioral, and care coordination outcomes of diabetes care.
Method	Electronic databases (Medline, PiCarta, PsycINFO, ScienceDirect, Telemedicine Information Exchange, ISI Web of Science, Google Scholar) were searched for relevant publications. The contribution to diabetes care was examined for clinical outcomes (eg, HbA1c, blood pressure, quality of life), behavioral outcomes (patient-caregiver interaction, self-care), and care coordination outcomes (usability of technology, cost-effectiveness, transparency of guidelines, equity of care access). Randomized controlled trials (RCTs) with HbA1c as an outcome were pooled using standard meta-analytical methods.
Findings	The selected studies suggest that both teleconsultation and videoconferencing are practical, cost-effective, and reliable ways of delivering a worthwhile health care service to diabetics. However, the diversity in study design and reported findings makes a strong conclusion premature. To further the contribution of technology to diabetes care, interactive systems should be developed that integrate monitoring and personalized feedback functions.
Comment	This review covered studies from 1994 to 2006. It showed that ICT based care improved diabetic care compared to usual care. However the improvements were mostly not statistically significant. The authors comment that technology did not compromise the care delivery process.

20	
Author	Botsis, T. and G. Hartvigsen (2008).
Title	"Current status and future perspectives in telecare for elderly people suffering from chronic diseases."
Reference	J Telemed Telecare 14(4): 195-203.
Objective	To assess if home telecare increases an elderly patient's independence and quality of life, and produces cost savings for the authorities.
Method	Reviewed the literature on home telecare for elderly patients suffering from chronic diseases. Articles published between 1990 and 2007 were identified via the PubMed database. The literature search yielded 485 papers. After reviewing the title and abstract from each, 54 were selected for closer examination.
Findings	The diseases in which home telecare had been used were diabetes (14 studies), heart failure (13 studies), cognitive impairment (dementia and/or Alzheimer's disease, 10 studies), chronic obstructive pulmonary disease (5 studies), chronic wounds (4 studies) and mobility disabilities (4 studies). Patients were generally satisfied with home telecare, but they preferred a combination of home telecare with conventional health-care delivery. Health-care professionals were positive about telecare. Users felt that on many occasions telecare led to a reduction in costs due to time savings and avoidance of travelling. Even though there were important benefits from home telecare, there are organizational, ethical, legal, design, usability and other matters that need to be resolved before widespread implementation can occur.
Comment	This review was positive in terms of the use of home telecare. The authors comment on several issues from the users' perspective such as reduced costs and travelling times. This is interesting given the desire to develop a patient centred service in Northern Ireland. The authors believe that due to an ageing population that home telecare could lead to significant benefits.

21	
Author	Dellifraigne, J. L. and K. H. Dansky (2008).
Title	"Home-based telehealth: a review and meta-analysis."
Reference	J Telemed Telecare 14(2): 62-6.

Objective	To identify studies on the effect of home telehealth on clinical care outcomes.
Method	The search was restricted to peer-reviewed publications (published between 2001 and 2007) about studies conducted in home or residential settings.
Findings	The search yielded 154 potential articles and dissertations. A total of 29 articles met the inclusion criteria and were included in a meta-analysis. The weighted mean effect size for the overall meta-analysis was 0.50, and the z-statistic was 3.0, indicating that telehealth had a moderate, positive and significant effect ($P \leq 0.01$) on clinical outcomes. Sub-analyses also indicated positive significant effects of telehealth for some disease categories (heart disease and psychiatric conditions), but not others (diabetes), patient populations and telehealth interventions. Overall, the meta-analysis indicated that telehealth positively affects clinical outcomes of care, even in different patient populations.

Comment	This review considered some of the more recent evidence published as it limited the search to 2001 to 2007. Of the 5 studies that looked at diabetes the meta-analysis did not support a link between telehealth and diabetes outcomes. Of the 5 studies on heart failure meta-analysis indicated a moderately positive relationship between telehealth and heart failure outcomes.
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Conclusions

As detailed in the introduction Northern Ireland faces demographic and social changes which will lead to an increasing prevalence of chronic conditions in the coming decades. Remote telemonitoring is the subject of global interest as a means of delivering a patient centred service capable of dealing with the rising prevalence and importance of chronic disease.

The task for this preliminary review of the existing evidence base was to identify key research publications that addressed remote telemonitoring in the management of diabetes mellitus, chronic heart failure and chronic obstructive pulmonary disease.

There is a growing volume of evidence in the field of telemedicine. Evidence from the literature is strongest for the use of home telemonitoring in the management of chronic disease, in particular the monitoring of vital signs. The evidence base is not without weaknesses and some of the main criticism of the current evidence is the lack of studies of large size and the relatively short duration of a number of the interventions. To date there has been insufficient economic appraisal of telemedicine interventions.

In reviewing the current evidence two issues posed a problem. Firstly the scope of a number of the systematic reviews identified was broader than the scope of interest both in terms of the range of conditions covered and also in the use of various types of telemedicine intervention. This review is specifically addressing the use of remote telemonitoring and only for three named chronic conditions (chronic heart failure, diabetes mellitus and COPD). The second issue that arises is the time period covered by the articles of the various systematic reviews. Several of the reviews covered articles dating back to the early 1990s. With the widespread availability of broadband technology only being available in the past 5 years or so it is quite plausible that the nature of the telemedicine interventions now available may well be qualitatively different to those covered by a substantial section of the current evidence base.

A number of the systematic reviews reported that home telemonitoring proved acceptable to both patients and health care professionals. Where mentioned, all the reviews also confirmed that remote telemonitoring was a feasible approach.

A number of studies of remote telemonitoring report improved quality of life, reduced hospital admissions, reduction in mortality, empowerment of patients and altered patient attitudes towards their condition.

Importantly the use of remote telemonitoring has not been associated with adverse outcomes where it has been used.

In summary, the implications for the European Centre for Connected Health are that the evidence base is relatively strong in favour of the use of remote

telemonitoring in diabetes mellitus, chronic heart failure and to a lesser extent for chronic obstructive pulmonary disease. Benefits offered from remote telemonitoring reported from this review are:

- Patient acceptance and satisfaction with remote telemonitoring
- Health Professional acceptance
- Reduction of chronic disease complications
- Improvement in patients quality of life to include reduction in days spent in hospital and travel time associated with appointments for patients
- Improvement in patient self management and education
- Patient empowerment
- Significant reduction in mortality associated with chronic heart failure
- Reduction in acute hospital admissions and rehospitalisation episodes

The state of the current evidence will become clearer over the coming months as the randomised controlled trials identified by this literature search are evaluated. Further evidence should also be forthcoming from a number of English pilots of telecare.

Patient selection will be an important element of any future remote telemonitoring service in Northern Ireland to ensure maximum gain for patients and the service. Maximal gain will only be achieved if there is an appreciation by those implementing the service that remote telemonitoring represents a systematically different way of delivering a service and has to be planned accordingly.

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