

For want of evidence: a meta-review of home-based telehealth for the management of long-term conditions.

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Summary

Telehealth is frequently seen as a potential solution for supporting people with long-term conditions (LTCs) in their own homes. There is a large evidence base, including numerous systematic reviews, about telehealth so it seems timely to take stock of the evidence by conducting a review of reviews.

A meta-review of systematic reviews of home telehealth for LTCs published between 2005 and 2010 examining the breadth and quality of the evidence base.

We identified 16 high quality systematic reviews covering 662 studies; several focused on telehealth for heart failure, diabetes, hypertension and mental health conditions. These reviews report improvements in various outcomes but not consistently. Evidence on resource utilization and cost-effectiveness is especially weak. Conclusions are frequently compromised by very poor quality primary studies.

Despite an abundance of trials and systematic reviews the evidence for the effectiveness of telehealth for managing LTCs remains inconclusive. We urgently need high quality primary research, especially robust economic analyses. Perhaps we should refrain from conducting further systematic reviews on telehealth interventions until we have a stronger evidence base.

Introduction – the rationale for this meta-review

“Water, water, everywhere,
Nor any drop to drink.” Coleridge, *The Rime of the Ancient Mariner*

As McLean et al¹ noted in this journal, telehealthcare ‘offers potential solutions to the challenges of managing long-term conditions’. Elsewhere, lobbyists² have claimed that telehealth can save the NHS £1bn annually, so the proliferation of internet and mobile technologies will surely only increase these benefits. There is a significant evidence base comprising randomized controlled trials and systematic reviews of a wide range of telehealth interventions for a variety of conditions. It therefore seems timely, and potentially straightforward, to take stock of the evidence base, to aggregate this research to see which types of telehealth interventions work best for managing long-term conditions. The meta-review which follows is the result of our endeavor to do just this and our conclusions are, unexpectedly, closer to those of Coleridge’s ancient mariner: that there is an excess of evidence, but it does not meet our needs.

Review methods

Rather than concentrate on specific telehealth modalities or particular conditions we set out to review the broad literature on home-based telehealth; that is interactions between patients and practitioners/services which are facilitated by digital technologies. Our question was general – which telehealth interventions are best for managing long term conditions (LTCs)? For this reason we conducted a review of reviews (or meta-review) to synthesise the findings of several systematic reviews. We included telephone and

internet-based interventions (such as telecoaching, telephone/internet counselling and follow-up) and telemonitoring of symptoms and vital signs, but not telemedicine (where technologies are used to share information between healthcare providers). We used the NHS National Service Framework³ and associated guidance⁴⁻⁸ to define long-term conditions (LTCs) (see Box 1).

Box 1: Long Term Conditions included in meta-review.

Long term conditions or Long-term conditions
Chronic Illness or Chronic Disease
Asthma
Coronary heart disease (CHD) or Heart failure or CHF
Cardiovascular disease (CVD)
Stroke and Transient Ischaemic Attack (TIA)
Hypertension
Diabetes mellitus
Chronic obstructive pulmonary disease (COPD)
Epilepsy
Thyroid disease (hypo or hyper)
Cancer
Dementia
Depression (& Anxiety)
Mental health-Schizophrenia/psychosis/paranoia/OCD/PTSD/Agoraphobia
Chronic kidney disease (CKD)
Atrial fibrillation
Obesity
Spinal cord injury
Multiple sclerosis
Motor Neurone Disease
Parkinson's Disease
Learning disabilities
Arthritis
Skin disease
Hearing difficulty
Headaches and migraine
Visual problems
Chronic liver disease
Endocrine disorders e.g. Addison's disease, Cushings syndrome
Bronchiectasis
Cardiomyopathy

Crohns disease/Ulcerative colitis
Glaucoma
Haemophilia
Hyperlipidaemia
SLE and other systemic auto-immune diseases
Smoking (in relation to specific LTCs)

We searched Medline, CINAHL, Embase, AMED, PsycINFO, The Cochrane Library (Cochrane Reviews, DARE, other reviews, HTA, NHS Economic Evaluations Database) databases for systematic reviews about telehealth and LTCs and our personal collections of research papers for January 2005 –March 2010 to obtain the most recent, ‘best’ evidence (A full list of search terms is provided in the supplemental materials- Box 2). We included published English language systematic reviews referring to home-based or mobile, synchronous (real-time) and asynchronous telehealth interventions about chronic diseases and LTCs. Reviews focused exclusively on children, inpatients or single conditions were excluded, as were Cochrane Reviews at protocol stage.

Two reviewers independently reviewed abstracts to agree papers for full-text retrieval. Where there was doubt about a paper, the full-text paper was retrieved. Two reviewers reviewed full papers to ensure they met inclusion criteria. Data were extracted using a standardized form (by AR) and checked by a second reviewer (AOC or CP). Where there were any discrepancies or uncertainties, reviewers discussed these to agree a resolution.

We assessed the quality of reviews using the five core questions from the Centre for Reviews and Dissemination for inclusion on the Database of Abstracts of Review of

Effects⁹ (see Table 1). A review was included if two reviewers agreed that it met at least the first three mandatory criteria and four out of five of the criteria.

Table 1 Quality assessment of 16 included reviews.

Author/Date	inclusion/exclusion criteria reported?	search adequate?	included studies synthesised?	validity of studies assessed?	sufficient details about studies presented?
Barlow 2007 ¹⁷	y	y	y	y	u
Botsis 2008 ¹⁸	y	y	y	y	y
Bowles 2007 ²⁰	y	y	y	n	y
Cole-Lewis 2010 ²²	Y	Y	Y	Y	y
Cuijpers 2008 ¹⁰	y	y	y	y	y
Dellifraire 2008 ¹¹	y	y	y	y	y
Garcia-Lizana 2007 ²⁶	y	y	y	y	y
Hersh 2006 ²³	y	y	y	y	u
Krishna 2009 ²¹	y	y	y	n	y
Murray 2005 ¹⁴	y	y	y	y	y
Oake 2009 ¹⁶	y	y	y	y	y
Pare 2010 ¹³	y	y	y	n	y
Polisena 2009 ¹⁹	y	y	y	y	y
Rains 2009 ²⁴	y	y	y	y	y
Stinson 2009 ¹⁵	y	y	y	y	y
Tran 2008 ¹²	Y	Y	Y	Y	Y

Findings

What is the evidence base?

We identified 36 reviews, 11 of these were excluded because they provided no outcomes, were not systematic, or focused on acute care, a single condition or on ‘smart home

technology'. Twenty-one reviews satisfied the first 3 mandatory quality criteria and 16 of these met at least 4 criteria. Our meta-review includes these 16 high quality systematic reviews which review 662 individual studies. Six reviews included a meta-analysis and quantitative evaluation of effectiveness.

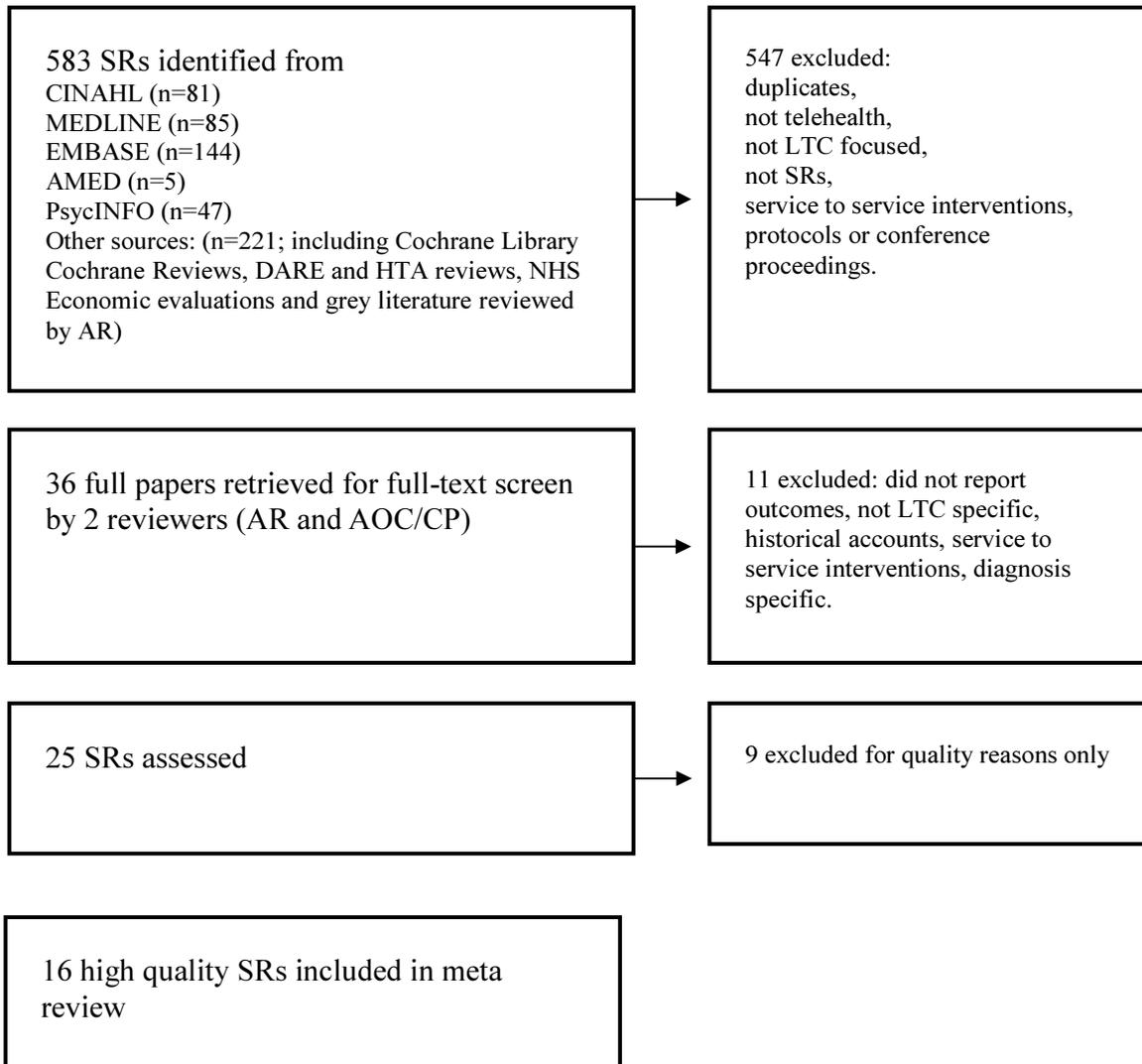


Figure 1: PRISMA flow diagram

The reviews included came from Canada (6), USA (5) and Europe (5) and covered a range of telephone, mobile, internet-based and computer interventions.

Table 3: Studies included in the review

Author Date	Design (No) of studies	Country of review origin	Outcomes measured	Disease (no. of studies) /Patient characteristics	Intervention type and control group details	Conclusions
Barlow 2007 ¹⁷	98 studies (68 RCTs; 30 observational studies)	UK	Health status (blood glucose, blood pressure); Quality of life; Satisfaction; Utilisation; Other (safety and security monitoring); Cost-effectiveness; Education.	Asthma (3%), arthritis, CHD/CHF (29%), chronic back pain (1%), COPD, dementia (1%), depression, Diabetes (31%), frail elderly (7%), hypertension (5%), assorted diseases (10%). Adults and elderly patients.	Telecare at home: including telephone support, internet and email, telemonitoring of vital signs, text messaging	More evidence is needed.
Botsis 2008 ¹⁸	54 studies; 47 RCTs or CCTs, 7 qualitative studies	Europe	Health status; Clinical; Quality of life; Satisfaction; Utilisation;	CHF (13), CHD, chronic wounds (4), Diabetes (14), Alzheimer's Disease or cognitive impairment (10), mobility disabilities (4). Elderly patients.	Home telecare: telehealth, video conferencing, virtual visits, telemonitoring of vital signs, teleconsultations- including real-time monitoring and communication	Could not replace nurse home visits.
Bowles 2007 ²⁰	19 studies- including RCTs, CCTs, observational, qualitative	USA	Health status; Quality of life; Satisfaction; Clinical; Support; Utilization; Behaviour change.	COPD (11), cancer, anxiety, CHF (9), CHD (1), CVD, hypertension (1), stroke (CVA) (1), spinal cord injury, chronic wounds, diabetes (8). Adults and elderly patients. Focus on older adults.	Telehomecare (by nurses): interactive visits, video visits, transmission of vital signs.	Telehomecare is best for patients requiring close monitoring and quick interventions (i.e. HF patients).
Cole-Lewis 2010 ²²	17 papers representing 12 studies (9 RCTs; 2 cross over, 1 quasi-experimental)	USA	Health status, Clinical; Behavioural change.	Asthma (1), diabetes (6), weight loss/prevention (2); 3 other (1 medication adherence; 1 physical activity; 1 smoking cessation). All studies included adults; 4 targeted adolescents or young	Text messaging (only component in 5 studies- others also used internet and email)	Evidence of a short term effect on behavioral or clinical outcomes. Text messaging useful in disease prevention and management interventions for weight loss, smoking cessation, and diabetes Effective for adolescents and adults, minority and

				adults, 1 study included 10-19 year olds.		nonminority populations, and across nationalities.
Cuijpers 2008 ¹⁰	12 RCTs	Europe	Health status; Quality of life.	Migraine/ recurrent headache (3); other problems (6); Pain (3). Children, adults, elderly.	Online CBT with a strong psycho-educational element. Control group- waiting list or self-help only.	Effective for some conditions, but unable to draw definite conclusions due to small numbers of studies. Very few studies compared the online intervention to face to face treatment. Unable to draw definite conclusions about whether CBT delivered through the internet was effective - more research on eCBT needed.
Dellifraigne 2008 ¹¹	29 studies (25 RCTs, 2 not randomized; 2 unable to tell)	USA	Health status, Utilization; Clinical.	Asthma (1), arthritis (1), anxiety (1), CHF (5), coronary artery bypass (1), COPD (1), depression (2), diabetes (6), hypertension (2), MS (1), multiple conditions (4), obesity (2), and schizophrenia (1). Children, adults, elderly.	Home telehealth- video-monitoring, telephone, internet, vital signs transmission	Effective for some conditions but limited information about intervention characteristics.
Garcia-Lizana 2007 ²⁶	24 RCTs	Europe	Health status; Quality of life; satisfaction; Clinical; Support; Utilization; Behaviour change; education	Asthma (5), CHF (6), CHD, CVD (2), diabetes (7), hypertension (3). Children, adults.	Information and communication technologies including interactive computer games, telemonitoring of vital signs, internet and web based interventions for disease management, telephone, videophone.	Some positive outcomes in utilization and clinical outcomes. Controlling and managing chronic diseases benefits were limited No agreement on appropriate features of interventions. Limitations of studies - lack of high quality evidence and data re the ability of ICTs to increase knowledge and social support for people with chronic disease.
Hersh 2006. ²³	106 studies including RCTs (class i), CCTs (class ii), Case series (class iii), Cohort (class iii), Case	Canada	Health status; Utilization.	Home-based interventions reported on only: Asthma (1), CAD (3), CHF (7), chronic disease (4), diabetes (6), hypertension (3), lung transplant (1), MS (1), obesity (1), psychiatry (1), Spinal cord injury (1).	Telemedicine: web-based monitoring; trans-telephonic monitoring; telemonitoring; HealthBuddy; remote monitoring; telemedicine; uploading electronic diary, video monitoring	Home-based services used to enhance the care of patients who already receive conventional services Limitations of studies included (i.e. small sample size and few well designed RCTs)

	control (class iii). ¼ met class I criteria. 28 of the studies were home-based interventions.			Mainly adult; 1 pediatric asthma study; 4 chronic disease in the elderly and 1 home based study mentioning senior agencies. 2 studies included veterans.		
Krishna 2009 ²¹	20 RCTs, 5 CCTs	USA	health status; Quality of life; satisfaction;; behavior change; education	Asthma (1), diabetes (9), general outpatient (2). HIV & Aids (2), health promotion (1), hepatitis vaccinations (1), hypertension (1), physical disabilities (1), smoking cessation (4), stress management (1). Adults & children.	Health information delivered via cell phones or text messaging	80% showed significant differences between intervention and controls.
Murray 2005 ¹⁴ (updated 2009)	24 RCTs	UK	Health status, Clinical; Utilisation, Cost-effectiveness; Education; Support; Behaviour change; Other.	Asthma (6), diabetes (6), breast cancer or leukemia (3), Alzheimer's Disease or memory loss (2), eating disorders (1), encopresis (faecal soiling- children) (1), HIV and AIDS (2), obesity (2), urinary incontinence (women) (1). Children, adolescents, adults.	Interactive Health Communication Applications (IHCAs): including computers, modems, telephone lines, internet and CD ROMs.	Significant positive effects on knowledge, social support, behavioural and clinical outcomes. Not likely to have positive effects on overall self-efficacy. No evidence of the effects on health service utilisation. Unable to determine effects on emotional or economic outcomes. Insufficient evidence to determine if IHCAs can benefit disadvantaged groups. Overall lack of high quality evidence.
Oake 2009 ¹⁶	32 RCTs 8 CCTs	Canada	Clinical; Health status, Quality of life, utilisation, satisfaction; behavioural change.	Appointment reminders (1), asthma (1), chronic pain (1), cervical cancer screening (1), CHF (3), diabetes (3), dyslipidemia (1), hypertension (1), immunizations (9), mental health (3), smoking cessation (3). Adult.	IVRS (interactive voice response systems) to contact patients at home with reminders or to track patient assessed parameters at home.	Caution against interpretation that technology improves outcomes as currently insufficient data.

Pare 2010 ¹³	62 studies: 46 RCTs (3/4).	Canada	Health status, quality of life, utilization, satisfaction.	Asthma (8), CHF (17), diabetes (24), hypertension (13). Age-not reported.	Telemonitoring	Positive effects reported for diabetes, asthma, and hypertension (associated with telemonitoring allowing for more frequent follow-up of patients). Failed to show a reduction in either mortality or hospitalization rates for HF, although some trend towards shorter lengths of stay in hospital. Better glycemic control and improved control of asthma and blood pressure. Larger trials are needed to confirm the benefits of this technology for these patients.
Polisena 2009 ¹⁹	22 studies- including 14 RCTs, 4 CCTs, 4 pre-post studies	Canada	Cost effectiveness (including 1 cost unit analysis).	Cancer (1), CHF (12; 1 allowed CHD), COPD (3), diabetes (5), stroke (1), wound care (1). Severe and moderate. Adolescents, adults and 1 study looked at >65 year olds.	Telehealth, telemanagement, Health Buddy devices, transmission of vital signs information.	Quality of the studies in terms of economic evaluations was poor. Studies heterogeneous so difficult to make an informed decision on resource allocation (p347) Potential of telehealth to be cost saving, but cannot be sure until higher quality studies are conducted
Rains 2009 ²⁴	28 pre-post test studies	USA	Health status, Quality of life, satisfaction; Behavioural change.	Back pain (1), breast cancer (5), chronic pain (1), chronic illness (2), CVD (1), depression (16), Diabetes (4), eating disorder (6), heart transplant (1), HIV/AIDS (1), panic disorder (1), Parkinson's Disease (1), weight loss maintenance (1), smoking cessation (1). 80% adult population (non-student). Remainder students or adolescents (focused on eating disorders and depression).	Computer mediated support groups (CMGs)	.
Stinson 2009 ¹⁵	29 studies- including 5 RCTs and 1 pilot RCT	Canada	Health status; Quality of life; Utilization; Satisfaction;	Asthma (including persistent asthma) (5), encopresis (1), obesity (1), recurrent headaches (1), Traumatic	Internet based self-management- including internet, web-based interactive programmes,	Improvements in symptoms in four of the five health conditions. Limited evidence regarding impact on healthcare

			Behaviour change	Brain Injury (TBI) (1). Children and adolescents only (5 targeted youth and parents; several used youth and parent dyads	email, telephone & email support	<p>utilisation, knowledge and QoL outcomes.</p> <p>Unable to determine effectiveness of internet interventions on self-efficacy, social support and emotional well-being.</p> <p>No definite conclusions about whether self-management interventions delivered through the internet are as effective as face-to-face therapies as most of the studies used usual care or wait-list control comparison groups.</p> <p>Limited data in studies in the review.</p>
Tran 2008 ¹²	78: 12 rcts (diabetes), 4 RCTs (chronic disease), 1 RCT (COPD), 13 RCTs (CHF), 8 observational studies (diabetes), 5 observational studies (CHF), 3 observational studies (COPD), 3 observational studies (chronic disease)	Canada	Health status, Utilisation, Cost- effectiveness Quality of life, Satisfaction;	CHF (35), chronic diseases (8), COPD (9), Diabetes (26). Adults and older persons (over 65 years)	Telehealth: telephone, videophone, telemonitoring, pager, mobile technology.	<p>Home telemonitoring and telephone support effective for improving glycemic control for patients with diabetes and for reducing mortality rates among patients with heart failure.</p> <p>Higher mortality among patients with COPD using home telehealth interventions, but few studies and sample sizes small.</p> <p>Variability in the quality of studies - poor study designs or small sample sizes.</p> <p>Home telehealth generally clinically effective, and no patient adverse events reported .</p> <p>Evidence on service utilization is more limited but shows potential.</p> <p>Economic review-overall quality of the original research was low.</p>

Does telehealth work?

While 11 reviews concluded that telehealth was effective for some LTCs or improved some outcomes, seven urged caution regarding weak research designs^{10, 11,12, 13, 14,16}.

Meta-analyses tended to support telehealth, although effect sizes were often small or moderate. Reviews without meta-analyses produced more mixed conclusions, although none reported telehealth was not effective at all. Four reviews^{12, 17-19} found some evidence for cost-savings but one was unable to determine cost effectiveness¹⁴.

The evidence for whether telehealth ‘works’ is inconclusive. Some, but by no means the majority of reviews show positive outcomes. Positive effects of telehealth interventions for diabetes were noted in 5/ 14 reviews^{12, 18,20, 21,23}, 4/12 reviews^{13, 15, 21, 23} noted some benefits, including improved symptom control for patients with asthma or Chronic Obstructive Airway Disease (COPD). Three meta-analyses¹¹⁻¹³ showed benefits for patients with heart failure or heart disease, including improved control of blood pressure in hypertension. Larger effect sizes were demonstrated in two meta-analyses^{11, 24} focused on mental health conditions.

What are the best outcomes?

Positive clinical outcomes, for example increased compliance or reduced burden of illness are frequently reported^{11-14, 18, 20-22}. Mortality appears to be reduced for patients with heart failure, but not for those with COPD. Two reviews reported improved educational outcomes^{14, 21} and eight reported significant positive behavioural change^{14, 16, 21-22, 24} particularly improved self-monitoring or management in patients with diabetes²⁰

and better treatment adherence^{16-17, 20}. Telehealth is less successful in promoting physical activity²².

There are few firm conclusions about the impact of telehealth on quality of life although one meta-analysis reported improvements associated with computer mediated support groups²⁴. Social support was rarely examined, and the three reviews which suggested that telehealth improved support^{14, 21, 24} were countered by three which reported inconsistent or insufficient evidence^{15, 17, 26}.

Does telehealth save resources?

The evidence regarding impact of telehealth on resource utilization is mixed. Telehealth is implicated in reduced admissions for heart failure, heart disease, diabetes and hypertension^{17, 20, 23, 26}, and reduced hospitalisations for elderly patients with LTCs¹⁸. But other reviews showed limited impact on service utilisation¹⁴⁻¹⁵ and meta-analyses reported that the evidence for positive impact of telehealth on resource utilisation was questionable^{12, 14, 16}.

Do patients like telehealth?

Three reviews commented on patient attitudes towards telehealth and indicated that patients find telehealth acceptable^{12, 18, 20}.

What type of technology works best?

Telephone-based interventions worked well according to 6/ 8 reviews considering them alone or as part of more complex interventions^{12, 17-18, 26}. The use of mobile phones and text messaging appeared to be effective²¹⁻²², particularly for promoting behaviour change. Vital signs monitoring was reported as producing clinical benefits in approximately half the trials in one review¹⁷ but other reviews suggested this might be limited to particular conditions, such as hypertension¹³, diabetes^{12-13, 16, 20}, heart failure^{16, 20} and respiratory conditions¹³. Telehealth interventions which included telemonitoring of vital signs were associated with elevated mortality amongst COPD patients and appeared to offer no benefits for dementia¹⁸, obesity or blood glucose control in diabetes²³.

Support for internet and computer technology was also mixed. Four of 7 reviews on this topic showed some positive effects^{10, 14-15, 24}. Text reminders appeared to work better than email or internet reminders²². Videoconferencing was associated with improved outcomes across a range of LTCs in one review¹¹ but there was inconsistent evidence for its use in delivering support and education¹⁷.

Do health professional have to deliver the care?

Few reviews compared different healthcare professionals delivering the intervention, or whether the presence of a professional was necessary. Professional care was not compared with lay or peer support. Telephone follow-up by nurses improved clinical outcomes and reduced service use¹⁷ and therapists or trained moderators seem to enhance internet interventions, particularly cognitive behavioural therapy¹⁰.

Which patients benefit most?

Few meta-analyses examined patient specific characteristics. DelliFraine and Dansky¹¹ suggested that younger patients, males and possibly black ethnic groups benefited most from home telehealth, but Cole-Lewis and Kershaw²² reported no differences in outcomes linked to age or gender. Few other reviews commented on patient characteristics and there was little agreement on who benefited most. There was insufficient evidence to say whether disadvantaged groups benefit¹⁴ but some suggestion that computer interventions may benefit those living in rural communities.

Conclusion: Evidence everywhere but ...?

We deliberately focused on high quality systematic reviews, but despite the apparently positive messages about telehealth most demonstrated that small sample sizes, weak study design and lack of adequate comparators mean that we still have very little good evidence to inform decisions about using home telehealth for people with LTCs. This conclusion is supported elsewhere^{25, 27-29}.

The size of the evidence-base indicates that telehealth is very popular. But the weight of the evidence cannot answer important questions or inform large scale investment decisions. We therefore take the unusual step of advocating taking a step back: we urge researchers to focus on producing high quality primary studies to improve the evidence base. If we are to answer the crucial ‘what works and for whom’ question we need studies

which provide high quality evidence and which specify the nature of and context for interventions. Telehealth has exciting potential but at a price, so we also urgently need high quality cost-effectiveness studies. We propose a moratorium on systematic reviews of home telehealth interventions. Instead research should be directed to rigorous evaluations of telehealth interventions versus usual care, and systematic comparisons of different types of interventions and technologies.

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Supplementary information

Table 2 [Supplementary] Quality assessment for 9 excluded reviews.

Author/Date	inclusion/ exclusion criteria reported?	search adequate?	included studies synthesised?	validity of studies assessed?	sufficient details about studies presented?
Bensink 2006	y	y	y	n	n
Brignell 2007	y	y	y	n	n
Gaikward 2009	y	n	y	n	n
Hylar 2005	y	y	y	n	n
Jaana 2009	y	n	y	y	y
Pare 2007	y	y	y	n	n
Rojas 2008	y	y	n	n	n
Rosser 2009	y	y	y	n	n
Wofford 2005	y	y	n	y	n

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Table 4: [Supplementary] Summary findings from reviews with meta-analyses

Author Date	Design (No) of studies	Country of review origin	Outcomes measured	Disease (no. of studies) /Patient characteristics	Intervention type and control group details	Effect size/conclusions by disease/condition/patient characteristics	Effect size/ conclusions by outcomes	Effects/size/ conclusions by technology, duration etc.	Conclusions
Cuijpers 2008	12 RCTs	Europe	Health status; Quality of life.	Migraine/ recurrent headache (3); other problems (6); Pain (3). Children, adults, elderly.	Online CBT with a strong psycho-educational element. Control group- waiting list or self-help only.	0.58 (moderate to large pooled effect size for 3 studies). Heterogeneity low. Compared to face to face care. Small to moderate for headache (3 studies-not pooled). 0.26 for Tinnitus. 0.46 or moderate for physical disabilities 0.70 or large for Parental mental health in pediatric brain injury. 0.22 for breast cancer.	Small for health indicators at 12 month follow-up.		Effective for some conditions, but unable to draw definite conclusions due to small numbers of studies. Very few studies compared the online intervention to face to face treatment. Unable to draw definite conclusions about whether CBT delivered through the internet was effective - more research on eCBT needed.
Dellifraie 2008	29 studies (25 RCTs, 2 not randomised; 2 unable to tell)	USA	Health status, Utilization; Clinical.	Asthma (1), arthritis (1), anxiety (1), CHF (5), coronary artery bypass (1), COPD (1), depression (2), diabetes (6), hypertension (2), MS (1),	Home telehealth- video- monitoring, telephone, internet, vital signs transmission	0.50 (overall mean weight effect for all studies). 0.13 for diabetes (6 studies). No support for diabetes outcomes. 0.32 for heart disease (6 studies) 1.42(z=2.5, p<0.05) or	Positive effect on clinical outcomes. Fewer emergency visits, fewer hospital admissions, shorter length of hospital stay and fewer physician consults. 0.46 (95% CI, 0.22-	0.78 (p=0.01) (8 studies) for video technology. 0.20) (7 studies) for internet technology. Telephone not evaluated in sub	Effective for some conditions but limited information about intervention characteristics.

				multiple conditions (4). obesity (2), and schizophrenia (1). Children, adults, elderly.		moderate for psychiatric diagnoses (5 studies); positive relationship between telehealth and mental illness outcomes. 0.61 (p<0.05) for 21-65 year olds; 0.41 (p<0.01) for elderly subjects. 0.77 for males; 0.32 for females. 0.36 (but significant p<0.01) or mild for race (few studies).	0.69) for knowledge or significant positive effect on knowledge with evidence of heterogeneity. 0.35 (95% CI 0.18-0.52) or significant positive effect on social support - no evidence of heterogeneity.	analysis due to small numbers of studies.	
Murray 2005 (updated 2009)	24 RCTs	UK	Health status, Clinical; Utilisation, Cost-effectiveness; Education; Support; Behaviour change; Other.	Asthma (6), diabetes (6), breast cancer or leukemia (3), Alzheimer's Disease or memory loss (2), eating disorders (1), encopresis (faecal soiling-children) (1), HIV and AIDS (2), obesity (2), urinary incontinence (women) (1). Children, adolescents, adults.	Interactive Health Communication Applications (IHCAs): including computers, modems, telephone lines, internet and CD ROMs.		SMD 0.24 (95% CI 0.00-0.48) for self-efficacy (all children trials) –positive effect on self-efficacy. No evidence of heterogeneity. SMD 0.46 (95% CI 0.22-0.69) for knowledge -significant positive effect. Substantial heterogeneity. SMD 0.35 (95% CI 0.18-0.52) for social support-significant positive effect. No evidence of heterogeneity. SMD 0.20 (95% CI 0.01 to 0.40) for behavioural-significant positive		Significant positive effects on knowledge, social support, behavioural and clinical outcomes. Not likely to have positive effects on overall self-efficacy. No evidence of the effects on health service utilisation. Unable to determine effects on emotional or economic outcomes. Insufficient evidence to determine if

							effect. Substantial heterogeneity. SMD 0.18 (95% CI 0.01 to 0.35) for Clinical-significant positive effect. Some heterogeneity.		ICHAs can benefit disadvantaged groups. Overall lack of high quality evidence.
Oake 2009	32 RCTs 8 CCTs	Canada	Clinical; Health status, Quality of life, utilisation, satisfaction; behavioural change.	Appointment reminders (1), asthma (1), chronic pain (1), cervical cancer screening (1), CHF (3), diabetes (3), dyslipidemia (1), hypertension (1), immunizations (9), mental health (3), smoking cessation (3). Adult.	IVRS (interactive voice response systems) to contact patients at home with reminders or to track patient assessed parameters at home.	A trend towards improvement in clinical measures associated with better disease outcomes in patients with diabetes, hypertension and dyslipidemia. Clinical endpoints are largely unstudied, but reduction in hospital days for Heart failure patients in 1/3 studies.	Disease status (6 studies) non-significant improvements overall. General health outcomes (5 studies) unable to pool data; in 2/5 studies associated with improved general health. Most common outcome was process adherence - 7.9% improvement in adherence with recommended treatments and tests.		Caution against interpretation that technology improves outcomes as currently insufficient data.
Rains 2009	28 pre-post test studies	USA	Health status, Quality of life, satisfaction; Behavioural change.	Back pain (1), breast cancer (5), chronic pain (1), chronic illness (2), CVD (1), depression (16), Diabetes (4), eating disorder (6), heart transplant (1), HIV/AIDS (1), panic disorder (1), Parkinson's	Computer mediated support groups (CMSGs)	$r = -.23$ (95% CI -.16 to -.29) showing a significant decrease in depression. Group size positively associated with the increase in quality of life reported at the baseline and completion $b = .001$, $SE = .0003$, $p = .03$, $K = 12$. Group size had non-significant impact on changes in depression.	$r = .16$ (95% CI .01 to .31) for 'Perceived a significant increase in social support.' $r = .14$ for quality of life and self-efficacy to manage condition	Longer duration intervention reported greater gains in social support (marginally significant) $r = .29$, $K = 4$; Access to synchronous and asynchronous channels reported greater	.

				Disease (1), weight loss maintenance (1), smoking cessation (1). 80% adult population (non-student). Remainder students or adolescents (focused on eating disorders and depression).		Group size negatively associated with perceptions of social support – possibly as group size increases, so does potential for members to feel isolated. CMSGs may be good for rural users.		increases in social support than those who simply had access to asynchronous channels such as a discussion board $r=.03$, $K=3$, $b=.26$, $SE=.09$, $p<.01$)	
Tran 2008	78: 12 rcts (diabetes), 4 RCTs (chronic disease), 1 RCT (COPD), 13 RCTs (CHF), 8 observational studies (diabetes), 5 observational studies (CHF), 3 observational studies (COPD), 3 observational studies (chronic disease)	Canada	Health status, Utilisation, Cost-effectiveness, Quality of life, Satisfaction;	CHF (35), chronic diseases (8), COPD (9), Diabetes (26). Adults and older persons (over 65 years)	Telehealth: telephone, videophone, telemonitoring, pager, mobile technology.		Mean difference of HbA1c between home telemonitoring and usual care (12 studies): 0.21 (95% CI -0.35, -0.08) Relative risk of heart failure (HF) patients rehospitalized (all-cause) between home telemonitoring and usual care (4 studies): 0.78 (95%CI 0.66,0.92) Relative risk of HF patients re-hospitalized (all-cause) between telephone support and usual care (8 studies): 0.91(95%CI 0.83,0.99) Relative risk of HF patients re-hospitalized (HF-related) between telephone support and usual care (5 studies):		Home telemonitoring and telephone support effective for improving glycemic control for patients with diabetes and for reducing mortality rates among patients with heart failure. Higher mortality among patients with COPD using home telehealth interventions, but few studies and sample sizes small. Variability in the quality of studies - poor study designs or small sample sizes.

						<p>0.77 (95% CI 0.66, 0.89)</p> <p>Relative risk of all-cause deaths of HF patients between home telemonitoring and usual care (6 studies): 0.65 (95% CI 0.49,0.87)</p> <p>Relative risk of all-cause deaths of HF patients between telephone support and usual care (10 studies): 0.87(95%CI 0.75,1.02)</p> <p>Relative risk of HF-related deaths of HF patients between telephone support and usual care (2 studies): 0.60 (95% CI 0.32,1.13)</p> <p>Relative risk of HF patients visiting emergency department between telephone support and usual care (2 studies): 0.95 (95% CI 0.82,1.11)</p> <p>Relative risk of mortality of COPD patients between telephone support and usual care (3 studies): 1.21(95%CI 0.84,1.75)</p>	<p>Home telehealth generally clinically effective, and no patient adverse events reported.</p> <p>Evidence on service utilization is more limited but shows potential.</p> <p>Economic review- overall quality of the original research was low.</p>
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Table 5: [Supplementary] Summary findings from reviews without meta-analyses

Author/ Date	Design (No. of studies)	Country of review origin	Outcome measured	Disease type (no. of studies)/ Patient characteristics	Intervention type and control group if cited	Main conclusions by disease/ condition/ patient characteristics	Main conclusions by outcomes	Main conclusions by technology, duration etc	Overall conclusions
Barlow 2007	98 studies (68RCTs; 30observational studies)	UK	Health status (blood glucose, blood pressure); Quality of life; Satisfaction; Utilisation; Other (safety and security monitoring); Cost-effectiveness; Education.	Asthma (3%), arthritis, CHD/CHF (29%), chronic back pain (1%), COPD, dementia (1%), depression, Diabetes (31%), frail elderly (7%), hypertension (5%), assorted diseases (10%). Adults and elderly patients.	Telecare at home: including telephone support, internet and email, telemonitoring of vital signs, text messaging	Telephone (less evidence for internet) interventions may reduce service use (for heart disease, asthma, diabetes). One trial found no evidence for HF.	Vital signs monitoring: mixed evidence; half of the studies suggested no clinical benefit. 3 studies showed improved medical adherence.	Telephone support by practitioners can improve clinical outcomes. Inconsistent evidence regarding the effects of internet and email for support and education. Evidence to suggest telecare can improve care for people with LTCs “but the strength of the evidence depends on the type of telecare application” (p178-9).	More evidence is needed.
Botsis 2008	54studies ; 47 RCTs or CCTs, 7 qualitative studies	Europe	Health status; Clinical; Quality of life; Satisfaction; Utilisation;	CHF (13), CHD, chronic wounds (4), Diabetes (14), Alzheimer’s Disease or cognitive impairment (10), mobility disabilities (4). Elderly patients.	Home telecare: telehealth, video conferencing, virtual visits, telemonitoring of vital signs, teleconsultations - including real-time monitoring and communication	No significant benefits of telecare for dementia or Alzheimer’s Disease- (possibly due to difficulty in learning to use equipment). Benefits for diabetes, HF & wound care, as well as reducing blood pressure and lowering cholesterol.	Many studies showed cost savings, elimination of travel expenses and fewer hospitalizations.	Patients generally accepting of technology.	Could not replace nurse home visits.

Bowles 2007	19 studies-including RCTs, CCTs, observational, qualitative	USA	Health status; Quality of life; Satisfaction; Clinical; Support; Utilization; Behaviour change.	COPD (11), cancer, anxiety, CHF (9), CHD (1), CVD, hypertension (1), stroke (CVA) (1), spinal cord injury, chronic wounds, diabetes (8). Adults and elderly patients. Focus on older adults.	Telehomecare (by nurses): interactive visits, video visits, transmission of vital signs.	Improves outcomes among patients with chronic disease; most often diabetes HF, chronic wounds. Improves self-management in diabetes patients. Telemonitoring reduces rehospitalization for HF and diabetes patients.	Long-term cost of chronic illness management seems to decrease with telehealth. Improved self-monitoring and reduced hospitalizations are the most common outcomes.	Patients accept technology but do not want to lose face to face care.	Telehomecare is best for patients requiring close monitoring and quick interventions (i.e. HF patients).
Garcia-Lizana 2007	24 RCTs	Europe	Health status; Quality of life; satisfaction; Clinical; Support; Utilization; Behaviour change; education	Asthma (5), CHF (6), CHD, CVD (2), diabetes (7), hypertension (3). Children, adults.	Information and communication technologies including interactive computer games, telemonitoring of vital signs, internet and web based interventions for disease management, telephone, videophone.	Benefit for controlling and managing chronic disease limited.	Some improvements in hospitalization, emergency room visits and mortality (for HF). Inconsistent improvements in clinical outcomes. Studies with most relevant clinical outcomes were for hypertension and HF.	More complex interventions that included both web-based medical record and permanent healthcare professional support accomplished significant benefits in HbA1c levels. (pP64) Support for simple telephone interventions (or no differences to more complex interventions). Suggest necessary to employ interventions long-term. No safety risks or problems reported.	Some positive outcomes in utilization and clinical outcomes. Controlling and managing chronic diseases benefits were limited No agreement on appropriate features of interventions. Limitations of studies - lack of high quality evidence and data re the ability of ICTs to increase knowledge and social support for people with chronic disease.
Krishna2009	20 RCTs, 5 CCTs	USA	health status; Quality of life; satisfaction;;	Asthma (1), diabetes (9), general out-patient (2).	Health information delivered via cell phones or text	Significant improvement in diabetes related outcomes in 8/9	8/10 showed changes in behaviour	Wide access to mobile phones so may reduce inequalities and the digital divide around	80% showed significant differences between intervention and

			behavior change; education	HIV & Aids (2), health promotion (1), hepatitis vaccinations (1), hypertension (1), physical disabilities (1), smoking cessation (4), stress management (1). Adults & children.	messaging	diabetes studies.	12/13 showed improved clinical outcomes. Limited evidence for quality of life except for one diabetes study.	access to internet or web-based interventions.	controls.
Polisena 2009	22 studies- including 14 RCTs, 4 CCTs, 4 pre-post studies	Canada	Cost effectiveness (including 1 cost unit analysis).	Cancer (1), CHF (12; 1 allowed CHD), COPD (3), diabetes (5), stroke (1), wound care (1). Severe and moderate. Adolescents, adults and 1 study looked at >65 year olds.	Telehealth, telemanagement, Health Buddy devices, transmission of vital signs information.		Found home telehealth to be cost saving from healthcare system and insurance providers perspective.		Quality of the studies in terms of economic evaluations was poor. Studies heterogeneous so difficult to make an informed decision on resource allocation (p347) Potential of tele-health to be cost saving, but cannot be sure until higher quality studies are conducted
Stinson 2009	29 studies- including 5 RCTs and 1 pilot RCT	Canada	Health status; Quality of life; Utilization; Satisfaction; Behaviour change	Asthma (including persistent asthma) (5), encopresis (1), obesity (1), recurrent headaches (1), Traumatic Brain Injury (TBI) (1).	Internet based self-management- including internet, web-based interactive programmes, email, telephone & email support	All 5 asthma studies showed positive effects; 1/1 studies showed positive effects on pain 1/1 obesity trial showed positive effects on body fat	2 asthma studies showed significant decreases in resource utilization (emergency visits and physician consultations).	For obese patients improved body fat and weight were not maintained at 2 year follow-up	Improvements in symptoms in four of the five health conditions. Limited evidence regarding impact on healthcare utilisation, knowledge and QoL outcomes.

				Children and adolescents only (5 targeted youth and parents; several used youth and parent dyads)		and weight at 6 months. 1/1 encopresis study showed positive effects on bowel habits (accidents); non-significant for knowledge 1/1 TBI study showed positive effects on self-management and compliance; Non-significant effect on child behaviour problems Limited evidence on utilization, knowledge and quality of life, or of impact of internet on self-efficacy, support, emotional well-being.	No studies measured self-efficacy, social support or emotional well-being. 4/9 studies showed significantly increased disease-related knowledge (2/3 asthma studies and 1 encopresis study). 2/6 studies showed significant improvements in quality of life.		Unable to determine effectiveness of internet interventions on self-efficacy, social support and emotional well-being. No definite conclusions about whether self-management interventions delivered through the internet are as effective as face-to-face therapies as most of the studies used usual care or wait-list control comparison groups. Limited data in studies in the review.
Hersh 2006.	106 studies including RCTs (class i), CCTs (class ii), Case series (class iii), Cohort (class iii),	Canada	Health status; Utilization.	Home-based interventions reported on only: Asthma (1), CAD (3), CHF (7), chronic disease (4), diabetes (6), hypertension (3), lung transplant (1), MS (1),	Telemedicine: web-based monitoring; transtelephonic monitoring; telemonitoring; HealthBuddy; remote monitoring; telemedicine; uploading electronic diary,	Some tailored interventions effective in asthma, congestive heart failure (CHF), hypertension and pulmonary disease. Home-based interventions, such as blood glucose measurements to	Three studies of chronic disease in the elderly showed benefit of the dedicated programme in functional status and reduced emergency department		Home-based services used to enhance the care of patients who already receive conventional services Limitations of studies included (i.e. small sample size and few well designed RCTs)

	Case control (class iii). ¼ met class I criteria. 28 of the studies were home-based interventions.			obesity (1), psychiatry (1), Spinal cord injury (1). Mainly adult; 1 pediatric asthma study; 4 chronic disease in the elderly and 1 home based study mentioning senior agencies. 2 studies included veterans.	video monitoring	improve management of diabetes were not found to be better than usual care.	visits and hospital admissions.		
Cole-Lewis 2010	17 papers representing 12 studies (9 RCTs; 2 cross over, 1 quasi-experimental)	USA	Health status, Clinical; Behavioural change.	Asthma (1), diabetes (6), weight loss/prevention (2); 3 other (1 medication adherence; 1 physical activity; 1 smoking cessation). All studies included adults; 4 targeted adolescents or young adults, 1 study included 10-19 year olds.	Text messaging (only component in 5 studies- others also used internet and email)	Increase in blood glucose monitoring and reporting via text message compared with e-mail among diabetic adolescents and young adults Non-significant difference in physical activity	Av. quality scores = 76% for disease prevention studies and 81 for disease management studies (range 0-100%) 8/9 support the effectiveness of text messaging as a tool for behaviour change Significant clinical outcomes incl. greater weight loss in obese adults at 4 and	No clear differences in intervention outcomes based on age, gender, or length of messages 4/12 studies failed to isolate the effect of the text messaging technology Only 2 studies measured whether text messaging is as effective as other technologies, these studies found that text reminders result in increased frequency of blood glucose monitoring when compared with e-mail reminders and that Hb A1c levels decreased when compared with an	Evidence of a short term effect on behavioral or clinical outcomes. Text messaging useful in disease prevention and management interventions for weight loss, smoking cessation, and diabetes Effective for adolescents and adults, minority and nonminority populations, and across nationalities.

							12 months and greater decrease in Hb A1c levels in adolescents and obese and non obese adult diabetics. Inconclusive results for peak expiratory levels in asthmatic adults	Internet-based monitoring system	
Pare 2010	62 studies: 46 RCTs (3/4).	Canada	Health status, quality of life, utilization, satisfaction.	Asthma (8), CHF (17), diabetes (24), hypertension (13). Age-not reported.	Telemonitoring	24 studies suggested a trend towards better glycemic control in diabetes. 5/6 RCTs on asthma showed significant improvement in PEF, a significant reduction in the symptoms and a large improvement in perceived quality of life. Home telemonitoring better at improving health state in hypertension than other approaches. (significant drop in blood pressure in the first 3 months of remote monitoring.)		Unclear whether the use of technology either promotes the resolution of symptoms, empowers the patient to self-manage their condition, or both.	Positive effects reported for diabetes, asthma, and hypertension (associated with telemonitoring allowing for more frequent follow-up of patients). Failed to show a reduction in either mortality or hospitalization rates for HF, although some trend towards shorter hospital stays. Better glycemic control and improved asthma and BP control. Larger trials needed to confirm the benefits of this technology for these patients.

Box 2 [Supplementary] Search terms used

Telemedicine
Telehealth or Tele-health
Remote consultation
Telenursing or Tele-nursing
Home healthcare or home health care
E-health or EHealth
Telehomecare or tele-home-care or tele home care
Telehealthcare or tele-healthcare or tele health care
Assisted homecare or assisted home care
Search terms referring to methodology
Meta-anal* or metaanal*
Methodolog* review or methodology overview
Quantitativ* review or quantitative* overview
Meta-review or meta-overview or meta review
Systematic review or systematic overview