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RAPID EVIDENCE SCAN

The effectiveness of Virtual Hospital models of care

A Rapid Evidence Scan brokered by the Sax Institute for Sydney Local Health District.
January 2020.

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It is not necessarily a comprehensive review of all literature relating to the topic area. It was current at the time of production (but not necessarily at the time of publication). It is reproduced for general information and third parties rely upon it at their own risk.

Acronyms and abbreviations

AR	Absolute risk
CAD	Coronary artery disease
CHF	Chronic heart failure
COPD	Chronic obstructive pulmonary disease
CR	Cardiac rehabilitation
DBD	Diastolic blood pressure
HCAD	Home care activity desk
HF	Heart failure
HR	Hazard ratio
LHD	Local Health District
LMIC	Low- and middle-income countries
LOS	Length of stay
MA	Meta-analysis
PDA	Personal digital assistant
PEDro	Physiotherapy Evidence Database
NSW	New South Wales
QoL	Quality of life
RR	Relative risk
SBP	Systolic blood pressure
SLHD	Sydney Local Health District
SR	Systematic review
STS	Structured telephone support
TSC	Telephone supported care

Contents

Executive summary

Background

There is international recognition of the need to reduce hospitalisations, readmissions and length of stay which are common and costly.[1-6] Virtual hospitals provide hospital-level care in the community with a view to relieving pressure on already overburdened health care systems and to achieving equivalent or better clinical and health system outcomes. The populations targeted by virtual hospital models are those whose conditions are most likely to increase demand on limited bed capacity and on the workforce. These include for example, patients who are frail, elderly and/or who have one or more chronic conditions, such as coronary heart disease, stroke, diabetes, chronic obstructive pulmonary disease (COPD) and mental health, among others. However, there is limited rigorous evaluation of the effectiveness of the virtual hospital models of care.

Because they aim to provide the same level of care as would be provided in hospital settings, virtual hospital models of care will include some of the following activities: identifying patients who are at high risk of hospitalisation, readmission or longer stays; assessing their health-related risks and needs; transitioning to the virtual hospital following discharge; developing individualised care plans; engaging the patient and family on treatment and care at home; coordinating care and facilitating communication including out of hours; providing direct treatment and rehabilitation using integrated multidisciplinary approaches; ensuring care is accessible; monitoring patients' progress and reviewing readiness for discharge based on reduced predictive risk. The workforce required to deliver virtual hospital care will vary according to the needs of local high-risk patients and the conditions addressed.[5]

At the local level, the population served by Sydney Local Health District is growing rapidly. The ageing population and increasing incidence of chronic conditions mean that demand for health care is increasing more than ever before. Despite recent capital investment in Concord and Royal Prince Alfred (RPA) Hospitals, capacity remains constrained. New models are needed that can deliver health care that is patient centred, effective and efficient and not reliant on infrastructure such as physical space or hospital beds.

Sydney Local Health District has begun planning for a new model of care, the RPA Virtual Hospital, (**rpa**virtual), with a view to delivering more care in the home, keeping people healthy, avoiding unnecessary hospital visits and reducing length of stay. **rpa**virtual will provide in-home nursing care to over 1,000 patients at any one time and harness new technology to connect with patients and deliver care using video, telephone, SMS and through suitable applications. To inform this service model, Sydney LHD commissioned a Rapid Evidence Scan about the effectiveness of virtual hospital models.

This review was guided by the following question:

What is known about the effectiveness of virtual hospital models of care?

Methods

To answer the review question, rapid but systematic searches were conducted of the peer reviewed literature. Cochrane, health.evidence.com and PubMed databases were searched in December 2019 using combinations of terms aligned to the key concepts. Papers published between 2014 – 2019 were included in this Rapid Evidence Scan.

Findings

We identified 16 reviews and 4 single studies that met the inclusion criteria for the review. No review evaluated a (complete) virtual hospital model of care. We therefore focused on the components of the model identified in the included reviews and single studies. These examined the provision of direct treatment or care including active treatment, rehabilitation or education ('tele-healthcare') or on the transmission of data from the home to a provider ('remote telemonitoring') or on models which delivered both. Tele-healthcare and remote telemonitoring were delivered using a range of modalities such as telephone, videoconferencing, wearable devices, e-programs, store and forward and computer based and robotic technologies and were delivered with or without face to face care. Reviews that assessed the effectiveness of these modalities are reported separately below.

Of the reviews and single studies included in this Evidence Scan, four reported on tele-healthcare only and 14 reported on both tele-healthcare and remote telemonitoring. Of these, two studies focused in particular on Aboriginal and Indigenous communities in Australia and elsewhere. Another two studies compared the use of different modalities alone or in combination, and one study conducted a sub-analysis comparing telephone-based to web-based technologies.

The majority of the studies examined cardiovascular disease, diabetes, cancer, stoke, respiratory and mental health conditions. Other conditions included speech function, eye disease, ear nose and throat or skin conditions, neurological, and nephrological or urological conditions.

Tele-healthcare

Three reviews and one single study examined tele-healthcare interventions.[7-10] Together these studies examined mostly clinical outcomes and had equal or better results than those of usual care for activities of daily living and motor function following stroke, active treatment for stroke and kidney disease, cancer survivors' symptom management and quality of life, and for rates of some complications for patients receiving enteral nutrition therapy.

Tele-healthcare and remote telemonitoring

Fourteen studies examined both tele-healthcare and remote telemonitoring interventions. A mixture of health system and clinical outcomes were assessed.

System outcomes included rates of hospitalisation and emergency department visits, readmissions, and length of stay. Six studies assessed the effectiveness of heart failure related hospitalisations. Of these, four resulted in decreased hospitalisations;[11-14], one found no difference in hospitalisations[15]; and in one study the intervention resulted in decreased all-cause hospitalisations.[12] Six studies measured the impact of tele-healthcare or remote telemonitoring on readmission rates. One found reductions in heart failure readmission rates[11], one found no significant difference in readmissions for COPD exacerbations[16], and in one study the findings varied.[17] Two studies assessed length of stay, and both reported reductions.[11, 13]

Clinical outcomes included: all-cause mortality and morbidity; symptom management; blood pressure; heart rate; weight; blood glucose; BMI; cholesterol; or HbA1c. The reviews found significant improvements in or found no difference in heart related and/or all-cause mortality (5 studies), quality of life (5 studies), hypoglycaemia (2 studies) HbA1c (2 studies), BMI (2 studies), blood lipids, blood pressure (3 studies), mental health (1 study). The teletransmission of health-related data appeared to have a significant impact on all-cause and heart failure related mortality.

Studies comparing tele-modalities

Two studies reviewed the effectiveness different technologies ('modalities') on clinical outcomes. The first compared five technologies: automated device-based telemonitoring, mobile telemonitoring, interactive voice response technologies, video-consultation and web-based monitoring.[14] It found that automated device-based telemonitoring and mobile technology were found to be effective in reducing the risk of all-cause mortality and heart failure related hospitalisations. The second[12] compared three forms of telemedicine for individuals with heart failure: structured telephone support; telemonitoring; structured telephone support combined with telemonitoring; video monitoring and electrocardiographic monitoring with usual treatment and with each other. The results showed that telemonitoring was the first ranked treatment, for both clinical and health system outcomes.

Studies conducted using remote modalities only

Of the 20 publications, eleven reviews[1, 8, 9, 11, 12, 16, 18-22] and 2 single studies[23, 24] report on the delivery of treatment and care delivered remotely i.e. using only telephone, videoconference or video-consultation, or telemonitoring). Of these, all demonstrated significant clinical and/or health system outcomes, with the exception of tele-oncology.

Two reviews reported on the delivery of treatment and care in addition to usual care[4, 13]; 3 reviews[7, 14, 25] and 1 single study[15] looked at care delivered remotely with or without usual care; and one single study reported on home visiting with telemonitoring only[10]; all reported similar or significant improvements with the exception of Lunney et al[25] whose results included 2 interventions compared to usual care in which outcomes were similar or significantly improved, and 8 studies where the intervention was delivered in addition to usual care – these studies demonstrated variable results in hospitalisations and in quality of life.

Summary

- We found no reviews in the peer reviewed literature that evaluated the effectiveness of a complete virtual hospital model of care.
- Reviews evaluated tele-healthcare (only) or tele-healthcare with remote telemonitoring interventions. These interventions reduced hospitalisations, readmissions, emergency department visits and length of stay or made no significant difference compared to usual care.
- For clinical outcomes, there was no difference or significant improvement in heart related or all-cause mortality, quality of life, hypoglycaemia, HbA1c, BMI, blood lipids, blood pressure, and mental health.
- Remote telemonitoring (the electronic transmission of health-related data) appears to have a significant impact on all-cause and on heart failure related mortality. This suggests it should be routinely included in all virtual hospital interventions
- Interventions delivered using only remote telehealth care or telemonitoring (without home visits or face-to-face care) all demonstrated similar or significantly better clinical and/or health system outcomes
- The use of the Internet showed mixed but promising results
- **The strongest evidence for tele-healthcare and telemonitoring is for cardiac failure patients and those with coronary artery disease, for people with diabetes and for stroke rehabilitation. There is less evidence available for cancer. The evidence for respiratory conditions such as COPD is inconclusive.** Recommendations made for sub-populations within disease or conditions, this has been noted in the findings for the disease or condition
- Nurses have a central role in home visiting, providing telephone support and education. The role of the centralised 'triage' person was held by a nurse or by administrative team member (generally after hours). All teams were multidisciplinary and reflected the diversity of conditions or diseases reported.
- However, the studies were heterogenous in terms of their populations, sample size, intervention model, outcome measures and modality and the results should be interpreted with caution. As reviews of the

effectiveness of (complete) virtual models of care were not found in the peer reviewed literature, a grey literature search may be warranted.

Introduction

There is international recognition of the need to reduce hospitalisations, readmissions and length of stay which are common and costly.[1-6] Virtual hospitals which provide hospital level care in the community, may potentially relieve pressure on the health care system, however there is little rigorous evidence of the effectiveness of the virtual hospital model of care.

A virtual hospital or virtual ward has been defined as a model of care that uses some of the systems of a hospital care to provide multidisciplinary care for community-dwelling patients.[2] Patients at high risk of admission or readmission are referred to a Virtual Hospital and receive care in the home using combinations of technological interventions and direct care from a multidisciplinary team. This is intended to improve health outcomes, increase access for those living at a distance from a hospital or health centre, improve patient experience and reduce costs to the healthcare system.

Virtual hospitals were first introduced in 2004 in the UK. One of the first studies to describe a virtual hospital was Lewis in Geraint 2006 (see Appendix C, Box 1). More recently, studies have provided more detailed descriptions of the model's components.[2-6, 26] These include:

- Identifying and stratifying patients, including through predictive risk modelling. Patients at high risk of hospitalisation or readmission are identified and short-listed for admission to a Virtual Ward
- Assessing health-related risks and needs, so that the level of intervention is tailored to the patient and the complexity of their health and social care requirements
- Developing individualised care plans. These may be conducted by a nurse, nurse practitioner or physician either prior to discharge or during the first home visit
- Transitioning patients following hospital discharge: Discharge summaries are provided to primary care physicians, community-based physicians with referrals made to home help services if needed
- Engaging the patient and family following hospital discharge. This includes patient education on treatment and the system of care including self-monitoring and the use of technology. Carers may also be taught ways to help the patient and are integral in the care planning process
- Coordinating care and facilitating communication among providers. Multidisciplinary team members meet daily and communicate regularly using electronic health records or other technology
- Providing direct treatment or care, using a combination of telephone, technology, remote monitoring, face-to-face care, or clinic visits
- Integrating additional care. Members of the care team vary as needed and can include: GPs, community nurses, occupational therapists, physiotherapists, mental health staff, practitioners from palliative care, psychological care or social work services, and voluntary sector services
- Making care or services more accessible. There is provision of in-home diagnostic tests, treatments, medications and equipment which are delivered to the patient
- Monitoring patients' progress. There is an extended service beyond office hours provided by team's physicians and nurses including an on-call nurse or clerical assistant to notify the appropriate multidisciplinary team member. This enables the patient to have fast-tracked consultations or services
- Reviewing readiness for discharge. This includes through death, self-discharge, a decision by the Virtual Ward team or a reduced predictive risk score.

Background to this review

Sydney Local Health District has begun planning for a new model of care, the RPA Virtual Hospital, (**rpa**virtual), with a view to delivering more care in the home, keeping people healthy, avoiding unnecessary

hospital visits and reducing length of stay. **rpa**virtual will provide in-home nursing care to over 1,000 patients at any one time and harness new technology to connect with patients and deliver care using video, telephone, SMS and through suitable applications.

In-home nursing care delivered in 'virtual' patient beds supports avoidable hospital presentations including readmissions, early discharge from hospital and complements primary care. Prominent examples of virtual community wards include the District's Sydney District Nursing service, Hospital in The Home, Residential Aged Care Facilities' Outreach Program and the Integrated Care Program Patients with Chronic Conditions. New technology provides an exciting opportunity to consider complementing existing community nursing 'virtual' wards and to extend out-of-hospital care into virtual service delivery. Providing care in the home through timely discharge from hospital care is acknowledged as a best practice model of care. The model supports patients being seen in general practice to support hospital avoidance and assists with patient flow across the District.

The Rapid Evidence Scan will provide evidence on the effectiveness of models of service delivery for virtual health care, where "effectiveness" is defined as equivalent clinical or health system outcomes to those of usual care. The purpose of the Evidence Scan is to inform and extend the early development of **rpa**virtual model of care.

Review question

This review was guided by the following question:

- What is known about the effectiveness of virtual hospital models of care?

Methods

We conducted a systematic search of the peer reviewed literature to inform this Rapid Evidence Scan. Rapid Evidence Scans are conducted in a 4-week timeframe and are limited to an analysis of 20 systematic reviews.

Peer reviewed literature search

For the peer reviewed literature, we searched Cochrane, Health Evidence and PubMed using combinations of search terms aligned to the key concepts in the review question and outlined in Table 1 below. The searches were conducted on 23 and 24 December 2019.

Table 1 Search terms

Field 1	Field 2	Field 3	Field 4
Virtual hospital	Tele*	Video consult*	Remote monitor*
Combine fields with AND	Limit from 2014 to 2019 and English full text only	Include Meta-Analysis, Review, Systematic Reviews, Human	

While the aim of the Rapid Evidence Scan was to identify the strongest evidence of effectiveness of virtual hospitals (i.e. meta-analyses, reviews, systematic reviews), we considered that, where a broader examination of a chronic condition, treatment, or comparator of interest to SLHD was warranted, single studies of randomised trials may also be included.

The searches yielded a total of 409 publications, of which 47 were removed as duplicates. The final set of 362 reviews and single studies were then screened for inclusion using the criteria outlined in Table 2. A PRISMA flow chart of this process is located in Appendix A. After title and abstract screening, 342 papers were excluded, leaving 20 papers for inclusion in the analysis. Data from these papers were extracted into tables, which are provided at Appendix B.

Table 2 Search strategy inclusion criteria

Inclusion	Exclusion
• Chronic condition • Referred to a virtual hospital • Study population is predominantly adults • Community based- or in-home setting	• Full text not available • Conference papers, abstracts, protocols • Studies not in English • Primary focus is carer • Low and middle income countries

Findings

A total of 20 publications met the inclusion criteria for this review. An overview of the included studies is provided in Table 3 (page 16). Comprehensive data tables are provided at Appendix B and summaries of the individual studies are provided at Appendix C.

Of the 20 publications, 7 were systematic reviews[1, 8, 11, 17, 18, 20, 25], 8 were systematic reviews and meta-analyses[7, 9, 12, 13, 16, 19, 21, 22], 1 was a an overview of systematic reviews[11], 3 were randomised controlled trials[15, 23, 24], and one was a randomised prospective study.[10]

The aim of the Rapid Evidence Scan was to select studies with the highest level of evidence - meta-analyses and systematic reviews. However, we included four single studies of randomised trials to amplify our understanding of the effectiveness of virtual hospitals for a chronic condition[15, 23], treatment[10], or comparator[24] of interest.

We found no reviews or single studies that evaluated a complete virtual hospital model. We therefore selected reviews or single studies which examined components of virtual hospital models. Of these, three reviews and one single study focused on tele-healthcare interventions only, 11 reviews and three single studies on tele-healthcare and remote telemonitoring, and 2 reviews focused on the comparative effectiveness of different types of technologies.

These reviews and studies reported on 10 modalities through which the Virtual Hospital interventions were delivered. These were telephone or mobile phone interventions (12 studies), videoconferencing (13 studies), remote telemonitoring (9 studies), smart device or tablets (4 studies), the Internet (8 studies), 'store and forward' (3 studies), email (5 studies), e-programs accessed at home (3 programs), messaging devices (4 studies) or (HCAD) (1 study).

The interventions targeted patients at high risk of hospitalisation or readmission. The most common conditions addressed were cardiovascular disease (7 reviews) and diabetes (5 reviews and 1 single study), followed by cancer (5 reviews), stroke (4 reviews) and respiratory conditions (2 reviews and 2 single studies), mental health conditions (3 reviews), or ear nose and throat conditions (3 reviews), gastro-intestinal conditions (1 review and 1 single study) and chronic disease (not further specified) (2 reviews). Neurological nephrological or urological conditions, eye disease, speech dysfunction, and skin conditions were each examined in 1 review or single study as were patients receiving palliative care or pre-anaesthesia consultations.

Evidence for specific conditions

The conditions for which there is best evidence is for cardiovascular disease, especially heart failure; diabetes; stroke rehabilitation; and cancer. The findings for chronic respiratory disease (COPD) were inconclusive.

- **Coronary artery disease and heart failure**: Seven reviews found that telemonitoring has beneficial effects for coronary artery disease related or heart failure related conditions for both clinical and health system outcomes compared to usual care (face-to-face or telephone).[11-14, 16-18] There were significant reductions in all-cause mortality, heart failure related hospitalisation, all-cause hospitalisation, and length of stay, as well as quality of life. It can be concluded that telemonitoring should form an integral part of the routine deliver of care for patient with heart failure.

For particular populations, one review found that improvements in heart failure-related hospitalizations from telemonitoring appeared to be more pronounced in patients with stable heart failure.[14] Risk reductions in mortality and all-cause hospitalizations appeared to be greater in patients who had been recently discharged (≤28 days) from an acute care setting after a recent heart failure exacerbation. One review stated that effectiveness may depend on the severity of the condition and disease trajectory of the participants, on the function of the intervention, and the provider and system involved. A third noted that telehealth delivered cardiac rehabilitation did not have significantly inferior outcomes compared to centre-based care for low to moderate risk CAD patients.

- **Diabetes**: Five reviews and one single study[1, 17-19, 22, 24] demonstrated significant impact on patients with type 1 and type 2 diabetes either to replace standard care[24] or as an add on to standard care.[19] Telemedicine was found to improve HbA1c[17, 19] and reduce the risk of moderate hypoglycaemia in diabetic patients[19, 22], reduced cholesterol[17] and blood pressure.[17, 22] Quality of life was similar or superior to usual care.[17, 22] No significant differences were observed for BMI. One review stated that targeting patients with higher HbA1c (≥9%) levels and delivering more frequent intervention (at least 6 times 1 year) may achieve greater improvement.
- **Stroke** treatment and rehabilitation: Four reviews reported on stroke treatment or rehabilitation.[7, 8, 20, 21] For stroke telerehabilitation, three studies found that tele-rehabilitation interventions have either better or equal salutary effects on motor function, higher cortical function and mood disorders and improved activities of daily living, compared with conventional face-to-face therapy.[7, 20, 21] For active therapy, one study[8] found favourable outcomes when comparing face-to-face and videoconferencing-assisted thrombolysis, with no significant differences between survival and intracerebral bleeds. The authors noted that the lack of CT scanning equipment in rural locations may limit the widespread introduction of 'telestroke' in rural areas.
- **Cancer treatment and care**: Five reviews reported on cancer treatment or care (symptom management).[1, 8, 9, 17, 18] In cancer treatment, one author noted that, although tele-oncology has been used routinely for more than 20 years in cancer treatment, there have been few formal studies conducted of its effectiveness.[8] Flodgren et al reported on symptom management and found no significant difference between those using automated symptom alert system and usual care.
- **COPD**: Two reviews and two single studies reported on chronic obstructive pulmonary disorder (COPD).[15, 17, 18, 23] Flodgren et al[17] found no significant difference in quality of life, self management (dyspnoea scores), or mortality using telemonitoring and tele-healthcare, although two studies in the Flodgren systematic review reported fewer emergency department visits and hospitalisation compared to usual care. For patients with stable, severe, and very severe COPD, there was no difference in mortality or hospital admissions although in one single study telemonitoring (including video-consultation) resulted in more moderate exacerbations.[15] One single study reported inconclusive results[23] but noted that patients with severe COPD could be treated for acute exacerbation at home using telehealth, with a proper organizational ''back-up.''

Evidence for the use of tele-modalities

The strongest evidence appears to be for telemonitoring, videoconferencing or consultation and for structured telephone support.

- **Telemonitoring:** Thirteen reviews [1, 7, 11-14, 16-21, 25] and two single studies[15, 24] included telemonitoring as a modality. Telemonitoring has equal or beneficial effects for coronary artery disease related or heart failure related conditions for both clinical and health system outcomes compared to face-to-face or telephone delivery of care. These include all-cause mortality, heart failure related hospitalisation, all-

cause hospitalisation, and length of stay as well as quality of life. It can be concluded that telemonitoring should form an integral part of the routine deliver of care for patients with heart failure.

Kotb et al[12] demonstrated that structured telephone support and telemonitoring interventions may be of significant benefit for rehabilitating heart failure patients. Kitsiou found that only automated device-based telemonitoring and mobile telemonitoring were effective in reducing the risk of all-cause mortality and heart failure-related hospitalizations.[14]

- **Structured telephone support**, usually conducted by a nurse, may significantly reduce HF-related hospital admission rate (xx) and Kotb demonstrated that structured telephone support and telemonitoring interventions and may be of significant benefit for rehabilitating heart failure patients.
- **Video conferencing and consultation**: Eight reviews and 4 single studies reported on the use of videoconferencing or video consultations, usually delivered with telemonitoring, which was found to be an effective way to increase access to screening and care, conduct medical consultations, supervise treatment and rehabilitation,[11] and was acceptable to Aboriginal patients.[18] Conditions for which it was effective included including for mental health and substance abuse.[17] Jhaveri et al[8] found no significant difference in delivering thrombolysis and home dialysis compared to usual care. Orlandoni et al[10] found that video consultation is associated with a reduction of metabolic complications. Rasmussen et al[24] noted that telemonitoring (including video consultation) may be an alternative to visits to outpatient clinics. Larson et al reported significant increases in quality of life using videoconferencing.[9] Chen et al reported no significant difference in abilities for daily living; Lin and Tchero also reported benefits.[13, 21]
- **Internet:** Nine reviews[7, 9, 16-19, 21, 22, 25] and two single studies[10, 24] reported the use of the Internet as an integral part of the tele-healthcare or tele-monitoring interventions. The Internet was used for education[7], self-management[9, 10, 17], telemonitoring,[17-19], rehabilitation[17, 18, 21], and web-based chats.[21] Overall, the need for the Internet was not conceived as a barrier, with use widespread including in older populations.

  In terms of its effectiveness, 8 reviews[7, 9, 16-19, 21, 22] and 1 single study[10] had mixed but promising results.

  One Web-based program for depression had no significant effect for patients (although it did for carers).[7] Another counselling program reported a positive experience for survivors of breast cancer, but no significantly better outcomes were demonstrated compared to the control group.[9] The same review identified a web-based program which significantly increased social function and decreased depression, but had no significant change in quality of life compared to the control group.

  Internet based monitoring blood results for diabetes had mixed results, with 10 studies included in the reviews demonstrating internet based monitoring was more effective than control groups[18, 22]; 3 studies reporting similar results[17, 19, 22]; and 4 individual studies demonstrated greater improvements in the control groups.[16, 17, 22] For BMI, four studies using the Internet favoured the telehealth group and two favoured the control group.

  For systolic blood pressure, 6 individual studies showed greater reductions in the intervention group, 1 study showed greater reductions in the control group and 1 study favoured usual care.[22] For Diastolic blood pressure, 7 studies showed the internet option to be more effective and one study favoured usual care.

  For enteral nutrition some outcomes were significantly lower for patients who engaged in videoconferencing, but it was unclear whether this related to the use of an internet database.[10]

  For telerehabilitation using the internet, one review found quality of life scores improved significantly more than the control group[9] and one[21] was unable to identify the optimal intervention.

Evidence about cost and cost-effectiveness

Few reviews reported actual costs to patients or the health system and no studies analysed the cost-effectiveness of tele-healthcare or telemonitoring. Two studies reported that costs for the participants were lower (e.g. $654 less costly rehabilitation), some mentioned reduced travel costs. Health system costs were reported to be lower than usual care in two reviews, one reported 40% savings, one report mixed results (costs were in some cases higher and in others lower) and 1 review reported a cost reduction of $867 per participant. No studies reported the costs of training staff to deliver care or the cost of equipment delivered to the home. Overall, costs appear to be lower to deliver equal or better clinical and/or system outcomes.[1, 7, 14, 17, 23]

Fourteen studies mentioned equipment provided to the home, although not all studies stated that the cost was borne by the health system. Home equipment included activity desks[7, 20], H-CAD[17], smartphones[19], ECG-devices, wireless weight scales and blood pressure or blood glucose monitors[12-16, 22-24], home telemonitoring systems using telephones, dialysis equipment[25], and home enteral nutrition equipment.[10] One study recommended that the patient's own technical equipment should be used, i.e. personal computer, tablet or smartphone; all of which would reduce the cost substantially.[24]

Workforce to deliver virtual hospital interventions

The workforce required to deliver virtual hospital care was rarely detailed. Most interventions were delivered by a home visiting nurse or telephone support nurse, with general practitioners, hospital physicians, allied health practitioners and specialist workers or physicians. Other reviews provided only general indications such as 'health care team' or 'clinicians'. Peer workers and Aboriginal health workers or Aboriginal medical staff were nominated as important; in Australia health services were delivered in partnership with ACCHS. A variety of health professionals may be required to deliver virtual hospital care; however the most frequently reported health care worker mentioned was the home visiting nurse.

Table 3 Summary overview of included papers

First author, Year	Study design	Setting	Tele-modality									Condition or disease											
			Telephone/ Mobile phone	Videoconferencing	Remote telemonitoring	Store and forward[1]	Internet / web-based	Smart device/table	Email	E program at home[2]	Messaging device	Home equipment	Cardiovascular disease	Diabetes	Cancer	Stroke	Respiratory (COPD)	Mental health condition	Ear, nose, throat	Gastro-intestinal	Chronic disease (NFD)	Neurological	Nephrological/Urological	Other
Tele-healthcare																								
Chen 2015	SR MA	Home	x	X	x		X			x	x	x				x								
Jhaveri 2015	SR	Home, remote	x	X											x	x								
Larson L 2019	SR MA	Home	x	X			X		x						x									
Orlandoni 2015	RPS*	Home		X			X													x				
Tele-healthcare plus remote telemonitoring																								
Bashi 2017	SR	Home	x	X	x								x											
Caffrey 2017	SR	Regional, remote		X	x	x								x	x			x	x		x			x
Flodgren 2015	SR	Various	x	X	x	x	X	x	x		x	x	x	x	x		x	x	x	x		x		x
Fraser 2017	SR	Various		X	X		X	x	x		x		x	x	x		x	x	x		x			x

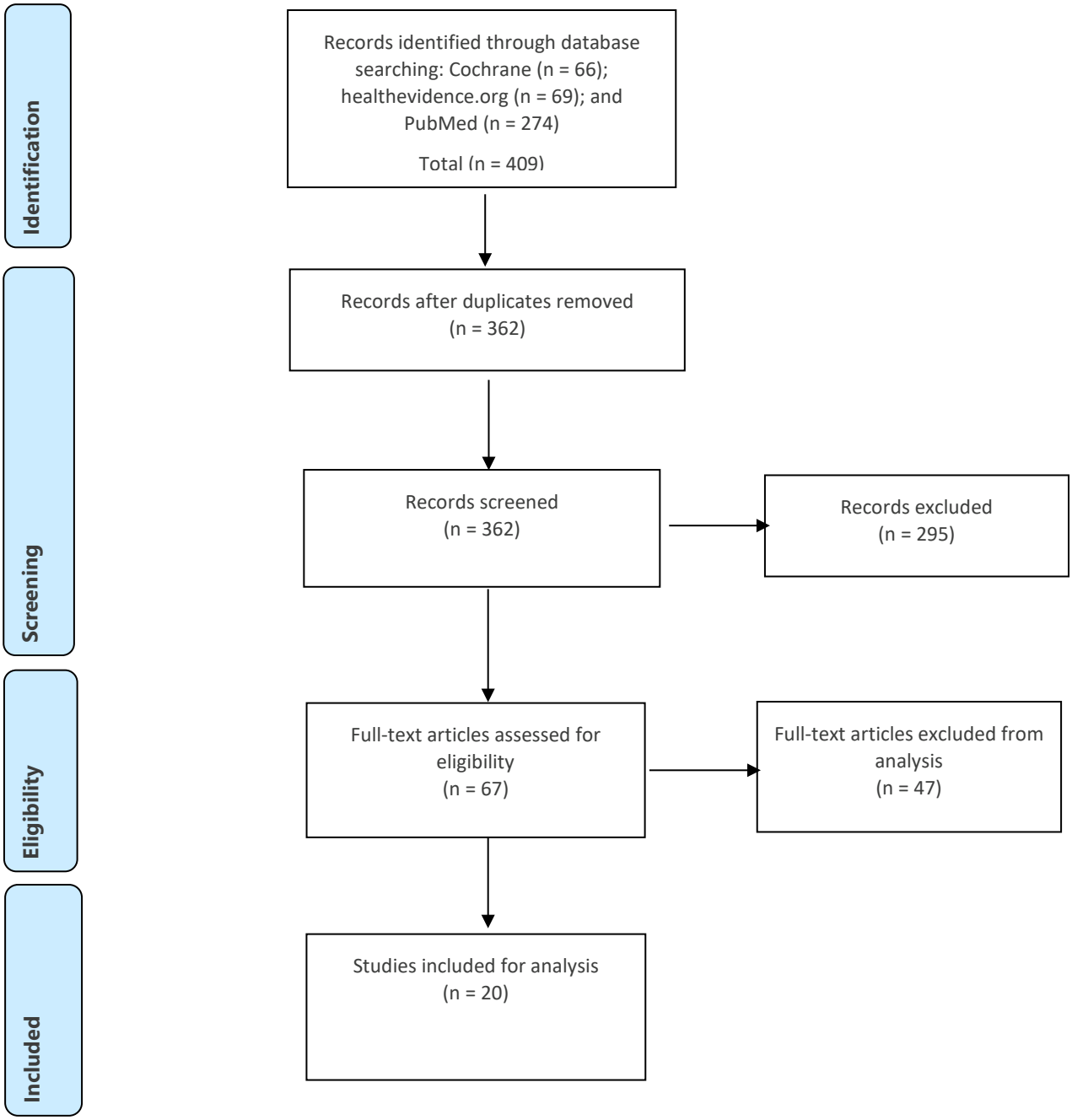
Hu 2019	SR MA	Home	x	X	X	x	X	x	x			x		x										
Huang 2014	SR MA	Community and home	x		X		X		x	x			x											
Jakobsen 2015	RCT	Home		X													x							
Lin 2017	SR MA	Home	x	x	X							x	x											
Lunney 2018	SR	Home and satellite clinic	x	x	X																		x	
Rasmussen 2016	RCT	Home		x			X							x										
Ringbæk 2015	RCT	Home and clinic		x	X			x									x							
Sarfo 2018	SR	Home and clinic	x	x	X			x		x	x	x				x								
Tchero 2018	SR MA virtual reality system, web based chats	Home	x	x	X		X									x								
Wu C 2018	SR MA	Home	x				X							x										
Tele-modalities																								
Kitsiou 2015	SR Overview	Home	x	x	x							x	x											
Kotb 2015	SR MA	Home	x	x	x								x											

*Store and forward: where information is sent electronically from the patient to a holding site and later transferred to the provider

**RPS: Randomised prospective study

Appendices

A. PRISMA diagram



B. Table of included studies

Author, year	Study design Method	Virtual hospital model name	VH components tested	Setting	Condition	Population	Intervention / comparator	Primary outcome measures)	Secondary outcome measures	Workforce	System outcomes	Clinical outcomes	Limitations
Bashi et al. 2017	Review of SRs. 19 SRs on the use of remote patient monitoring (RPM) inter-ventions.	N/A	**Tele-monitoring**: Home telehealth, mobile phone-based monitoring and other PDAs, and video conferencing. .	Home-based.	Heart failure.	Patients with heart failure.	Variety of interventions including tele-monitoring; home telehealth; mobile phone-based monitoring; and video conferencing.	All-cause mortality and heart failure mortality.	Quality of life, rehospital-isation, emergency department visits, length of stay, self-care and knowledge.	Not stated.	Rehospital-isation, emergency department visits, length of stay was less frequently reported.	All-cause mortality, and heart failure mortality were most frequently reported.	English language only. Possible double counting of studies included in more than one SR.

Caffrey et al. 2017	SR 14 articles describing 11 services. Sample size ranged from 1 (case study) to 5,539 (4 had n < 20).	N/A	**Telehealth**: one or more of: video consultation (8 studies), store-and-forward of patient data (6 studies), or remote monitoring (2 studies).	Home based rural, remote and very remote.	A number of chronic conditions e.g. mental health, diabetic retino-pathy, palliative care, chronic diseases, cancer, speech therapy, ear health, ENT screening.	Aboriginal and Torres Strait Islander people.	Mostly no comparisons.	Numbers accessing services; number of travelling distances; transfers out of area.	Various	Nurse, general practitioner, Aboriginal health worker, psychiatrist, speech therapist, other allied health, oncologists, ENT surgeons.	Increased numbers accessing services, decreased travel and transfers out of area, increased children screened, increased. referrals, decreased time to review.	Estimated cost saving of 40%.	Poor quality study design (4 pre post), small sample sizes, possible publication bias (no negative results reported).

Chen et al. 2015	SR & MA. 11 RCTs with 1025 subjects. Data pooled from 7 studies to allow meta-analyses on 3 out-comes of interest.	N/A	**Tele-rehabilitation** telephone, instruction of exercises via in-home message device, physical training by desktop videophone, Virtual therapy program via video-conferencing, therapy via DVD, multi-formats via internet, HCAD.	Home-based	Stroke	Stroke survivors living at home.	Tele-rehabilitation.	Disability or activities of daily living.	Motor function, cognitive function, health-related quality of life, satisfaction, cost-effectiveness, and adverse events.	Not stated	Cost-effectiveness was only preliminary discussed.	No significant difference in abilities or activities of daily living and motor function between groups.	Small no. of studies, and small sample size in some individual studies.

Flodgren et al. 2016	SR. Peer reviewed, grey literature, and trial sites such as Clinical-Trials, US National Institutes of Health. Included 93 eligible RCTs; sample size 22,047.	N/A	**Remote monitoring** of chronic condition; and/or education and consultation using video-conferencing.	Primary, secondary tertiary and comm-unity care settings	Any clinical condition e.g. cardio-vascular disease, diabetes, respiratory conditions, mental health or substance abuse conditions, specialist consult-ation, co-morbidities, urogenital, neurological, gastro-intestinal conditions, neonatal specialist care, organ transplantation, and cancer.	Patients with any clinical condition	Tele-medicine provided remote monitoring (55 studies), or video-conferencing (38 studies), used either alone or in combination.	Mortality; disease-specific and general health status using validated measures for treatment quality of life; healthcare resource use; and costs. Ad-missions.	Patient and healthcare professional acceptability and satisfaction measured with a validated scale.	Various: primary care physicians; nurses; specialists; 'clinicians'.	Admissions to hospital showed a range from a decrease of 64% to increase of 60% at median eight months follow-up.	Improved quality of life compared with usual care at a median three months follow-up.	

Fraser et al. 2017	SR. 32 articles examined: health outcomes; accept-ability for clients and 'health pro-fessionals'; and feasibility of telehealth for health services.	N/A	**Telehealth** using real time video-conferencing, internet based applications and portals, and asynchronous technologies. Also used tele-medicine, teleophthalm-ology, computerised therapy, web-based therapy, and tele-mental health. Video-conferencing used in all but one study.	Home based	Chronic conditions included cancer, congestive heart failure, COPD, type II diabetes, mental health, otitis media, heart failure, diabetic retinopathy and injury.	Indigenous people of any age from Australia, North America, New Zealand and the Pacific Islands.	Matched cohort.	Morbidity, hospitalis-ation rates and length of stay; quality of life (transfers prescript-ion drug use and specialist review wait times).	Acceptability for patients assessed by cultural acceptability and for health professionals in terms of productivity and service delivery. Health service impact, such as diagnostic capabilities.	N/A	Improved client involve-ment with health services. Improved productivity and healthcare competence . Diagnostic reliability using asynchron-ous images (ENT) cancer and screening. Video-conference-ing for mental health diagnosis acceptable.	Improved morbidity, QOL and reduced mortality. Increased the percent-age of people who obtained diabetic retino-pathy screening examina-tions.	Hetero-geneity limits generalis-ability. Study types varied including RCTS, pre/post, and prospective. Small sample size, short surveillance periods, retro-spective data, lack of controls, lack of randomis-ation, potential screener bias, and delayed comparison interval.

Hu et al. 2019	SR & MA. 14 quantitative studies in the SR (n=1,324), and 10 in the meta-analysis Duration 3, 6 or 9 months.	N/A	**Tele-medicine** remote exchange of medical information and/or services. Use computer software, internet-based monitoring system, and smart devices. Devices used included telephone, email, fax, SMS, computer-ised systems for informat-ion exchange, Internet, and other mobile devices.	Not stated for most studies, but home implied.	Diabetes: Type I Type II or both.	People aged 18 or over with diabetes: Type I, Type II, or both. Mean ages ranged from ~25 to ~68. Percentage of males ranged from 41% to 80%.	Intervention: Health data uploaded using a variety of means, with intervals varying from 3+ times per day to once per month. Clinician contact was on a regular schedule in some; in others, contact was in response to adverse data. Comparator: "usual care".	Rates of hypo-glycaemia (types 2–5) and levels of HbA1c.	BMI.	Physicians diabetes teams; clinical decision support systems.	N/A	Significant reduction in hypo-glycaemic episodes; significant improve-ment in HbA1c. No significant change in BMI.	Outcome assessment not blinded. Hetero-geneity addressed with subgroup analyses. Longer follow-up times desirable. English-language only. Subgroup comparison s showed higher impact for Type I diabetes. Comparing at 3 and 6 months, results at 3 months not significant; possibly due to time to learn how to use equipment.

Huang K et al. 2014	SR & MA. 15 studies of reporting 9 trials. 781 participants in the telehealth intervention group and 765 in the centre-based group, range 30 to 525.	N/A	**Telehealth** intervention delivered CR using telephone (7 trials); computerized participant management system with telephone and the Internet (1 trial); Recording-transmitting electrocardiography (ECG)-device by telephone and email (1 trial).	Community- or home-based program.	Coronary artery disease (CAD)	Patients with coronary artery disease, myocardial infarction or myocardial infarction and revascular-isation. Three trials enrolled patients with only low or moderate risk of CAD. 79.69% of participants were male. Average age 60.9 years.	Telehealth interventions versus centre-based cardiac rehabilitation. Telehealth intervention was a structured community- or home-based exercise program delivered by telephone, computer, internet or videoconferen-cing. Centre based care: supervised program in a hospital or rehabilitation centre with structured exercise training as a core component.	All-cause mortality and other cardio-vascular events; modifi-able risk factors (blood lipids, total cholest-erol, HDL and LDL and TG, blood pressure, smoking, weight). Additional measures: exercise capacity, heart rate, QoL, psycho-social and cost. Short term follow up 3 to 24 months. Long term 1 to 6 years.	N/A	Nurses; physiothera pists; a specialist); a facilitator; exercise physiolo-gist; not stated.	N/A	No significant difference between in exercise capacity, weight, systolic/ diastolic blood pressure, lipid profile, smoking, mortality, quality of life and psycho-social state.	Varied quality of trials and telehealth intervention models, contact with patients, CR character-istics (duration, frequency, length, intensity) and outcomes measured.

Jakobsen et al. 2015	RCT. Quantitative n= 57 across two study centres. Non-participation rates were high (51%). Data collected at baseline, during the intervention and 30, 90 and 180 days after discharge.	N/A	**Telehealth:** Remote monitoring and self-measurement with a range of devices; video conferencing on virtual ward rounds and on demand by the patient.	Home based.	Severe or very severe COPD.	Patients aged 45 and over, with severe or very severe COPD and exacerbation, and expected hospitalisation over 2 days.	Home based vs hospital care.	Treatment failure: re-admission due to exacerbation in COPD within 30 days after initial discharge, length of stay.	Mortality, need for manual or mechanical ventilation or non-invasive ventilation; physiological parameters, HR QoL, user satisfaction, healthcare costs, and adverse events.	Nurses	Length of hospitalisation not significant	However, patient satisfaction and ease of use survey results were positive.	

Jhaveri et a. 2015	SR 14 studies: 9 on tele stroke, 3 on tele dialysis, 2 on tele oncology.	N/A	**Telemedicine** real time video conferencing; using video conferencing or telephone; a single study used tele-haemodialysis	Remote sites including stroke centres, remote hospitals, community hospitals, regional clinics, home settings.	Stroke, cancer and nephrology.	Patients receiving active treatment for stroke, cancer or kidney/ renal disease	Telemedicine supervised active treatment for rural patients with stroke, cancer or nephrology versus usual care (face-to-face treatment.	Delivery of treatment to rural, remote or regional patients for chemo-therapy, thrombo-lytic infusions or dialysis.	Patient satisfaction with treatment.	Nurse, specialists.	**Tele-stroke:** Delivery of tPA was longer via VC but it faster if inter-hospital transfer were required. **Tele-dialysis** With direction, dialysis can be administered from centralised renal centres. **Tele-oncology:** No inter-hospital transfers after tele-oncology. One found 96% of patients felt they received adequate care.	**Tele-stroke:** Similar to control group**.** No significant difference in adverse outcomes (intra-cranial bleeding) **Tele-dialysis:** Not enough studies to draw a conclusion **Tele-oncology:** Limited studies to draw a conclusi-on.	Limitation in delivery of tele-stroke widely is that availability of CT scanning (rural towns lack access to this.) Number of studies on tele-oncology and tele-dialysis were limited, more research required. Quality of studies was poor due to lack of RCTs and small participant numbers.

Kitsiou et al, 2015	SR & MA. 15 SRs.	N/A	**Tele-monitoring** video-consultation, with or without transmission of vital signs; mobile tele-monitoring, automated device-based tele-monitoring; interactive voice response; and web-based tele-monitoring.	Home based.	Chronic heart failure.	Adult patients with chronic heart failure. The mean age range was 48 to 85.	All-cause mortality and heart failure-related hospitalis-ations compared with usual care.	Heart failure related hospitalisations and all-cause mortality.	Health care costs, quality of life, and length of stay in hospital.	Mainly nurses.	Reduced RR of HF - related hospitalis-ations (0.64 to 0.86). AR reductions ranged from 3.7%-8.2%. Improve-ments more pronounced in patients with stable HF: (HR) 0.70 (95% credible interval [CrI] 0.34-1.5]). Risk reductions in all-cause hospitalisat-ions greater in patients recently discharged (≤28 days) from acute care after a recent HF exacerbatio n: HR 0.67 (95% CrI 0.42-0.97).	Reduced RR of all-cause mortality (0.60 to 0.85) compared with usual care. Absolute risk reductions ranged from 1.4%-6.5%. Risk reductions in mortality greater in patients recently discharged (≤28 days) from an acute care setting after a recent HF ex-acerbation: HR 0.62 (95% CrI 0.42-0.89).	

Kotb et al. 2015	SR & MA. 30 RCTs included; pooled *n* = 10,193. Mean age > 65. Male > 50%. 27 studies collected data for at least 6 months; 19 studies collected data for more than 6 months.	N/A	Tele-medicine: Structured telephone support (STS), tele-monitoring, STS and tele-monitoring combined, video monitoring, and electro-cardiographic, monitoring.	Home based.	Chronic heart failure.	Adults with chronic heart failure.	Intervention: Telemedicine (5 different kinds). Comparator: Usual care, but also comparisons between different forms of virtual hospitalis-ation.	All-cause mortality (recorded in 29 studies).	Hospitalisation: due to heart failure (recorded in 16 studies), and due to all causes (20 studies).	Mainly nurses.	No significant results from the network meta-analysis for all-cause hospitalisation.	Some evidence for a decrease in LDL (four studies, N = 1692; MD -12.45, 95% CI -14.23 to -10.68; P < 0.00001; I2 = 0%) and blood pressure (four studies, N = 1770: MD: SBP:-4.33, 95% CI -5.30 to -3.35, P < 0.00001; I2 = 17%; DBP: -2.75 95% CI -3.28 to -2.22, P < 0.00001; I2 = 45% in TM as compared with usual care.	

Larson L et al. 2019	SR & MA 11 studies. Total n= 1349, 709 in the control group and 640 in the intervention group. Of 11 studies 6 involved breast cancer, 1 colorectal, 1 cervical, 1 oesophag-eal and 2 multiple forms of cancers.	N/A	**Telehealth:** telephone, email, video conferencing, web-based self-management program and an Internet-based tele rehab intervention.	Home setting.	Cancer	Cancer survivors including breast, oesopha-geal, colorectal, and cervical cancer, and some with multiple forms of cancer. Average age range was form 46 - 66 years old, 75% female participants .	Telehealth intervention supporting survivors of cancer managing physical and emotional symptoms versus in person usual care.	Quality of life (QOL).	Social functioning, depression and fatigue.	Nurses, research assistants, psychologists, research staff, professionals with a health promotion background.	N/A	In 8 of the 11 studies there were no significant improvements in QOL scores compared to the control group however the meta-analysis found the telehealth showed statistically significant improvements on QOL for cancer survivors compared with usual care (Δ =0.141-0.144, p< 0.05).	Quality of the study method is moderate to high in line with the PEDro scale.

Lin et al. 2017	SR & MA. 39 RCTs. Follow-up ranged from 3 months to 1 year for the tele transmission studies and 3 months to 3 years for the TSC studies. Pooled *n* was 11,758; *n* for individual studies ranged from 20 to 1,653.	N/A	Telemedicine: 21 studies used tele-transmission intervention and 21 used telephone supported care (TSC). 3 studies used both.	Home based.	Chronic heart failure (CHF).	Adults diagnosed with chronic heart failure.	Mean ages ranged from 43 to 83; males ranged from 31% to 100%. All but two studies had participants with an impaired left ventricular ejection fraction (LVEF), i.e. LVEF < 50% or < 40%; in those two studies there were a total of 91 participants with preserved LV function.	Intervention: Tele-medicine **plus** usual care, with tele-medicine either teletrans-mission or telephone supported care (TSC). Teletrans-mission: auto-mated upload of cardiac-related data, with interventi on based on that data. TSC: a schedule of phone calls by a nurse. Comparat-or usual care (including scheduled clinic visits).	All-cause and HF-related: mortality, hospital admission rate, and length of stay.	N/A	Tele-medicine personnel were mainly nurses.	All tele-medicine: No reduction in all-cause admissions or LOS. Reduction in HF-related admissions and LOS. TSC: No reduction in all-cause admissions or LOS. Reduction in HF-related admissions but not in LOS Tele trans-mission: No reduction in all-cause admissions or LOS. Reduction in HF-related admissions and LOS.	All telemedicin e: Reduction in all-cause mortality (30 studies) and in HF-related mortality (8 studies). TSC: No improveme nt in clinical outcomes - no reduction in all-cause mortality (17 studies), nor in HF-related mortality (2 studies). Tele transmissio n: Reduction in all-cause mortality (13 studies) and in HF-related mortality (6 studies).

Lunney et al. 2018	SR 11 articles describing 10 studies. *n* ranged from 11 to 135.	N/A	Telehealth: 4 telephone only; 4 electronically transferred data to healthcare workers who acted on it as needed. One stud y used a health information portal and 2 used video-conferencing. There were 6 studies on haemodialysis , 2 on home dialysis, 2 on supported self management of dialysis sessions, 1 on mental health 1 connecting specialists with remote clinics.	Mainly home, but one satellite clinic.	End-stage renal disease (ESRD).	Adults with ESRD receiving dialysis (either haemodialy sis [6 studies] or peritoneal dialysis [4 studies]).	Of the 10 studies, 2 evaluated telehealth **compared** to usual care; and 8 evaluated telehealth **plus** usual care.	The SR included mixed outcome measures. Six studies evaluated clinical outcomes, six evaluated patient-reported experienc e, five evaluated process measures. Specific measures included: QoL; hospitalis-ations; readmissi ons or transfers; and serum measures.	N/A	Health care team, nurses. Others.	Telehealth **compared** to usual care: similar or reduced hospitalisati ons Telehealth **plus** usual care similar or reduced hospitalisati ons One study noted high patient satisfaction with telehealth.	Telehealth **compared** to usual care: mixed results for processes of care [serum and HD sessions]; no differences laboratory surrogate markers; overall, similar or better results. Telehealth **plus** usual care: No significant improve-ments in process of care or surrogate markers. QoL and mental health improved or similar.	

Orlandoni et al. 2015	Random-ised Prospective Study. 100 patients randomly assigned to receive video consultation in addition to regular monthly home visits. 88 patients only received regular home visits.	N/A	**Video Consultation** for the monitoring of home enteral nutrition in frail older patients. The home visiting staff and the physician used a Samsung Galaxy tablet to conduct the video conferencing	Home based setting.	Receiving enteral nutrition (HEN).	Patients 65 years or older receiving home enteral nutrition from the Department of Clinical Nutrition at an Italian geriatric hospital. The participants were 74% women, 26% men and the mean age was 85.5 years.	Telehealth intervention versus usual care. Telehealth intervention included video consultations to specialist physician facilitated by the home care nurse at regular monthly home visits. Usual care only included monthly home visits which included assessments and examinations of the patient completed by the nurse.	Outcomes included incidence rates of complicat-ions, outpatient hospital visits, and hospitalis-ations. Indicators from the Italian National Guidelines for Tele-medicine.	N/A	Trained caregivers, physicians specialised in clinical nutrition and nurses.	No statically significant difference was found regarding outpatient visits (CI)= 0.650-1.303) (P= 0.6244), overall hospitalisati ons (CI)=0.538-1.19) (P= 0.2574, and hospitalisat-ions for complicat-ions of HEN (CI) = 0.263-2.287).	Metabolic/ gastrointes tinal complicatio ns significantly lower for patients receiving video consultatio n (CI)= 0.115 - 0.357) (P= <0.0001), (CI) 0.443-0.764 (P= 0.0001) respective-ly and overall complicatio ns (CI) = 0.563-0.766) P = <0.0001). No statistical difference mechanical or tube complicatio ns (CI) = 0.719-1.091), (P= 0.2432).	This study acknowledg es the lack of clinical and economic benefit of tele-medicine models.

Rasmussen et al. 2016	RCT. 40 patients with type II diabetes mellitus allocated from October 2011-July 2012 randomised to either treatment at home by video conferences only or standard outpatient treatment.	N/A	**Tele-medicine:** Videoconference using videophone; broadband installed and serviced by Danish Telephone Company; and blood pressure monitors.	Home based.	Type II Diabetes.	Patients aged 40-85 with type II diabetes mellitus referred by their GPs for treatment to the outpatient clinic. Patients followed standard screening process, were given treatment plans and received outpatient diabetes education and advice on lifestyle inter-ventions. Patients were then randomised and the interventio n lasted 6 months for all patients.	Treatment at home by videoconferen ce only versus standard outpatient treatment	HbA1c and blood glucose levels.	24 hour blood pressure, cholesterol levels and albuminuria.	General Practitioner. 2 nurses in the tele-medicine group and 3 in standard care group did most consultation s. Doctor sometimes present or asked for advice in both groups.	N/A	All patients achieved planned goals. The two treat ments (changes in % of tele-medicine vs standard) showed significant differences in HbA1c (_15 vs _11%), mean blood glucose (_18 vs _13%) and cholesterol (_7 vs _6%). No differences in LDL (_4 vs _6%), weight (_1 vs 2%), DBP (_1 vs _7%), and SBP (0 vs _1%).	

Ringbæk et al. 2015	RCT. 281 patients: 141 in tele-monitoring group, 140 in usual care control.	N/A	**Telemonitoring**: recording of symptoms, saturation, spirometry, and weekly video consultations.	Home-based.	Chronic obstructive pulmonary disease (COPD).	Patients with severe COPD at high risk of exacerbat-ions.	Tele-monitoring vs usual care.	No. of hospital admission for exacerbation of COPD during the study period.	All-cause hospital admissions, time to first hospital admission, time to first hospital admission caused by exacerbation in COPD, visits to emergency rooms, visits to the outpatient clinic, exacerbations in COPD requiring treatment with systemic steroid and/or antibiotics but not admission to hospital, length of stay, and all-cause mortality.	Nurses, respiratory nurses.	No difference in drop-out rate between groups. No difference in hospital admissions for COPD between groups. Telemonitoring patients had more moderate exacerbations (i.e. some treatment without hospital admission); whereas the control group had more visits to outpatient clinics.	No difference in mortality between groups.	The call centres were only operating Mon-Fri in the daytime. No data on the patients' number of visits to their GP during the study period.

Sarfo et al. 2018	SR & MA. 22 studies (RCTS, pilot or feasibility trials). Sample size in the intervention group 484 (range 5-51) comparators 566 (range 5-143). 16 studies conducted in high-income countries 6 studies conducted in LMIC.	N/A	**Tele-rehabilitation** interventions and assessments by telemedicine, tele-communication media, and intervention programs including phone, video-conferencing, tele-rehabilitation system robot assisted rehabilitation and virtual and augmented reality therapy.	Home- and community-based resource-limited rural settings or LMIC.	Stroke.	Stroke survivors recovering from motor dysfunction, higher cortical dysfunction and post-stroke depression.	Stroke survivors that received any tele-rehabilitation therapy compared with usual (face-to-face) care.	Motor function (duration 2-24 weeks), higher cortical dysfunction (aphasia and hemi-neglect), and de-pression.	Cost effective-ness, carer strain.	Physiotherapists; 'therapists'; care-givers, peers and 'professionals'; or not stated.	N/A	11 studies assessed mobility from hemiparesis with 6 on upper limb limitations, 1 on ankle disability. All studies improved motor disabilities – (both groups). 7 reported significant differences. Studies of aphasia and visuo-spacial neglect improved high cortical deficits but not significantly Non-significant differences reported for depression.	.

Tchero et al. 2018	SR & MA. 15 studies, with 12 studies included in the pooled analysis, sample size range between 9 and 536 patients.	N/A	**Tele-rehabilitation** (details not found).	Home-based.	Stroke.	Stroke survivors.	Tele-rehabilitation vs usual care.	Activities of daily living and balance function.	Quality of life.	Not stated.	N/A	No significant differences between groups in measures of activities of daily living, and balance function. Most studies showed that both groups were com-parable in health-related quality of life.	Small sample size of some individual studies. Different scales or data formats in the included studies. Could not assess risk of publication bias, as funnel plot-based methods are not accurate for <10 included studies per outcome.

Wu C et al 2018	SR & MA 18 RCTs. 6294 participants. 3269 in the telehealth group and 3025 in the usual care. Length of intervention in each study varied form 6 - 12 months. Mainly trials with sample sizes larger than 100.	N/A	**Telehealth intervention:** Internet and phone; internet and mobile phone; just mobile phone; just telephone; just internet; telephone from peer or nurse.	Home based	Diabetes	Adults with diabetes. Mean aged ranged from 45.5 to 68.4 years (intervention group) and 50.9 to 67.9 (usual care group).	Usual care for diabetes management (control) versus intervention group which involved self-monitoring and management of diabetes. Participants required to transmit data using a telehealth device weekly, or less than weekly to receive feedback regarding medication adjustment, healthy diet and physical activity.	Haemoglobin A1 c (HbA1c) - glycaemic control.	Changes in blood pressure, blood lipid body mass index (BMI) and quality of life (QOL).	Nurses, physicians, clinical health psychologis, diabetologists, exercise experts/clinicians or endocrinologist.	N/A	The intervention statistically significantly reduced systolic blood pressure (P<0.001) and diastolic blood pressure (DBP) levels (p<0.001 as well as glycaemic control (p< 0.00001). No benefits were observed in BMI (P=0.79) or cholesterol levels. For BMI and diastolic blood pressure - interpret with caution due to high heterogeneity.	25% of studies showed successful outcome assessment blinding. Small amount of direction provided on outcomes of telehealth diabetes management. Beneficial to identify if impact of telehealth is influenced by how often and when data is delivered, the form of the intervention, the baseline indicator level and the participants targeted.

C. Summary of included reviews

Reviews examining tele-healthcare interventions

Chen et al (2015) aimed to determine whether telerehabilitation leads to an improvement in abilities of activities of daily living for stroke patients. A systematic review of 11 RCTs with a total of 1025 subjects, with data pooled from 7 studies. Patients were stroke survivors living at home. Telerehabilitation included: care via telephone; instruction of exercises via in-home message device; physical training by desktop videophone; VR therapy program via videoconferencing, therapy via digital videodisk, multi-formats via internet, Home Care Activity Desk (HCAD).

Primary outcomes were disability or activities of daily living. Secondary outcomes measures included: motor function, cognitive function, health-related quality of life, satisfaction, cost-effectiveness, caregivers stress, and adverse events. The authors found moderate evidence that telerehabilitation has equal effects with conventional rehabilitation in improving abilities of activities of daily living and motor function for stroke survivors. The limitations of the study include: small no. of studies, and small sample size of some individual studies.

Jhaveri et al (2015) carried out a systematic review of the literature on supervision via telemedicine of rural patients receiving active treatment for stroke, cancer or kidney disease. The authors reviewed 14 studies, 9 regarding telestroke, 3 involving teledialysis and 2 studies on tele-oncology compare to usual care. Active therapy was provided using video-conferencing-assisted thrombolysis (stoke), videoconferencing (dialysis), and there were too few studies to report on chemotherapy (oncology).

Telestroke demonstrated favourable outcomes when comparing face-to-face and videoconferencing treatment and no significant different in complications between the two groups. For teledialysis, the limited available studies found that dialysis supervised via videoconferencing at home had similar outcomes for patients compared with dialysis delivered in a in hospital setting.

Larson et al (2019) examined the effectiveness of telehealth in providing emotional support (counselling or psychiatric consultations focused on relieving anxiety and depression) or self management of symptoms (physical and functional issues) on the quality of life (QOL) of cancer survivors. The authors carried out a systematic review and meta-analysis of 11 studies involving 1349 participants with 709 participants in the control group and 640 assigned to the intervention group. The intervention group involved telehealth technology such as video conferencing or a web-based program and the control group was usual care, not defined.

The analysis demonstrated a statistically significant, large effect of telehealth interventions on cancer survivors' quality of life.

Orlandoni et al (2015) studied the effect of video-conferencing in conjunction with regular monthly home visits on outcomes of frail older patients receiving home enteral nutrition therapy (HEN), compared to home visits only. Videoconferencing with a clinical nutrition physician was supported by the home-visit nurse and was in addition to examinations and assessments that occur in a home visit. The study assessed outcomes included incidence rate of complications, outpatient hospital visits and hospitalisations.

In the intervention group a video consult with a clinical nutrition physician occurred at the time of the home visit a facilitated by a home visit nurse. The home visiting nurse would support the use of the video conference device for the physician to assess the patient. The video consult was completed in addition to all the usual examinations and assessments that occurred during the home visit. Following the video consult the physician would then adjust the patient's nutrition and/or pharmacology if required.

The study found incident rates for metabolic, gastrointestinal and overall complications were significantly lower for patients who received the video consultation. However, the intervention had no impact on mechanical or tube relate complications and no impact on hospital attendance or admission.

Reviews of tele-healthcare and remote telemonitoring interventions

Bashi et al (2017) aimed to evaluate effects of remote patient monitoring (RPM) interventions on the health outcomes of patients with heart failure. The authors reviewed 19 systematic reviews on the use of RPM interventions. A wide variety of interventions were included: telemonitoring, home telehealth, mobile phone-based monitoring, and video conferencing. The most frequent outcomes were all-cause mortality, and heart failure mortality. Other outcomes included: quality of life, rehospitalisation, emergency department visits, length of stay. Less frequent outcomes included: self-care, and knowledge.

Telemonitoring was found to be generally effective in reducing heart failure readmissions and mortality. Key elements of telemonitoring include: monitoring of blood pressure, heart rate, weight, and ECG. There was not enough evidence to support conclusions about the effect of video-monitoring, mobile phone-based monitoring, or PDA monitoring.

Caffrey et al (2017) examined the effectiveness of telehealth for Aboriginal and Torres Strait Islander people. Eleven studies addressed populations which were outer regional or remote. Accessibility was a focus for 7 studies, and reducing patient travel and transfer was a focus for 5 studies; screening was a focus for 6 studies. The main telehealth techniques used were video consultation (8 studies) and store-and-forward of patient data (6 studies). Study quality was generally low.

The review found almost all positive outcomes on access, social & emotional wellbeing and clinical outcome measures across a range of diseases and types of intervention. Among the four better-quality studies, the benefits of telehealth were concentrated in accessibility and treating in-community. Following the introduction of telehealth, higher patient numbers received screening or other interventions, and lower numbers of patients needed to be transferred or otherwise travel out of area for treatment, away from their social support. It is also worth noting that two of the better-quality studies included an assertive outreach-type screening component, which may have been a factor in their success. For populations which are hard to reach because of remoteness or other barriers, telehealth offers an increase in the accessibility of treatment.

Flodgren et al (2015) assessed the effectiveness, acceptability, and costs of interactive real time telemedicine (38 studies) and remote monitoring (55 studies), across a number of conditions, delivered in addition to, or as an alternative to, usual care. The authors assessed 93 eligible randomised controlled trials with a total of n=22,047 participants. Telemedicine was mostly used for monitoring, treatment and rehabilitation, education and advice for self-management, specialist consultations, screening and assessment. Participants used mobile phones including automated voice response software, as well as digital devices and 'store and forward' technology to transfer clinical data.

The results from these studies provide a good indication of the likely effect of using telemedicine to deliver health care to people with heart failure and with diabetes. The findings from the other studies are less certain, due to a relatively small number of studies recruiting participants with other clinical conditions.

Results differed for admissions to hospital. There was some evidence for a decrease in LDL cholesterol and in blood pressure in the intervention groups. Participants with different mental health and substance abuse problems reported no differences in the effect of therapy delivered over video-conferencing, compared to face-to-face delivery.

Fraser et al (2017) used a systematic meta-synthesis to describe the effectiveness of telehealth for the care of Indigenous people with chronic conditions. Telehealth for managing chronic conditions in Indigenous populations was critiqued in three ways: the effectiveness of telehealth in terms of health outcomes (morbidity, mortality and quality of life); the acceptability of telehealth in terms of its wholistic model of health for Indigenous peoples and for healthcare professionals; and the feasibility of uptake for health services.

The most common telehealth intervention, described in 6 of the 11 studies, was home internet-based monitoring. Other telehealth interventions were 3 asynchronous image/data transfers for screening, diagnosis and monitoring and two evaluations of real-time assessment and management of chronic conditions. Studies were based in the USA with American Indian and Alaska Native people (n=7), Austral with Australian Aboriginal and/or Torres Strait Islander People (n=3), and Maori people from New Zealand (n=1). Not all participants in 4 studies were Indigenous.

Telehealth needs to be culturally appropriate for it to have meaningful health benefits and staff need to have cultural competency. The results were fairly consistent despite variation in study design. Telehealth is feasible and may have the potential to improve health care for Indigenous people, however the modality needs to be culturally competent and the care received must be culturally safe.

Hu et al (2019) aimed to evaluate the effectiveness of telemedicine for diabetes Types I and II, examining clinical outcomes: occurrences of hypoglycaemia, HbA1c results, and BMI. Service or system outcomes were not measured. They reviewed 14 studies (n ranged from 35 to 154; total n = 1,324) but were only able to include ten in the meta-analysis. Modalities used were divided into three groups: (computer software), internet-based monitoring systems and smart devices. Included studies used telephone, email, fax, short message service, computerised systems for information exchange, internet and other mobile devices.

Participants were patients with diabetes Type I (4 studies), diabetes Type II (7 studies), or both (3 studies). Telemedicine modalities were divided into three categories: internet-based monitoring system (6 studies), smart devices (6 studies), and computer software (2 studies). Duration of studies was either 3 months (5 studies) or 6 months (9 studies).

The meta-analysis found a significant reduction in hypoglycaemic episodes (10 studies) and significant improvement in HbA1c (13 studies), but no significant change in BMI (7 studies), all compared to usual care.

Huang et al (2014) compared a telehealth intervention to usual (centre-based) care for cardiac rehabilitation, using a structured community- or home-based exercise program delivered using telephone, computer, an internet based computerised participant management system and ECG recordings transmitted by telephone and email.

Outcome measures varied and included exercise capacity, modifiable risk factors (blood lipids, systolic and diastolic blood pressure, smoking and weight), all-cause mortality, adherence to studies, health related quality of life and psychosocial state (anxiety and depression). Most of the trials were evaluated as low to moderate risk in all bias measures except performance bias.

This systematic review found no significant difference in main outcomes for those who received telehealth interventions or centre-based supervised CR in the short term (12 weeks to 12 months) and long term (up to six years). The authors conclude that telehealth intervention delivered CR does not have significantly inferior outcomes compared to centre-based supervised program in low to moderate risk CAD patients. Telephone-based interventions have the greatest weight of evidence for secondary prevention.

Jakobsen et al (2015) conducted a randomised controlled noninferiority trial, comparing home-based telehealth hospitalisation with usual hospital care for patients with severe or very severe COPD and exacerbation. The intervention condition used remote monitoring and self-measurement with a range of devices, combined with video conferencing and unscheduled 24 hour access to clinical support via a touch screen. The primary outcome measure was treatment failure, defined as re-admission due to exacerbation within 30 days of initial discharge. The noninferiority margin was set at 20% of the control group's risk of readmission.

None of the outcome measures were significant and the results are not able to guide practice for COPD. However, survey results regarding patient satisfaction and ease of use for the technology were positive.

Lin et al (2017)'s systematic review and meta-analysis examined the clinical effectiveness of telemedicine for chronic heart failure. Intervention groups received a combination of telemedicine and standard care. Telemedicine could be either teletransmission, defined as automated upload of cardiac-related data, with intervention contingent on that data; or telephone supported care, a schedule of phone calls, usually made by a nurse, for monitoring and clinical management. Control groups received standard care only; defined as guideline-based standard care and scheduled clinic visits.

Telemedicine was shown to be effective overall and was associated with benefits to the patients with health failure related hospitalisation and mortality. Teletransmission reduced both all-cause and heart failure-related mortality; it also reduced heart failure -related admissions and length of stay. In contrast, telephone supported care only reduced heart failure -related admissions. The authors recommended the implementation of teletransmission monitoring in patients with chronic heart failure.

Lunney et al (2018) studied the impact of telehealth on the processes and quality of care for patients with end-stage renal disease (ESRD) compared to or in addition to usual care. Outcomes measured included hospitalisation, patient self reported physical or mental health, experience, or ESRD process measure (action to follow the provision of care).

Modalities included telephone call only; the teletransmission of clinical data or patient reported outcomes to providers who would act on the information received; or videoconferencing. Data transmission used video, store and forward, remote monitoring and mobile health. The telehealth workers were nurses in 4 studies and a team of health care workers in a further 4 studies. Overall, none of the intervention conditions produced inferior results to standard care; all outcome measures were either significantly better or not statistically different from standard care alone. Broadly speaking, where there were improvements, they were mainly in hospitalisation metrics and quality of life measures.

Rasmussan et al (2016) conducted a randomised controlled trial to compare treatment at home by video-conference consultations only versus standard outpatient treatment. Video-consultations occurred by videophone, broadband installed and serviced by the Danish Telephone Company, and blood pressure monitors. Outcome measures were HbA1c and blood glucose levels, 24 hour blood pressure, cholesterol levels and albuminuria.

Patients achieved planned goals irrespective of telemedicine or standard treatment. There were significant improvements in HbA1c, mean blood glucose, and in cholesterol. No differences in LDL, weight, diastolic diurnal blood pressure, and systolic diurnal blood pressure were found. Overall patients had equivalent or better outcomes after 6 months treatment. The study demonstrated low cost, accessibility for low-income families and over long distances, ensuring implementation in rural areas.

Ringbæk et al (2015) aimed to investigate the effect of telemonitoring with the option of video consultations on exacerbations and hospital admissions in patients with chronic obstructive pulmonary disease (COPD), compared to usual care. Video consultation used a tablet computer with web camera,

microphone, measurement and measurement equipment. Measurements were sent to a call centre at each participant's local hospital and were triaged by a trained respiratory nurse. Where warranted, patients could confer with the specialist in respiratory medicine.

The authors found no difference in drop-out rate and mortality between groups. They also found no difference in hospital admissions for COPD between groups. Telemonitoring patients had more moderate exacerbations (i.e. some treatment without hospital admission), whereas the control group had more visits to outpatient clinics. Telemonitoring (including video consultations) in addition to usual care in outpatient clinics did not reduce hospital admissions, but telemonitoring may be an alternative to visits at the respiratory outpatient clinic.

Sarfo et al (2018) investigated the impact of home based telerehabilitation in which a clinician, using telephone, videophone, robot assisted technologies and virtual and augmented reality therapy, provided evaluation and distance support for people with disability at home. Comparator groups received conventional or no rehabilitation.

Overall, telerehabilitation interventions were found to be promising, with significant improvements in recovery from motor deficits, higher cortical dysfunction and depression in the intervention groups in all studies assessed. Significant differences were reported compared to controls in 8 of 22 studies in favour of tele-rehabilitation group while the remaining studies reported non-significant differences. The results are likely to be applicable in Australian settings.

Tchero et al (2018) evaluated telerehabilitation compared to usual centre-based care in post-stroke patients. The telerehabilitation intervention included a mix of: telephone calls, videoconferencing, educational videos, Web-based chats, and virtual reality systems. Primary outcomes included: activities of daily living, and balance function. Secondary outcome measure was health-related quality of life.

No significant differences between groups in measures of activities of daily living and balance function. Most of the included studies showed that both groups were comparable in health-related quality of life, and in patients' satisfaction with care.

Telerehabilitation can be a suitable alternative to usual rehabilitation care in post-stroke patients, especially in remote or under-served areas. Larger studies are needed to evaluate the health-related quality of life and cost effectiveness.

Wu et al (2018) compared the clinical outcomes of tele-health plus usual care compared to usual care alone in diabetes management. Participants relayed data to a health professional via internet and telephone or using a mix of mobile phones, internet, telephone and telephone calls from a peer or nurse. Participants in the review were all adults living with diabetes. The primary outcome measure was change in haemoglobin A1c (HbA1c) levels and secondary outcomes included changes in blood pressure, blood lipids, body mass index (BMI) and quality of life (QOL). Most of the trials were evaluated as low to moderate risk in all bias measures except performance and detection bias.

The meta-analysis found the tele-health intervention group to be more effective than usual care in controlling glycaemic index and reducing systolic and diastolic blood pressure. Total cholesterol and QOL levels were found to be similar in both groups, whilst there was no benefit observed in the control of BMI for the intervention group. The review and metanalysis demonstrated that telehealth has the potential to be more effective for improving the clinical management of diabetes than usual care.

Reviews comparing the effectiveness of modalities

Kitsiou et al (2015) compared five types of home-based technologies for their effectiveness on all-cause and heart failure related mortality, and all-cause and health failure related hospitalisations: automated device-based telemonitoring, mobile telemonitoring, interactive voice response technologies, video-consultation and web-based monitoring.

Automated device-based telemonitoring and mobile technology were found to be effective in reducing the risk of all-cause mortality and heart failure related hospitalisations. More research is needed on interactive voice response technologies, video-consultation and web-based monitoring.

All types of home telemonitoring combined were also assessed. Home telemonitoring interventions without home visits are associated with a statistically significant relative risk reduction of all-cause mortality and heart failure related hospitalisations. There was no significant reduction in relative risk of all-cause hospitalisations.

Kotb et al (2015) compared three forms of telemedicine for individuals with heart failure. structured telephone support; telemonitoring; structured telephone support combined with telemonitoring; video monitoring and electrocardiographic monitoring with usual treatment and with each other. The results showed that telemonitoring was the first ranked treatment for all three outcomes, for both clinical and systemic outcomes.

Structured telephone support reduced mortality and hospitalisation due to heart failure; telemonitoring reduced mortality and hospitalisation; ECG data monitoring reduced hospitalisation due to heart failure, but not mortality. None of the three reduced all-cause hospitalisation.

Larsen et al conducted a sub-analyse was completed comparing 5 telephone-based studies to 7 web-based technology studies to determine the influence of technology type. There was no significant effect on the mean from the web-based group however the telephone group had a large mean effect significant enough to effect the QOL scores, showing the type of technology can have influence over outcomes.

D. Box 1: Summary of the virtual wards model (Lewis 2006)

- Patients identified by a predictive risk model as being at high risk of a future emergency hospital admission are offered 'admission' to a Virtual Ward.
- Virtual Wards use the systems, staffing and daily routines of a hospital ward, however, there is no physical ward building—hence the term 'virtual'.
- Virtual Ward patients receive multidisciplinary preventive care at home through a combination of home visits and telephone-based care.
- Each Virtual Ward has a fixed number of 'beds'; once these 'beds' are full, no more patients can be admitted to the Virtual Ward until a bed becomes available.
- Each Virtual Ward is linked to a small number of specific GP practices.
- Specialist staff (e.g. a cardiac nurse specialist) may work across several Virtual Wards.
- The composition of the Virtual Ward multidisciplinary team will vary according to the needs of local high-risk patients. It may include a community matron, district nurses, a ward clerk, pharmacist, social worker, physiotherapist, occupational therapist, mental health professional and a representative from the voluntary sector etc.
- Medical input comes from the duty doctor at each constituent GP practice as well as from the patient's usual GP.
- The role of the administrator ('ward clerk') is seen as being pivotal in supporting and coordinating members of the Virtual Ward staff.
- The Virtual Ward team uses a shared medical record.
- Systems are put in place to notify local hospitals, NHS Direct, the local ambulance trust and GP out-of-hours cooperatives about which patients are being cared for on each Virtual Ward. This information is used to alert Virtual Ward staff automatically should a Virtual Ward patient present to any of these services (e.g. to a local A&E department).

References

1. Caffery LJ, Bradford NK, Wickramasinghe SI, Hayman N, Smith AC. Outcomes of using telehealth for the provision of healthcare to Aboriginal and Torres Strait Islander people: a systematic review. Australian and New Zealand Journal of Public Health. 2017;41(1):48-53.
2. Dhalla IA, O'Brien T, Morra D, Thorpe KE, Wong BM, et al. Effect of a postdischarge virtual ward on readmission or death for high-risk patients: a randomized clinical trial. JAMA. 2014;312(13):1305-12.
3. Klein S, Hostetter M , D M. The Hospital at Home Model: Bringing Hospital-level Care to the Patient. New York: The Commonwealth Fund; 2016.
4. Leung DY, Lee DT-F, Lee IF, Lam L-W, Lee SW, et al. The effect of a virtual ward program on emergency services utilization and quality of life in frail elderly patients after discharge: a pilot study. Clinical Interventions in Aging. 2015;10:413.
5. Lewis G, Bardsley M, Vaithianathan R, Steventon A, Georghiou T, et al. Do 'virtual wards' reduce rates of unplanned hospital admissions, and at what cost? A research protocol using propensity matched controls. International Journal of Integrated Care. 2011;11
6. Sonola L, Thiel V, Goodwin N, Koder D. South Devon and Torbay: Proactive Case Management Using the Community Virtual Ward and the Devon Predictive Model. London: The Kings Fund; 2013.
7. Chen J, Jin W, Zhang X-X, Xu W, Liu X-N, et al. Telerehabilitation approaches for stroke patients: systematic review and meta-analysis of randomized controlled trials. Journal of Stroke and Cerebrovascular Diseases. 2015;24(12):2660-68.
8. Jhaveri D, Larkins S, Sabesan S. Telestroke, tele-oncology and teledialysis: a systematic review to analyse the outcomes of active therapies delivered with telemedicine support. Journal of Telemedicine and Telecare. 2015;21(4):181-88.
9. Larson JL, Rosen AB, Wilson FA. The effect of telehealth interventions on quality of life of cancer survivors: a systematic review and meta-analysis. Health Informatics Journal. 2019:146045821986360.
10. Orlandoni P, Jukic Peladic N, Spazzafumo L, Venturini C, Cola C, et al. Utility of video consultation to improve the outcomes of home enteral nutrition in a population of frail older patients. Geriatrics & Gerontology International. 2016;16(6):762-67.
11. Bashi N, Karunanithi M, Fatehi F, Ding H, Walters D. Remote monitoring of patients with heart failure: an overview of systematic reviews. Journal of Medical Internet Research. 2017;19(1):e18.
12. Kotb A, Cameron C, Hsieh S, Wells G. Comparative effectiveness of different forms of telemedicine for individuals with heart gailure (HF): a systematic review and network meta-analysis. PLOS ONE. 2015;10(2):e0118681.
13. Lin M-h, Yuan W-l, Huang T-c, Zhang H-f, Mai J-t, et al. Clinical effectiveness of telemedicine for chronic heart failure: a systematic review and meta-analysis. Journal of Investigative Medicine. 2017;65(5):899-911.
14. Kitsiou S, Pare G, Jaana M. Effects of home telemonitoring interventions on patients with chronic heart failure: an overview of systematic reviews. J Med Internet Res. 2015;17(3):e63.
15. Ringbæk T, Green A, Laursen L, Frausing E, Brøndum E, et al. Effect of telehealthcare on exacerbations and hospital admissions in COPD: a randomised controlled trial. European Respiratory Journal. 2015;46
16. Huang K, Liu W, He D, Huang B, Xiao D, et al. Telehealth interventions versus center-based cardiac rehabilitation of coronary artery disease: a systematic review and meta-analysis. European Journal of Preventive Cardiology. 2015;22(8):959-71.
17. Flodgren G, Rachas A, Farmer AJ, Inzitari M, Shepperd S. Interactive telemedicine: effects on professional practice and health care outcomes. Cochrane Database of Systematic Reviews. 2015(9)
18. Fraser S, Mackean T, Grant J, Hunter K, Towers K, et al. Use of telehealth for health care of Indigenous peoples with chronic conditions: a systematic review. Rural and Remote Health. 2017;17(3):4205.
19. Hu Y, Wen X, Wang F, Yang D, Liu S, et al. Effect of telemedicine intervention on hypoglycaemia in diabetes patients: a systematic review and meta-analysis of randomised controlled trials. Journal of Telemedicine and Telecare. 2018;25(7):402-13.
20. Sarfo FS, Ulasavets U, Opare-Sem OK, Ovbiagele B. Tele-rehabilitation after stroke: an updated systematic review of the literature. Journal of Stroke and Cerebrovascular Diseases. 2018;27(9):2306-18.
21. Tchero H, Tabue Teguo M, Lannuzel A, Rusch E. Telerehabilitation for stroke survivors: systematic review and meta-analysis. Journal of Medical Internet Research. 2018;20(10):e10867.

22. Wu C, Wu Z, Yang L, Zhu W, Zhang M, et al. Evaluation of the clinical outcomes of telehealth for managing diabetes: a PRISMA-compliant meta-analysis. Medicine. 2018;97(43):e12962.
23. Jakobsen AS, Laursen LC, Rydahl-Hansen S, Ostergaard B, Gerds TA, et al. Home-based telehealth hospitalization for exacerbation of chronic obstructive pulmonary disease: findings from "the virtual hospital" trial. Telemedicine Journal and E-health. 2015;21(5):364-73.
24. Rasmussen OW, Lauszus FF, Loekke M. Telemedicine compared with standard care in type 2 diabetes mellitus: a randomized trial in an outpatient clinic. Journal of Telemedicine and Telecare. 2016;22(6):363-68.
25. Lunney M, Lee R, Tang K, Wiebe N, Bello AK, et al. Impact of telehealth interventions on processes and quality of care for patients with ESRD. American Journal of Kidney Diseases. 2018;72(4):592-600.
26. McCarthy D, Coihen A, MB J. Gaining Ground: Care Management Programs to Reduce Hospital Admissions and Readmissions Among Chronically Ill and Vulnerable Patients. New York: The Commonwealth Fund; 2013.