### Telemonitoring In Long-Term Conditions: Evidence Summary

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### The following is a high-level review conducted for the Virtual Capacity Group (Deputy CMO) of the Scottish Government in May 2023. While not a systematic review it is considered to be a fair representation of the current state of the art. The literature is reviewed regularly and there appears to have been no new research in the last year which changes the conclusions.

### The problem

 Currently 17 million people in the UK suffer from some form of long-term condition. Most have more than one. This is set to increase. Even if resources could be found to increase the numbers of doctors and nurses in primary care (and it is more likely that this will fall) it is clear that current methods of managing these conditions are no longer going to be sufficient. Self-management has been promoted as a potential solution to this, but the evidence for the effectiveness of self-management alone is not strong. For example, there is some evidence from trials that self-management of high blood pressure (HBP) may be effective in the short term, but not when more rigorous outcomes such as ambulatory blood pressure monitoring are applied. (1) The use of asthma self-management plans is associated with fewer hospital admissions, but plans are often not offered or adhered to in practice. (2) In type 2 diabetes (DM) self-monitoring alone has been found to be associated with increased anxiety and no improvement in HBA1C.(3) Patients left to self-monitor lack confidence in knowing how to respond to abnormal readings and felt abandoned by clinicians.(4) These results have led to the suggestion that self-monitoring supervised at a distance using telehealthcare may be a solution.

**Why use telemonitoring?**

Underlying theory: Telemonitoring will save time for clinicians and patients; It will result in better clinical outcomes; it will enhance patient confidence in self-management; it will provide better data for management and service planning.

**What is the evidence?**

Evidence from randomised controlled trials (RCT) has been slowly building over the years, much of it from Scotland, which has confirmed the efficacy of telehealthcare in the management of some conditions (HBP, DM, and to an extent congestive heart failure (CCF)). However, for others the traditional approach of relatively intensive remote clinician monitoring has not shown additional benefit over usual care(chronic obstructive pulmonary disease (COPD), asthma) and newer ‘light-touch’ models based around self-management are under explorations.

Demonstrating cost-effectiveness has been more problematic and with a few exceptions has relied on modelling based on assumptions of better outcomes rather than immediate reductions in workload. This paper summarises the evidence for the most common long-term conditions in which telehealthcare has been applied (COPD, HBP, CCF, DM, Asthma) and identifies the challenges still to be overcome.

**The effect of COVID and other potential pandemics**

The COVID pandemic has up-ended many of the assumptions on which the evidence is based. Prior to vaccination there was little alternative to telemonitoring for many vulnerable patients to manage their long-term conditions. Some patients will remain vulnerable because of immunosuppression and failure to immunise and all patients will be at risk of a sudden change in virulence or infectivity of the virus. It is important therefore not ‘write off’ some of the telemonitoring approaches described below as likely to be ineffective as they may be required by some patients or if the overall context changes.

 **Strong evidence of effectiveness**

**High Blood Pressure (HBP)**

In Scotland 1.2 million appointments are taken up for BP management alone (with many more appointments where BP is measured).(5) Home measured BPs are more predictive of outcomes than those carried out in the surgery and are less prone to ‘white-coat’ effects. While self-monitoring of blood pressure, on its own, is associated with a short-term reduction in blood pressure, self-monitoring with clinician oversight using telemonitoring is more effective.(6)

There is very strong evidence for the effectiveness of telemonitoring for HBP. A recent meta-analysis of 24 RCTs and 8292 patients, (6) including a large Scottish RCT (7), showed that in actively monitored patients there was a mean 6.9mm reduction in systolic BP over the course of one year compared with control. Such a reduction would result in a >20% lowering in the incidence of stroke and 15% reduction in myocardial infarction if sustained for 5 years. While RCT results are not necessarily sustained in a normal clinical setting, an implementation study in routine practice from Scotland demonstrated that the similar falls in BP to those found in the RCTS occurred. (9)

**Cost-effectiveness**: As HBP is a symptomless condition, and the incidence of cardiovascular events relatively infrequent during the course of a clinical trial, usual cost-effectiveness calculations to calculate quality adjusted life years (QALYs) are problematic. However, the mean societal and clinical costs in the first 12 months after a stroke have been estimated at £45,409 and £24,003 respectively, (9) underlining the potential gains from lowering BP. A health economic analysis, applying modelling of potential health gains using data from the TASMINH 4 randomised controlled trial, showed that telemonitoring was likely to be cost-effective at a cost of £17,424 per quality-adjusted life year gained .(10) A recent RCT of telemonitoring for hypertension from Canada,(17) also concluded that telemonitoring is cost-effective with costs per QALY coming in at C$1929. In the Scottish implementation trial there were large reductions over the course of one year in face-to-face appointments for continuous monitoring compared with a routine care comparator group (24% v 9%). (8)

**VERDICT: The evidence for large scale telemonitoring of HBP is very strong. It appears to work equally well in routine clinical practice as in RCTs with no increase in clinician workload. It should be adopted at scale across Scotland within an evaluative framework.**

**Diabetes mellitus**

Just over a quarter of a million people in Scotland have been diagnosed with diabetes. (12) Around 88% of diabetes is type 2 and managed mainly in primary care. A recent meta-analysis of 38 randomised controlled trials of telemedicine among 6855 people with diabetes (13) (including one Scottish study (14)) reported a significant decline in HbA1c level in interventions compared with control groups when biological data were sent weekly combined with quick feedback. This resulted in 1.8 times as many people in the intervention group achieving improved glycaemic control (HBA1C < 7%) than in the control group, when feedback was given daily or immediately (RR 1.83, 95% CI 1.35 to 2.47). (13) There was also significant reduction in systolic BP (weighted mean difference -1.33 mm Hg) and body mass index (weighted mean difference -0.25 kg/m2). As with HBP, telemonitoring studies in diabetes were not prolonged and it is unclear if this effect would be sustained over time or if implemented at scale if it would be taken up by patients and practices.

**Cost-effectiveness:** There are fewer papers exploring cost effectiveness. Limited evidence for use in glycaemia of pregnancy (15) and managing foot ulceration(16) and one small study from China(17) show positive outcomes in terms of reduced FTF consultations.

**Verdict: There is strong evidence that telemonitoring of diabetes improves glycaemic and BP control. Further evidence is required to determine cost effectiveness. Should be scaled up but in the context of a well-planned implementation study which will allow a judgement on cost-effectiveness.**

**Congestive Cardiac Failure (CCF)**

CCF is one of the commonest reasons for hospital readmission in Scotland. Early intervention may prevent deterioration and hospitalisation and telehealthcare has been seen as a means to facilitate early detection. Telemonitoring of CCF has mainly been carried out by specialist CHF nurses rather than by primary care staff. A large number of trials have been carried out with varying results. The most recent systematic review (18) which included 26 trials and 4923 patients showed a significant reduction in all cause mortality in 12 studies at 180 days ( 40% reduction in the odds (OR: 0.6 p<0.01) ), but in the 6 studies which continued for 365 days the reduction became insignificant (OR 0.85; p=0.461). Telemonitoring did not have a significant impact on the odds of all-cause hospitalization at 180 days (OR: 0.97; p = 0.902) or 90 days (OR: 0.81; p = 0.472) and was associated with an increase in emergency room visits (OR 1.51 p<0.05). While telemonitoring may confer a short term benefit, perhaps in terms of a period of intensive monitoring post-discharge, evidence suggest no benefit to long-term monitoring.

**Cost-effectiveness:** Costs reflect the service organisations of the countries in which studies have taken place and how the system was implemented. A study in 2013 from the UK concluded telemonitoring is cost-effective with ICER of £11 873/QALY (19) and one during the COVID pandemic in Hong Kong (20) that it was cost effective with an incremental cost-effective ratio of US $4292/QALY. However, the same authors exploring cost-effectiveness of an implementation post-discharge in the USA (21) found it not to be cost-effective with an ICER of $100,458/QALY.

**Verdict: There is good evidence that telemonitoring of CCF improves reduces hospital admissions and deaths in the short to medium term but less evidence it is effective long-term. Scaling up should be targeted at higher-risk patients for example post-discharge. Scaling up should be within an evaluative framework as further evidence is required to determine cost effectiveness.**

**Less evidence of benefit of traditional telemonitoring**

**Asthma**

Self-management alone of asthma is associated with fewer hospital admissions. It can be difficult to separate the effects of this from telemonitored supported self-management. In a systematic review McLean and colleagues analysed a wide range of telehealthcare interventions for asthma in 27 trials.(22) Meta-analysis showed no significant improvement in emergency department use or hospitalisation at 3 months, but, in a subgroup of four smaller studies, a significant reduction in hospitalisations compared to usual care at 12 months. No benefit was conferred with respect to reported symptoms. However, in many of the studies the control groups were given enhanced face-to-face care making it challenging to show the benefits of telemonitoring. The authors concluded that telehealthcare was unlikely to confer benefits in mild-moderate asthma but that those at higher risk of hospitalisation may benefit and that considerably more research was needed to investigate the cost effectiveness of telehealthcare-centred models of care. A review in 2018 focussing on child and adolescent asthma found 8 RCTs which showed no benefit of continuous monitoring.(23) Another more limited Cochrane review exploring two more recent papers on the use of asthma apps found contradictory results and concluded that evidence was insufficient to recommend the use of mobile apps for managing asthma. (24)

**Cost-effectiveness:**  There is no strong evidence that continuous telemonitoring for asthma is cost-effective

**Verdict: There is no strong evidence that remote clinician telemonitoring of Asthma improves symptoms or reduces hospital admissions overall particularly for people with mild moderate asthma. However, there is some evidence that telemonitoring may be effective for a more severe group with high risk of hospital admission. Ongoing work is exploring the use of technology to encourage adherence to asthma self-management plans, which are known to be effective, with onward forwarding to clinicians to aid regular review. However, such interventions should be within an evaluative framework as further evidence is required to determine cost effectiveness. Such a study is currently underway in the UK with some Scottish sites.**

**Chronic Obstructive Pulmonary Disorder (COPD)**

COPD is one of the leading causes of hospital admission mainly because of exacerbations of the condition. Early identification of exacerbations and timely treatment can prevent severe deterioration and hospital admission.(25) Daily telemetric monitoring of symptoms, pulse oximetry and in some cases spirometry has been used to help identify these early exacerbations. Previous systematic reviews which relied on relatively poor quality studies had concluded that telehealthcare may be effective.(26) However, many of these studies were very complex and included additional nursing and medical support in their interventions which made it difficult to identify whether or not the telehealthcare component led to any change that had been detected.(27) The most recent systematic review of 29 studies shows variation in outcomes but that large, high quality studies demonstrated no improvement in outcomes.(28) The most recent cluster RCT conducted in Denmark showed no impact on QoL and was not cost effective.(29) A large Scottish RCT (30) set out to explore the impact of telemonitoring where equivalent additional support was given to controls. This demonstrated no impact of telehealthcare on time to admission or total admission time, but it was associated with many ‘false positive alerts’ which lead to an increase in workload.

**Cost-effectiveness:** has not been demonstrated in studies carried out in the context of RCTs.(30,31,32) One German observational study suggested savings, but it is unlikely patient groups were comparable.(33)

Analysis of the telemetric data in the Scottish study showed that the algorithm in use was poorly predictive of serious exacerbations and research is now focussing on improving these algorithms.(34). A ‘light-touch’ variation on telemonitoring encourages the patient to take and transmit readings but leaves the patient to self-monitor and self-manage and to call the clinician only if problems arise. The clinician can then make use of the collected data to advise the patient. Observational studies seem to suggest this is successful in terms of reducing workload (35) and a large observational study in Scotland (DYNAMIC-SCOT) is underway. (36)

**Verdict: There is little evidence that continuous clinician telemonitoring of COPD provides better outcomes than usual care. There is some observational evidence that the use of self-monitoring to aid self-management and which uses forwarded data to aid review may be helpful. Such developments show promise but should be scaled-up only in the context of an evaluative framework.**

**REFERENCES**

1. Omboni S et al. Clinical usefulness and cost effectiveness of home blood pressure telemonitoring: meta-analysis of randomized controlled studies. J Hypertens. 2013;31(3):455-67
2. Pinnock Het al.  Systematic meta-review of supported self-management for asthma: a healthcare service perspective. *BMC Medicine* 2017;15:64
3. Farmer A et al. Impact of self monitoring of blood glucose in the management of patients with non-insulin treated diabetes: open parallel group randomised trial. BMJ. 2007;335(7611):132
4. Peel E et al. Blood glucose self-monitoring in non-insulin-treated type 2 diabetes: a qualitative study of patients' perspectives. Br J Gen Pract. 2004;54(500):183-8
5. ISD. GP Consultations / Practice Team Information (PTI) Statistics http://www.isdscotland.org/Health-Topics/General-Practice/GP-consultations/ Last Accessed 17/03/20
6. Tucker KL et al. Self-monitoring of blood pressure in hypertension: A systematic review and individual patient data meta-analysis. PLOS Medicine. 2017 Sep 19;14(9):e1002389.
7. McKinstry B et al. Telemonitoring based service redesign for the management of uncontrolled hypertension: multicentre randomised controlled trial. BMJ 346, f3030

Hammersley V et al. Telemonitoring at scale for hypertension in primary care: An implementation study. *PLoS Med*. 2020;17(6):e1003124. Published 2020 Jun 17. doi:10.1371/journal.pmed.1003124

1. Patel A et al (2017). Current, future and avoidable costs of stroke in the UK. Executive summary Part 1: Burden of stroke in the next 20 years and potential returns from increased spending on research. London: Stroke Association.
2. Monaham M et al. Cost-Effectiveness of Telemonitoring and Self-Monitoring of Blood Pressure for Antihypertensive Titration in Primary Care (TASMINH4). Hypertension 2019;73:1231–1239
3. Padwal RS et al.Cost-effectiveness of home blood pressure telemonitoring and case management in the secondary prevention of cerebrovascular disease in Canada. J Clin Hypertens 2019 Feb;21(2):159-168
4. Scottish Diabetes Survey Monitoring Group. Scottish Diabetes Survey 2014 https://www.scotpho.org.uk/health-wellbeing-and-disease/diabetes/data/scottish-diabetes-survey Last Accessed 17/03/20.
5. Kim Y et al. Comparative effectiveness of telemonitoring versus usual care for type 2 diabetes: A systematic review and meta-analysis. *J Telemed Telecare*. 2019;25(10):587–601. doi:10.1177/1357633X18782599
6. Wild SH et al. Supported telemonitoring and glycemic control in people with type 2 diabetes: The Telescot Diabetes Pragmatic Multicenter Randomized Controlled Trial. PLoS medicine 2016; 13: e1002098–e1002098.
7. Lemelin A e al. Demonstrated Cost-Effectiveness of a Telehomecare Program for Gestational Diabetes Mellitus Management. Diabetes Technol Ther. 2020; 22(3):195-202.
8. Fasterholdt I et al. Cost-effectiveness of telemonitoring of diabetic foot ulcer patients. Health Informatics J. 2018 Sep;24(3):245-258.
9. Tsuji S e al. Cost-Effectiveness of a Continuous Glucose Monitoring Mobile App for Patients With Type 2 Diabetes Mellitus: Analysis Simulation. J Med Internet Res 2020;22(9):e16053
10. Pekmezaris R et al. Home Telemonitoring In Heart Failure: A Systematic Review And Meta-Analysis. *Health Aff (Millwood)*. 2018;37(12):1983–1989. doi:10.1377/hlthaff.2018.05087
11. Thokala P et al. Telemonitoring after discharge from hospital with heart failure: cost-effectiveness modelling of alternative service designs. BMJ Open. 2013;3(9):e003250.
12. Jiang X et al. Cost-effectiveness of a Telemonitoring Program for Patients With Heart Failure During the COVID-19 Pandemic in Hong Kong: Model Development and Data Analysis
J Med Internet Res 2021;23(3):e26516
13. Jiang X et al. Telemonitoring Versus Usual Care for Elderly Patients With Heart Failure Discharged From the Hospital in the United States: Cost-Effectiveness Analysis. *JMIR Mhealth Uhealth*. 2020;8(7):e17846.
14. McLean S. Telehealthcare for asthma. Cochrane Database Syst Rev. 2010 Oct 6;(10):CD007717.
15. Jung Y et al. Effectiveness of Telemonitoring Intervention in Children and Adolescents with Asthma: A Systematic Review and Meta-Analysis. J Korean Acad Nurs. 2018 Aug;48(4):389-406.
16. Marcano Belisario JS, e al. Smartphone and tablet self management apps for asthma. Cochrane Database of Systematic Reviews 2013, Issue 11
17. Seemungal TAR et al. Effect of exacerbation on quality of life in patients with chronic obstructive pulmonary disease. Am J of Respir Crit Care Med 1998; 157: 1418-1422
18. Polisena J et al. Home telehealth for chronic obstructive pulmonary disease: a systematic review and meta-analysis. J Telemed Telecare 2010;16:120–7
19. McLean S et al. Telehealthcare for chronic obstructive pulmonary disease: Cochrane Review and meta-analysis. Br J Gen Pract. 2012 Nov; 62(604): e739–e749
20. Kruse C et al. Telemonitoring to Manage Chronic Obstructive Pulmonary Disease: Systematic Literature Review. JMIR Med Inform. 2019;7(1):e11496. Published 2019 Mar 20. doi:10.2196/11496
21. Lilholt PH et al . Telehealthcare for patients suffering from chronic obstructive pulmonary disease: effects on health-related quality of life: results from the Danish 'TeleCare North' cluster-randomised trial. *BMJ Open*. 2017;7(5):e014587.

Pinnock H et al. Effectiveness of telemonitoring integrated into existing clinical services on hospital admission for exacerbation of chronic obstructive pulmonary disease: researcher blind, multicentre, randomised controlled trial. BMJ 2013;347:f6070

Witt Udsen F et al. Cost-effectiveness of telehealthcare to patients with chronic obstructive pulmonary disease: results from the Danish ‘TeleCare North’ cluster-randomised trial. BMJ Open 2017;7:e014616.

1. Ancochea J et al. Efficacy and costs of telehealth for the management of COPD: the PROMETE II trial. Eur Respir J. 2018 May 30;51(5):1800354.

Achelrod D et al Health-economic evaluation of home telemonitoring for COPD in Germany: evidence from a large population-based cohort. Eur J Health Econ. 2017;(7):869-882

Orchard P et al. Improving Prediction of Risk of Hospital Admission in Chronic Obstructive Pulmonary Disease: Application of Machine Learning to Telemonitoring Data. *J Med Internet Res*. 2018;20(9):e263. Published 2018 Sep 21. doi:10.2196/jmir.9227

1. MacNab M et al. Oximetry-supported self-management for chronic obstructive pulmonary disease: mixed method feasibility pilot project BMC Health Services Research 15 (1), 1
2. DYNAMIC-SCOT <https://www.dhi-scotland.com/projects/dynamic-scot/>