

Telehealth – A Review of the Literature

Abstract

*Telehealth, which involves the use of technology and digital health platforms to review patient health remotely, has become an increasingly popular delivery method of healthcare in recent years. The most common aim of using Telehealth is to prevent hospital admission, reduce length of in hospital stays and support care and treatment of chronic or acute health conditions. However, there seems to be little available literature that evaluates the outcomes for patients using Telehealth to manage their health, or the experiences of health-care professionals working with Telehealth, as well as targeted themes of interest e.g., clinician and patient satisfaction, caregiver/family burden, readmission or length of hospital stay, and so on. Further to this, several remote healthcare models have emerged. Which all encompass the same higher-level objective of using Telehealth, these include Virtual Wards, Hospital-at-home, telemedicine, telemonitoring and care at home. **Methods:** We searched Google Scholar, PubMed, BMJ and ScienceDirect for studies and articles using the search terms; “virtual ward”, “remote monitoring”, “hospital at home”, “Telehealth”, “telemedicine”, and “telemonitoring”. Following this, more refined aims and themes of interest were identified to provide structure and direction to the review, including virtual ward models, respiratory problems and covid-19, cardiovascular disease, frailty, diabetes, stakeholder satisfaction, effect on readmission/length of stay, cost effectiveness, effect on the caregiver, environmental factors, and several others. Articles were included providing they observed the use of a virtual ward or hospital at home care model and were dated 2000 onwards. In total, 70 papers and 11 articles met criteria and were included in this scoping literature review. **Findings:** Almost all included research papers seemingly support the use of Telehealth in healthcare, in the form of a virtual ward or hospital at home model. It is emphasised that caution is taken when admitting patients to a Telehealth service, with particular focus on suitability and ability to adhere. Also highlighted throughout is that clinician involvement in design and implementation is essential to its success, along with ensuring patient and clinician feedback is collected. **Interpretation:** Published articles suggest that Telehealth can be safely and effectively implemented for the management of long-term health conditions, as well as post-discharge, providing the patient is suitable and the correct parameters have been met. However, there is currently a lack of sound valid evidence surrounding cost effectiveness, as well as a lack of research from the angle of clinician experience and perspective. The literature is also deprived of patient feedback. **Acknowledgements:** This literature review was developed and executed by the authors with no external or commercial support. **Funding:** The Welsh Government. **DOI:** We declare no competing interests.*

Contents

1. Introduction
2. Virtual Ward Models
3. Types of Virtual Ward
 - 3.1 *Respiratory problems and COVID-19*
 - 3.2 *Cardiovascular Disease*
 - 3.3 *Frailty*
 - 3.4 *Diabetes*
 - 3.5 *Mental Health*
 - 3.6 *Other Health Conditions*
4. Considerations
 - 4.1 *Stakeholder Satisfaction*
 - 4.2 *Effect on Readmission/Length of Stay*
 - 4.3 *Cost Effectiveness*
 - 4.4 *Effect on the Caregiver*
 - 4.5 *Environmental Factors*
 - 4.6 *Social Care*
 - 4.7 *Quality of Life*
 - 4.8 *Wider Impact on Healthcare Services*
5. Future of Remote Monitoring
6. Conclusion
7. References

1. Introduction

Telehealth is the use of technology and digital health platforms in enabling overview and evaluation of patient health, outside of a clinical setting. Telehealth typically involves the use of medical devices, wearable sensors, symptom surveys and online clinical dashboards, for remote data collection, all of which are overlooked by healthcare practitioners for clinical assessment and decision making via video conferencing, telephone calls and home visits (1). The aim of Telehealth is to aid the prevention of readmission to hospital, reduced length of hospital stays and support the care and treatment of chronic or severe health conditions, as well as the transition of care after hospital discharge. The recent COVID-19 pandemic saw an acceleration in technology use within the NHS, with forced uptake of remote methods of healthcare such as e-consultations, Video Calls, and use of the NHS App; over 4 million patients registered for the NHS app between Jan 2019 and May 2021, with appointment booking through the app reaching up to 42,664 per month during this period (2). This indicates patients are open to adopting digital technologies in the NHS, and whilst it poses an ideal opportunity for the NHS to increase its use of technology in healthcare, particularly remote methods of providing care, there are several considerations to be made. Hutchings (3) highlights the importance that the approach taken to further introduce technology and digital healthcare must be that of a sustainable one, which considers all aspects of embedding Telehealth effectively following strong research and evaluation. There are now several types of remote healthcare models and programmes which use Telehealth, those included in this review are as follows; Virtual Wards, Hospital-at-home, telemedicine, telemonitoring, and care at home. The following literature review will seek to understand the current literature surrounding Telehealth, encompassing models of Virtual Wards (VW) and remote monitoring (RM) in the NHS and types of ailments treated with Telehealth models/programmes. The review will consider the success of different types of Telehealth and aim to address six considerations of Telehealth implementation; stakeholder satisfaction, cost effectiveness, effect on readmission/length of stay in hospital, family burden, environment changes and impacts on other services.

1. Virtual Ward Models

Typically, in traditional healthcare processes, over one-third of patients are readmitted to a hospital ward within 90 days of discharge (4), but estimates suggest that over 59% of those readmissions are avoidable (5). Virtual Wards (VW), one of the most used terms for Telehealth in the NHS, were originally created to encourage earlier discharge and avoid unnecessary readmissions; they can be suitable for the management of many conditions. The first VW in the UK was introduced in Croydon Primary Care in 2005 and was implemented for patient treatment in 2006 (6) using a combined model (a blend of in-person care and with remote oversight/monitoring) which allocated 'virtual beds' to patients who were identified as being at the highest risk of readmission to hospital. Initially, in the combined model, patients are assessed to determine if their condition can be managed at home with the assistance of wearable devices, which incessantly send observations (breathing, heart rate, etc.,) to the ward staff, and through means of communication with the healthcare team e.g., a tablet. There is a multidisciplinary rapid response team which consists of community nurses, therapists and doctors; they can travel to the patient in a matter of hours to deliver care, as per a patient specific treatment plan, should it become necessary, based on reported observations (7). It is stated that the main strength of the combined model is that it enables predicted need to be mapped across a borough, and that the number of people it must cater for can be adjusted. A rapid evaluation of Croydon VW in 2021 concluded that they deliver cost savings, whilst seeming to deliver a service that patients are largely satisfied with, as over 87% of patients gave a positive review of the technology (8) Other examples of VW models include the 'predictive combined models', used in Devon and the 'patients at risk of re-hospitalisation model', used in Wandsworth.

The 'predictive combined model' was introduced in Devon in 2010, it uses a range of variables to predict risk of future hospitalisation, including data such as demographics, diagnoses, frequency of admission and chronic conditions, as well as data associated with the community in which the patient resides, e.g., deprivation levels and characteristics of local hospitals (9). South Devon have

also more recently developed their own predictive modelling tool for VW, the Devon Predictive Model (DPM), which uses a combination of primary care and secondary care data to risk-stratify patients. The tool is used by virtual ward teams to objectively identify patients for pro-active and complete management of cases by a multi-disciplinary team – this team is backed by a general practitioner (GP). It is reported that the model reduces hospital admissions and length of stay in hospital, for patients with complex conditions (10). Therefore, it is reasonable to infer that the VW model used here offers benefits for both patients and the health-board; whilst patients can receive efficient care from the comfort of their own home, the health-board benefits from less in-hospital pressure and has an increased number of beds available. The most debilitating issue Devon VW encountered was the handling of information, with regards to difficulties navigating between provisions of data protection; primary care trust analysts were provided with honorary contracts at each GP practice to overcome this (11).

Wandsworth NHS employs a slightly different structure for VW, using a ‘patients at risk of re-hospitalisation’ model, which only observes those who were previously admitted to hospital and does not consider those who may be at high risk of admission – this could be considered a limitation of the model as it does not identify as many high-risk patients as other VW models, and so likely has less impact on hospital admission numbers. Notably though, this model employs a full-time GP who provides primary care and deals with the most complicated patients/health conditions on each VW. Unlike that of Croydon and Devon, there seems to be little research that directly assesses the effectiveness of the VW model used in Wandsworth (11).

In a 2013 review Lewis et al., (12) explored the differences between each of these wards and aimed to comparatively evaluate their success; all three areas seemed to provide organisational support through policies that sought to reduce hospital admission and improve quality of care provided. Chronic illness sufferers are often subject to fragmented care due to the need for multiple pathways of maintenance; a benefit of VW is that it’s multidisciplinary teams (in Devon and Wandsworth) give rise to the possibility for each avenue of care to be covered, as organised

by the GP. Furthermore, the study highlights that having a GP involved is vital and ensures that the multidisciplinary nature of the VW stays available and consistent. Also noted, was that data sharing and information management were important to all three VW, both for the generation of risk-identification, as well as keeping notes on patients whilst admitted to the ward; Wandsworth and Devon utilised GP records whereby VW staff could read and add to them.

Eines et al., (13) asked healthcare professionals about their experiences of interpersonal collaboration in treating patients with multimorbidity in a Norwegian Community Virtual Ward. Thematic analysis was used to analyse the interview data of 17 healthcare professionals, the results of which suggest interprofessional collaboration in a community ward may be a sustainable way to organise healthcare services for patients with multimorbidity, as it allows for emphasis on increased health promotion. As well as this, the study revealed how using assessment tools and whiteboard meetings are useful instruments for facilitating interprofessional collaboration.

As the UK's National Health Service is increasingly implementing VW, there have been further studies examining their efficacy compared with other methods and models of Telehealth Norman et al., (14) looked at the close relationship between virtual wards and hospital at-home services for the elderly. This review observes virtual wards as a hospital-led service that uses technology such as apps, wearable devices and kit such as a pulse oximeter, to deliver acute health care. It also observes the definition of hospital at home as a service that provides face-to-face hospital care in the home via a multidisciplinary team based in the community. During the analysis, twenty-eight evidence syntheses were used, most of them relating to hospital-at-home care. The results indicate that hospital at home is a good option clinically, but virtual wards are less effective; highlighting a lack of guidance for key aspects such as team characteristics and data protection. It is noted that dissemination of evidence-based guidance for VW delivery should be prioritised. In their study, Norman et al., (14) pointed out that caregiver strain is particularly

relevant and suggests further research be conducted to integrate the development of the Virtual Wards Model.

Published by the Digital Health and Innovation, Sexual and Reproductive Health and Research team at the World Health Organisation, a guide aimed at policy decision-makers and telemedicine design implementors; Consolidated Telemedicine Implementation Guide (15). It encompasses the advancements in telemedicine as a result of the covid-19 pandemic, how to accomplish remote patient monitoring/telemonitoring, and recommended fundamentals for its implementation. It discusses telemedicine intervention case studies across different countries; India and Cabo Verde. The objectives of the telemedicine intervention in India, the eSanjeevani programme, include addressing shortage of doctors & specialists, and to reduce burden on limited hospital & tertiary care facilities at primary care level. The programme operates in two pathways, one for health-worker to health-worker teleconsultation and another for patient to health-worker teleconsultation. For the latter, availability to communicate is made through web and mobile applications; patients can request an appointment and receive consultation, examination and prescription through the web or mobile application. The programme did face some challenges, one being the struggles faced by health-workers unfamiliar with technology or digital interventions, as well as conducting remote patient examination; training sessions put in place which involved multiple trials with test cases for each practitioner and this enabled them to use the programme with ease. Also, a challenge were the capabilities and attitudes of patients, notably those of rural areas, who took time to develop a trust and understanding of telemedicine practices. These were addressed by aggressive, but educational, social media campaigns from health authorities to increase telemedicine awareness in more rural communities accompanied by user instruction videos. Cabo Verde's national telemedicine programme was implemented to provide specialised teleconsultations across differing health-workers, facilitate distance training, promote use of ICT in health and reduce the inequalities present in healthcare across the country. The model exhibits hubs on each of the 9 inhabited islands and involves a videoconferencing system at sites equipped with high-definition cameras and electrocardiograms. Consultations are

held by GP's and other non-specialised medical practitioners, alongside specialist practitioners e.g., neurologists, dermatologists, cardiologists etc. A major challenge faced here was the resistance to change from health-workers as a consequence of lack of knowledge and confidence in telemedicine and technology; addressing this involved placing emphasis on raising awareness among health-workers and ensuring continuous support was provided to overcome barriers with technology and ICT, along with adapting clinical services to better serve in a telemedicine context. Noted here is the essential requirement to involve local leaders (e.g., MP's, counsellors, health-board leads, health minister) and representatives of professional organisations to obtain their feedback and encouragement. It is discussed that political influence and adoption is critical in the success of telemedicine implementation, and engagement and training with health-workers must be relevant and often.

Uminski et al., (16) reviewed evidence evaluating the effect of post-discharge VW vs usual community-based care on hospital admissions and mortality using randomised trials, with heart failure and non-heart failure populations. It was concluded that post-discharge VW model can provide additional benefits to usual community-based care in attempting to reduce all-cause mortality and heart failure admissions among patients. Recommendations for future research highlighted the need for evaluation of VWs in other chronic disease settings.

3. Types of VW

3.1 Respiratory problems & covid-19

A common ailment which VW are used to monitor, and treat are respiratory problems, these wards are known as 'Acute respiratory infection virtual wards' (ART-VW). NHS England deems that these should be available for referral of adults, by registered professionals e.g., GP, with primary diagnosis of a respiratory infection – this may include COVID-19. The intention is to treat patients needing acute care and prevent their admission to hospital. Importantly, this ward is not designed for the management or treatment of chronic diseases such as Asthma (17). A 2021

study¹ investigated the helpfulness and challenges of using VW to aid early discharge of patients with covid-19 respiratory symptoms, saw 65 patients from discharge from hospital until discharge from the VW. The study highlights that prior to VW implementations, in November 2020 mean length of hospital stay (for patients not accessing high dependency care) was 5.5 days, this was reduced to 3.3 days when patients were discharged to VW (18). What is important to note, though, is that this study is limited by not having a case-matched control group for comparison data, meanwhile cost outputs are based on point estimates and not actual figures.

Initially designed to relieve the pressure that readmissions place on NHS hospitals, VW have since found value in monitoring patients with chronic and persistent health conditions, in order to prevent hospital admission all together. Northampton General Hospital found that implementing VW for asthma patients' during the COVID-19 pandemic resulted in benefits for the patients; reduced admission, early discharge and improved patient care, as well as for the hospital; increased clinical capacity. Also noted here was that asthma patients themselves like the use of a VW, it poses less inconvenience of hospital admissions e.g., finding childcare as a single parent, and encourages living a 'normal' life despite the debilitations that come with having a chronic illness (19).

Also benefitting from the implementations of VW are Chronic Obstructive Pulmonary Disease (COPD) sufferers, these VW aim to support early and safe discharge from hospitals. These wards are secondary care led, consisting of a multidisciplinary team including respiratory specialists, nurses, and advanced practitioners just to name a few; a clinician oversees the clinical care of patients and telephone consultations take place regularly (20). Paneroni et al., (21) looked at the feasibility, adherence to and satisfaction of home-based reinforcement telerehabilitation program (TRP) for Chronic Obstructive Pulmonary disease by comparing its outcomes to a standard outpatient rehabilitation program (ORP). The TRP program mirrored that of a typical ORP program, with the implementation of a tailored approach individual to each patient; on the

¹ Study not yet peer reviewed and so conclusions should be inferred with caution and not yet used to directly guide clinical practice.

TRP program patients reported their results before and after prescribed exercises via a remote-controlled TV monitor. Results of this comparison study showed TRP to be acceptable for 82% of patients who fit inclusion criteria, providing a positive experience related to patients' clinical expectations for 88% of participants. Furthermore, 88% also stated they would recommend the treatment to others. Notably, although there were little statistically significant differences between methods (ORP vs TRP) with both producing significant improvements for walking capacity and quality of life, improved dyspnoea (a common side effect of COPD) rates were found in a higher percentage of participants in the TRP group. The study does however list selection bias as a limitation, as participants who agreed to participate are likely more open to trying new experiences with treatments. Although in some cases difficulty with using technology was reported, suggesting that not all those who agreed to take part are particularly 'tech savvy', and their results may still be that of a true experience of TRP. This study goes in support of the use of Telehealth services for rehabilitation of those with respiratory problems, with results at least as good as that of traditional methods. It also highlights the importance of providing sufficient training and information upon its implementation, for best possible performance. Also used for COPD, specifically for patients with chronic respiratory failure, is a treatment called Long Term Oxygen Therapy (LTOT), which involves the use of oxygen which is breathed in through a tube placed just inside the nose, for a minimum of 15 hours per day. It requires close monitoring to ensure its usage is safe and sufficient – most of this monitoring involves hospital-based tests, but there are concerns over their validity; they may not be predictive of actual oxygen demand, especially during physical activity. Following a study of real-time monitoring of LTOT patients using a Bluetooth enabled oximeter sensor and an accelerometer, which sent results to a mobile phone which uploaded them to a server for observations. Patients were 76% satisfied with user friendliness of the monitoring, alongside results that indicate standard in hospital assessments may incorrectly predict oxygen demand. The study concluded that a telemonitoring system for LTOT which combines oximetry with physical activity evaluation, can enable more accurate and valid prescription of oxygen (22).

Fernandez-Granero et al., (23) highlighted hospitalisations as a result of Acute Exacerbations of COPD (AECOPD) to be a costly area of COPD complications. They investigated the feasibility of AECOPD prediction using a multimodal telemonitoring mobile health system. 16 patients used a dedicated mobile device to respond to daily questionnaires, with responses being sent to a telemedical server within the hospital. This was then classified using an automatic classifier developed for the purpose of the study, which would trigger an alarm if there were 2 consecutive days of exacerbations. Patients engaged with this at-home telemonitoring for 6 months, following which it was found that 80.5% of AECOPD incidents were detected early, with an average of 4.8 days prior to onset. The novel strategy utilised in this study allowed for an increased precision of AECOPD detection, simultaneously enabling estimation of severity and duration of episodes. Furthermore, this enabled unreported AECOPD detection, in which 7/8 unreported AECOPD episodes were detected throughout the study. It was concluded that the telemonitoring mobile health system allowed for empowerment of self-management of COPD, also improving clinical efficiency of AECOPD prediction. More research is required into the area with a larger sample size; however, this study provides yet further support for the notion that COPD can be better managed with the adaption and utilisations of Telehealth

A VW model for post discharge covid-19 care in Singapore was adapted from an existing Hospital at Home model of Telehealth (24); patients admitted to the ward were provided with an admission package which included instructions and equipment for home monitoring and uploaded their parameter to a clinical dashboard via secure messaging; daily consultations via video or telephone were conducted alongside this. It was found that 717 days of hospitalisation were avoided (7.9 days per patient), concluding that the programme did demonstrate the possibility to expect covid-19 patients to safely recover at home when placed onto a VW.

A further Singapore study aimed to address the impact of using virtual wards for early discharge (referral from covid-19 inpatient ward) and admission avoidance (direct referral from primary care) of patients with confirmed or suspected covid-19. Ko et al., (25) observed the outcomes of

238 patients admitted to a COVID virtual ward over a 48-day period in autumn 2021. These were made up of patients transferred from hospital COVID wards (early discharge), and admissions from emergency departments or community referrals (admission avoidance), split 58% and 42% respectively. Patient demographics, utilisation measures and clinical outcomes were retrieved from the electronic health record system, whilst primary outcomes were escalation to hospital and mortality. Patient experience was also evaluated via a quality improvement feedback form. In total, 15.9% of the early discharge group, and 19% of the admission avoidance group, were admitted to hospital from the virtual ward, totalling to 41 patients overall. Despite this, mortality rate was low at 2.1%, all patients died of covid-19 pneumonia and had either been escalated to hospital or put on end-of-life care at home. Feedback from patient and caregiver experience was largely positive, with over 90% rating 4/5 for safety at home and ease of use, meanwhile 100% of patients reported that they would recommend the programme to others. The findings of this study indicate that virtual wards can provide a safe, easy and efficient alternative to in-hospital care for a cohort of covid-19 patients.

In a rapid systematic review, Vindrola-Padros et al., (26) carried out an analysis of the employment and impact of Telehealth (specifically remote monitoring) for COVID-19 patients. They sought to answer questions about determining appropriate patient populations, recognising patient deterioration, and expected outcomes of Telehealth implementation. Using PICO analysis and discussed inclusion criteria, 11 articles were eventually included in the review. It was concluded that to develop a successful and useful pathway, primary and secondary care collaboration is recommended, along with primary care led pathways seemingly easier to adapt with developing patient needs. It was noted that the use of apps made follow-up of a higher volume of patients more manageable, but the ability to also conduct telephone-call follow ups was more inclusive to less digitally able patients. The review also tells that in cases where patient engagement is higher, better patient outcomes are seen, therefore the authors highlight the importance of recording such data where possible. Most identified limitations were associated with use of pulse oximetry; some articles appeared to argue that pulse oximetry can successfully

and safely identify the need for hospitalisation when using a 92% saturation level cut off. However, the authors of this review state they struggled to reach decisions about patient safety and how well Telehealth can actually detect deterioration at earlier stages in the disease journey. It is stated that a lack of standardised reporting also makes it difficult to make these conclusions and achieve thresholds. This review further supports the notion that a lack of 'universally agreed' approaches to the telehealth world is continuing to create barriers for its development, however it does well at collecting recent evidence of using Telehealth for COVID-19 patients.

Cushen and colleagues (27) also explored the feasibility and clinical outcomes of using a community virtual ward (CVW) over a period of 12 weeks in Autumn 2020 for management of chronic respiratory disease, through comparison of symptoms and health status of 20 patients on admission and discharge. Patients were given Telehealth equipment to monitor and record their oxygen saturation, heart rate and spirometry quantities on a password-protected patient and hospital portal, via a Bluetooth-enabled device (smartphone/tablet). Patients had a diagnosis of either asthma, COPD or asthma and COPD combined, with comorbidities of cardiovascular disease or anxiety/depression. It was reported that all patients admitted were successfully managed at home, length of stay ranged from 5 to 24 days, with average at 10 days. Prior to admission, symptom burden was reported as high, which decreased on reassessment at discharge, meanwhile scores on an asthma control test were also improved by discharge. All reported improvements were deemed clinically significant, from both a symptom and health status perspective, and therefore determined a CVW to be a feasible and acceptable method of management of chronic respiratory disease patients. As is consistent with other studies, the paper does highlight the importance of home visits to identify barriers and individual patient circumstances; physical presence at a patients' home enhances a clinical teams' understanding of a patients physical and social environment. Additionally, any associated psychological factors that may encourage or inhibit a patients' ability to adhere to disease management recommendations and requirements can be identified. Notably though, this study only consists of a small sample group (20 patients), and does not consist of a control group for comparison, which would further

validate the conclusions presented and potentially demonstrate further perceived benefits or challenges of CVW vs. In-hospital care.

3.2 Cardiovascular Disease

A systematic review (16) previously mentioned in the HTW report which evaluated the use of VW for heart failure patients, concluded that patients on post-discharge VW had a reduced risk of mortality and hospital readmission. This provides strength to the argument that Telehealth has further benefits to usual community-based care among patients with heart failure. As the costs of atrial fibrillation (AF) hospital admissions continue to mount on the NHS, Kotb et al., (28) has explored how virtual AF wards may have the ability to reshape the future for AF management. Patients with a primary AF diagnosis were admitted to a VW whereby they could access an electrocardiogram recording device, Bluetooth integrated blood pressure machine and a pulse oximeter to provide daily readings via smart phone or tablet. The information is uploaded to an integrated digital platform for review by a multidisciplinary clinical team undertaking twice daily VW rounds. After a 6-week period, the results of 13 patients yielded 100% positive patient experience, with evidence suggestive of reduced financial burden of AF on the NHS, as well as reduced backlog pressures, all whilst maintaining patients' quality of care and safety. There will however be a requirement for further research to be conducted to provide additional support to these conclusions, specifically with a larger patient cohort.

As a common risk factor of cardiovascular disease, the importance of accurately monitoring and treating hypertension is evident. Kaihara et al., (29) observed the use of telemonitoring to control blood pressure on a remote Japanese Island in a randomised control trial; 60 participants, all of whom had hypertension or possible hypotension, were assigned to either a Telemonitoring group or Control group. The study looked at both home blood pressure (HBP) and office blood pressure (OBP) monitoring. HBP was self-measured by participants in the morning and evening, using three consecutive 15-second intervals. The telemonitoring group also utilised blood pressure monitors with a telemonitoring system, in which data was stored and sent to a secure website,

whilst the control group utilised conventional blood pressure monitors. OBP was measured using conventional blood pressure monitors on the first, fourteenth and twenty-eighth days, also using three consecutive 15-second intervals. It was found that reductions in morning and evening systolic blood pressure were greater in the telemonitoring group as compared to the control. Furthermore, motivation to perform HBP measurements was found to be higher in the telemonitoring as opposed to the control group. These results would suggest that when patients accept the responsibility of performing routine self-monitoring in the comfort of their own home, they are more likely to comply with treatment requirements.

Also seeking to understand how to improve the control of blood pressure and hypertension, Bernocchi et al., (30) carried out a non-randomised trial to evaluate the effectiveness of how home-based telemedicine services perform for uncontrolled hypertension. The results of 74 patients assigned to a home-based telemedicine (HBT) programme were compared to that of 94 patients who received usual care. The HBT group were educated by a nurse on how to correctly take their blood pressure measurements at home – these measurements were sent via Bluetooth to a mobile phone, which uploaded them to a server for observation by a nurse who could adjust the course of treatment where required. This educational session was later noted fundamental to the success of treatment, with the researchers highlighting how it increases patient motivation to take control and accountability of their course of treatment, in turn leading to more positive outcomes. The group also received scheduled telephone appointments during which a nurse interviewed the patient on their general clinical condition and provided counselling on common hypertension risk factors. The usual care group were followed by their GP without any structured program. The results of the study indicated that whilst technology alone is unlikely to increase a patient's self-management goals and patient outcomes, a more structured and hands-on approach to compliance with regular BP monitoring and adjustments to treatment, influenced more directly and often by nurses and healthcare professionals, can have a positive impact on blood pressure control. This study offers support for the use of Telehealth in treating uncontrolled hypertension by showing the role it can play not only in providing nurses and other healthcare

professionals with the ability to monitor patients more closely, but also provides patients with a sense of control and responsibility for their own health.

In an effort to improve safety of patients with implantable cardioverter defibrillators (ICD), Bifulco et al., (31) explored how Telehealth has a role to play in ensuring patients are less likely to experience inappropriate shocks which can impair patients' quality of life. ICDs are battery powered devices placed under the skin to keep track of heart rate, playing a vital role for who have life threatening arrhythmia (32). Internationally recognised guidelines recommend ICD patients should be followed-up every 3-6 months, with increased frequency as battery life of the ICD reduces, to ensure the device is functioning correctly and safely; this report highlights how this could be better managed and more closely monitored with the implementation of Telehealth. Bifulco and colleagues discussed how ICD routine follow up lends itself to a Telehealth approach, in the sense that clinicians can keep a 'closer eye' on patients; effective care can be provided with opportunity for enhanced patient safety and potentially reduced costs. This report is an example of how Telehealth can be implemented not only to reduce costs and increased availability of services but also to enhance the quality of services for complicated health conditions, whilst improving patient safety and experience.

To evaluate Telehealth efficiently, potential problems and limitations need to be considered. Siebermair et al., (33) investigated this in a study which used a telemonitoring system for patients with cardiovascular issues, that automatically transmitted data of ICDs to a service centre using a standard phone line. Six months after enrolment, the first analysis of the Telehealth data was carried out and those who had unsuccessful transmissions were informed, admitted to the clinic and given extensive set-up training. Notably, no on-site training or support was offered once patients were set up. The next analysis was performed at 12 months, and thereafter the final was at 16 months. Results showed that after 16 months, 23.9% of patients had failed to transmit their data. The most common reason for this was patients had lost initial interest in the telemonitoring system, so refused to install it (50% of patients). Mental overload was identified as the most

influential factor in loss of interest, alongside lack of support from the responsible individuals regarding the telemonitoring system; a further 26% reported technical issues during installation. Demographic data was also considered in analysis, finding that patients with a shorter distance to the clinic performed the first transmission earlier and then more frequently, whilst age showed as an insignificant trend towards less successful first transmission rates. However, when the authors conducted a separate analysis of the patient group that had lost interest, they found a significantly higher mean age compared to a group made up of all other reasons of unsuccessful transmission. This led the authors to draw a tentative conclusion of age playing a potential role in regard to patient motivation to engage with Telehealth and therefore highlights it as a factor to address in the roll out of Telehealth services. This study presents some of the many possible challenges which may be encountered when implementing Telehealth to manage cardiovascular disease, but as most of the issues raised are not directly related to technology or tools only seen on a cardiovascular virtual ward, it is important to consider that these challenges may not be exclusive to a cardiovascular Telehealth service.

3.3 Frailty

Another health condition VW have been seen to help is frailty; where the aim is to monitor individuals to prevent hospital admission or social care interventions, by managing and stabilising their condition with at-home care (34). A UK case study of VW for frail people in Leeds claims to have saved nearly 10,000 hospital beds since 2019, and coordinates care for up to 70 moderately to severely frail individuals in their own homes across Leeds at a given time (35).

Teo and Wright (36) aimed to establish the ability of a virtual ward to avoid hospital readmission for frailty patients. Patients discharged from the Emergency Department and the Acute Family Unit are followed up by nurses through Virtual Frailty Wards (VFW). In an acute hospital setting, VFW has reduced the length of stay for frail elderly patients, ensured patient safety, and been successful in the prevention of hospital readmissions while co-ordinating with community

services. It would be fair to say that the use of Telehealth in caring for frailty patients can positively impact the strain placed on the NHS by frailty, as well as quality of patient life; arguably a significant benefit to the use of Telehealth due to the importance of everyday for the elderly and their loved ones.

In a 2022 risk prediction exercise, Lewis et al., (37) collected prospective data on patients admitted to a community virtual ward (CVW) in Ireland designed to reduce adverse events in frail community dwelling patients; regression analysis was used to examine relationships between risk, health states and adverse outcomes and 3 set stages after implementation. The results of 88 community dwelling frailty patients, mean age 82.8 years, showed that CVW enable better care at home, with fewer episodes of increased care requirement, alongside fewer occasions of intervention by healthcare professionals. Results also found a significant reduction in the number of falls, as well as reduced unplanned hospital visits, and clinically meaningful indications that self-neglect was more easily recognised among the CVW population. The conclusions of the study included how a CVW can provide an efficient framework for case management of frailty patients, at the benefit of them remaining at home, whilst there was better ability to recognise when institutional care may be required. This provides yet further evidence and support for the notion that Telehealth can enhance the quality of life of, and care provided to, the elderly frail population.

Westby et al., (38) recently developed a rapid realist review, which aims to identify different types of frailty VW, as well as address how and why virtual wards can offer safe and effective frailty care; doing so by considering the findings and conclusions of 28 pieces of either published or grey literature. It is reported that a frailty VW can be short term and acute, whereby a patient is admitted when very near to or already in crisis, and consequently receives acute reactive care; long-term they are discharged to primary care. Alternatively, they can also be long-term and preventative, whereby patients admitted are those determined to be at high-risk of deterioration or admission to in-hospital care. Information sharing processes are also discussed, and it is informed when this is done best, professionals are better informed and feel more confident

making decisions, since they have a view of the whole patient record, a clinical team is in a better position when it is fully informed; this also provides caregivers and patients with better confidence in the care being received. Furthermore, multi-disciplinary team meetings are recommended to ensure a holistic method of patient management is achieved, with decision making processes also enhanced in efficiency and effectiveness. The review details several other important components of VW, but, on the whole, recommends that frailty VW should be observed from a long-term and sustainable perspective that prioritises hands-on care from a standpoint of reducing risk of future crises.²

3.4 Diabetes

The effectiveness of Telehealth for individuals with diabetes has been investigated by Aikens et al., (39). They identified that individuals with diabetes, and their social networks, often have informational support gaps, for a variety of reasons including caregiver burnout, insufficient information regarding patients' self-management (specifically for long-distance caregivers) and a lack of tools required to monitor patients' health changes. A mobile health service was created to address these gaps. Within the mobile health service, weekly interactive voice response (IVR) calls were implemented to provide immediate support and monitor self-management, where patients would respond to automated prompts. These calls also included an assessment of health status and self-care of patients. Structured updates were provided to out-of-home patient caregivers regarding the patients' health status, as well as notifying primary healthcare teams if patients encountered abnormal patterns regarding blood glucose or blood pressure levels. Caregivers were also provided with structured guidance to help support the patient's self-management. Patients were enrolled to the program for two durations, initially for a 3-month period, and then for a 6-month period following promising initial results. It was found that the intervention significantly improved medication adherence, physical functioning, depressive symptoms and diabetes related stress. When looking at self-management concerns, the

² Report is a preprint and therefore is yet to be peer reviewed, so should not yet be used to directly guide clinical practice.

intervention also significantly improved checking feet regularity and frequency of abnormal self-monitored blood glucose readings. Whilst results appear to be encouraging, the study did not utilise a control group, meaning there may have been extraneous variables that impacted the results seen. Secondly, all data was self-reported, raising concerns regarding social desirability bias and recall effects, reducing the validity of the results. Further research should be carried out utilising a randomised control trial, as well as looking to utilise more sources of health information that are not self-reported.

In addition to how Telehealth can perform, it is also important to consider patient perception of Telehealth for complicated health conditions – diabetes being one of them. Smartphone-based artificial pancreas (AP) systems collect data which could aid the use of Telehealth in the treatment of blood glucose control; Place et al., (4) asked 20 experienced patients who tested AP and Telehealth in an outpatient study in France and Italy to respond to an online questionnaire consisting of 11 items. Although the sample size of this study was very small to begin with, and just 17 patients responding, all of them reported that Telehealth was useful, reassuring and essential to the success of blood glucose control; 88% believed that Telehealth should go hand in hand with AP but only when absolutely necessary, with 75% believing that Telehealth could help lead to improvement of blood glucose control. Larger studies must be performed with a validated questionnaire and a larger sample size with wider populations, but this study is able to demonstrate how patients' perceptions of Telehealth are positive; they understand how Telehealth can allow for full access to their own medical data, as well as how it provides opportunity for better access to a clinician when necessary.

Lau et al., (41) investigated the effect of patient use of a patient portal on diabetes outcomes. All patients participated in a 15-minute diabetes education session initially. They were also introduced to a free web-based patient portal, no training for this was provided but telephone support was available, with calls aimed to be returned within 48 hours. The patient portal provided medical education documents, personal lab values and a secure messaging system to

ask questions to their caregivers involved in diabetes care. Patients completed an initial A1C test, that measured their average blood sugar level over the last 3 months, and a follow-up A1C test between 6 months and 2 years after the initial A1C test. If patients completed multiple A1C tests in this time, the latest one was used for comparison. It was found that patients that utilised the patient portal were more likely to have A1C under control and lower A1C levels at follow-up, leading the authors to conclude that accessing a patient portal is linked to improved glycaemic control. Again, Telehealth is presented to be an effective method of encouraging patients to be more concerned about their healthcare, alongside better compliance with treatment.

3.5 Mental Health

Whilst many previously mentioned studies have looked at Telehealth in relation to physical health conditions, a study by Price and Gros (42) looked at Telehealth efficacy for mental health conditions, specifically looking at previous Telehealth experience as a moderator for treatment response of PTSD and depression in veterans. Participants engaged in 8 sessions of Behavioural Activation and Therapeutic Exposure (BA-TE), which were designed to improve treatment outcome of patients with PTSD and depression. Participants engaged in these sessions using home treatments using home-based technologies, in which they used either an internet-based instant video service or an analogue videophone operating via telephone service. It was found that comfort and previous experience with Telehealth or televideo technology both had no effect on treatment response, even after controlling for age. The authors concluded that clinicians, therefore, should not hesitate to use Telehealth for the reasoning of patients not feeling comfortable or not having previous experience using Telehealth. However, the clinicians involved in delivering the care via Telehealth in this study were highly trained in the usage of Telehealth, and thus were able to deal with any troubleshooting issues quickly themselves, making the experience more seamless. This is often not the case with Telehealth delivery in a healthcare setting. This study also utilised a sample of only veterans, who have used Telehealth technology

or have been exposed to it frequently, thus they may have a higher baseline level of experience, familiarity and comfort with Telehealth.

Integrated Telehealth care could also serve as a platform for treating older adults with chronic illnesses and comorbid depression in a hospital-affiliated home healthcare setting as suggested by Gellis, Kenaley and Have (43), who evaluated an integrated Telehealth intervention (Telehealth education and Activation of Mood; I-Team) in a bid to improve specific chronic illness (congestive heart failure, COPD and comorbid depression) in a home healthcare setting with medically frail older homebound individuals (n = 102). The randomised controlled trial consisted of two groups, a control group (UC+P) who were allocated normal in-home nursing and psychoeducation and an intervention group (ITEAM) who received integrated Telehealth chronic illness and depression care, a Telehealth nurse who conducted daily monitoring of body weight, medication use, symptoms, weekly sessions of problem solving treatment for depression and communication with primary care physicians who prescribed antidepressants. The groups were compared at baseline, 3 and 6 months on clinical measures and then at 12 months on health utilization. Results showed that the ITEAM group had 50% lower depression scores and significantly improved problem-solving and self-efficacy in managing their medical conditions, as well as having significantly fewer emergency department visits (p=0.01) but did not have significantly less days spent in hospital after 12 months. This suggests that integrated Telehealth care packages for older adults with certain chronic illnesses and comorbid depression can reduce symptoms and reduce physical hospital visits in home health settings.

Mood disorders are often associated with high levels of morbidity and mortality causing massive costs in society due to their high prevalence, early onset, and episodic course. The burden with assessing and treating mood disorders can be caused by numerous factors but are mainly due to major difficulties with patients care, such as pharmacological treatment, as well as patient relapses. In the field of mood disorders there has been considerable progress over the last few decades, from using a pen and pencil with various assessment methods to more sophisticated and

targeted methods such as wearable systems. Javelot et al., (44) highlighted the PSYCHE project (Personalised Monitoring Systems for Care in Mental Health) who have developed fully interactive systems that focus on the long and short-term recording of set clinical parameters from patients who are affected by mood disorders using wearable recording devices such as smart fibres, interactive textiles as well as smartphones. Studies of bipolar disorder have addressed the questions of benefits from monitoring physiological parameters and mood changes as potential predictors of relapses. The PSYCHE system could offer a user-friendly way of collecting multivariable multiparametric data building on preliminary studies that showed the potential of single parameters to record and identify mood states. They highlight that although there has been a dramatic increase of knowledge in the field of mood disorders and wearable monitoring systems that there still is a lot to learn; however, it is now possible to actively promote wearable health systems in the mental health field highlighting the many protocols for assessing the benefits of multiparameter monitoring with different pathologies along the bipolar disorder spectrum. This paper suggests that the healthcare system could look very different in the future by reshaping the positions of patients and clinicians, however particular thoughts should be targeted toward the exact future of this field as there are many challenges, risks and questions that could provide many useful opportunities in the future.

To deter patients away from hospital admission, a virtual psychiatric acute care ward was launched in Canada, which used daily video or telephone calls to deliver remote treatment. Documentation of emergency department visits and hospitalisation for the 6 months prior to admission and 30 days following discharge was obtained. Castillo et al., (45) reported that the costs of the virtual ward were lower than in hospital care, meanwhile patient outcomes included 75 cases of suicidal behaviour and 38 cases of psychosis or mania; this was the only predictor of in-hospital transfer. Although a full-text copy of this study is not available to review the full discussion, it does conclude that a virtual ward for psychiatric care is both feasible and effective, whilst potentially being a cost-saving intervention for psychiatric care, specifically in the case of

hospital admission-avoidance. This paper is another example of how Telehealth can be utilised for successful monitoring and management of mental health.

3.6 Other health conditions

Some studies, however, have found that VW have no significant impact on a patient's outcomes, across a variety of clinical settings including dialysis or patients with severe respiratory illnesses. Gallier et al., (46) reported that discharging patients from an in-hospital covid-19 ward without a virtual ward did not result in an increased volume of negative outcomes such as re-admissions or deaths compared to outcomes published data for virtual ward discharges. Furthermore, Dhalla et al., (47) reported that no statistically significant effect of discharging a patient to virtual ward care, for rates of readmission or death.

For end stage renal disease, it has been suggested that VW could address the care gaps which incur as part of hospital discharge to at home care, and potentially reduce the rate of hospitalisation. In a pilot trial (48) assessing the feasibility and practicality of implementing a Home Dialysis VW (HDVW), patients were admitted to the ward for; (1) after hospital discharge, (2) completion of in-hospital medical procedure, (3) antibiotic prescription, (4) completion of home dialysis training. These patients were followed for a 2-week period and were assessed via clinical led telephone interview to oversee care gaps including requirement for change in prescription, or requirement for co-ordination in follow up care. Primarily, it was proven that HDVW can be feasible and practical, with care gaps identified in 67% of the VW admissions. The pilot study successfully demonstrates the potential for Telehealth to aid in and even improve the quality of post-hospital care for ESRD patients during a window of vulnerability, which in turn presents benefits for both the patient and the service.

Adherence to treatment of children with allergic rhinoconjunctivitis during the grass pollen season using internet based telemonitoring suggests that it may enhance their treatment (49). Children and adolescents with moderate-to-severe seasonal allergic rhinoconjunctivitis to grass pollen, who require daily administration of a nasal corticosteroid (NCS Mometasone) were recruited into

a paediatric allergy practice and were randomised into either an internet-based monitoring group (Allergy Monitor, AM) or to a usual care group (no diary, control) and studied between 13th May (2013) to 15th June (2013) with an intermediate visit halfway through. Principal adherence to therapy was shown as the intake of at least 0.190 g/day of momestone which corresponds as one puff through a nostril per day and was measured by canister weights during the middle and end of the study period. Secondary outcomes were measured by the reported disease severity (validated self-questionnaire), quality of life (AdoIRQLQ questionnaire), disease knowledge (multiple choice questionnaire), nasal flow and resistance at baseline and at the end of the study. Results showed that the use of momestone as both optimal adherence rate (48.4% vs. 12.5%; $P = 0.002$) and average daily use (0.20 ± 0.12 g/day vs. 0.15 ± 0.07 g/day; $P = 0.037$) was higher in the AM group ($n = 31$) than the control ($n = 32$). Disease knowledge also improved in the AM group ($P < 0.001$) compared to the control group ($P > 0.05$). However, no differences were observed in the reported severity of the disease, nasal flow, resistance and quality of life at both baseline and follow-up visits, which suggests that internet based telemonitoring improves adherence to NCS treatment and disease knowledge amongst young people with seasonal allergic rhinoconjunctivitis.

Telemonitoring of physical activity and nutrition has also been highlighted to aid with weight loss and markers of metabolic syndrome over a period of 12 months (50). In Germany, 184 patients with metabolic syndrome attended a two-hour meeting concerning the importance of physical activity and a combination diet. They were then randomised into a control group ($n = 62$) or one of two different intervention groups, Active Body Control Program (ABC Group - University of Magdeburg) whose information and motivation was delivered by weekly letters ($n = 60$) and the 4S (4Sigma) telephone coaching intervention group ($n = 58$), whose motivation was delivered by monthly telephone calls from carers, both groups were also issued accelerometers. Clinical and biochemical data was collected at 0, 4, 8, and 12 months without any face-to-face meetings between patients and carers. The primary endpoint was loss of weight, and the secondary endpoint was the presence of metabolic syndrome. This study demonstrated that the after 12

months the control group's weight losses were 3.7%, the 4S group's weight loss was 8.6% and the ABC group's weight loss 11.4%. Between the two intervention groups (ABC and 4S), the ABC group was more effective than the 4S group ($p = 0.041$). The diagnosis of metabolic syndrome was also no longer applicable in 58% of the ABC group, 41% of the 4S group and 33% of the control group which suggests that telemonitoring of physical activity and nutrition improves weight loss and markers of metabolic syndrome.

Those who suffer from headaches and live in rural areas far from treatment centres are at increased risk of unmet needs which is a concern for medical professionals, however, with the rapid development of communication technology such as Telehealth it could serve as an opportunity to treat these patients who have limited or no access. Dick et al., (51) demonstrated this opportunity with adolescent and adult outpatients with severe headaches who had been referred to a pain management programme (Pain101) at a tertiary care hospital and comparing those who attended in person to those who attended via Telehealth platform. The programme focused on pain education, cognitive reappraisal, emotional regulation, activity management, and reducing physiological arousal. No significant differences were found between patients who attended in person to those who attended via the Telehealth platform, and several patients reported that they would not have been able to attend without the option of Telehealth, with cost saving estimated to be 1650-6600Euros. There were several complaints regarding the Telehealth delivery which were regarded as technical difficulties and some reported not feeling as involved as other patients who were physically involved in a group setting, however, strong support for Telehealth technology was found for those with severe headaches who live far from treatment centres and potentially could serve as an effective tool in delivering headache treatment in the future.

Following the above discussions spanning several types of VW and conditions that can be treated by Telehealth, the majority of studies do support its use and claim it can enhance the quality of care provided to patients, alongside more positive patient outcomes (25, 27, 30). Some studies,

however, have found that VW have no significant impact on a patient's outcomes, across a variety of clinical settings including dialysis or patients with severe respiratory illnesses (46, 47).

4. Considerations

4.1 Stakeholder satisfaction

Most studies discussed thus far have indicated that patients tend to be satisfied with their care and treatment when enrolled onto a Telehealth service, providing the necessary training and instructions are implemented for ease of use. During the Covid-19 pandemic, Telehealth models were implemented to prevent unnecessary hospitalisations and infection and appropriately escalate care. It is recommended that patients take and record readings and escalate care if necessary. Walton et al., (52) evaluated a Telehealth model for Covid-19, to assess patient engagement and experiences. During March to June 2021, an England-based rapid mixed-method study was conducted; surveying patients and carers remotely and conducting semi structured interviews. Rapid assessment procedures sheets were used to summarise the interview findings, thematic analysis was carried out. In addition, descriptive statistics were used to analyse survey data. Walton et al (52) found that positive experiences were reported by patients and caregivers who feel they received excellent care and were reassured by the service and human contact. Despite this, some patients and caregivers expressed concerns about engagement, such as escalation hesitancy. Several factors influenced engagement, including the support of the family, the level of service provided, and accessibility to information and equipment.

Alongside patient satisfaction, which is the focus of most telemedicine studies currently, the importance of clinician satisfaction and attitude in the implementation of successful Telehealth practice has been highlighted by some researchers. Thus far, clinicians have tended to be in favour and more satisfied with telemedicine (Telehealth) based on four factors: if they have contributed in some way to its development, sufficient admin support for the programme, reliable and easy-to-use technology, and adequate reimbursement for its use. In a review, Ramsey et al., (53) stated

that most clinicians recognise how telemedicine can lead to improved access to care for those geographically distant from a healthcare setting, as well as those who are homebound or without an easy method of travel to a healthcare setting. It seems that although evidence which incorporates clinician satisfaction and acceptance is limited, there does seem to be clinician support of Telehealth programmes, providing they are suitable and sufficient for use.

A study by Sharma and Clarke (54) looked to investigate potential challenges of implementing Telehealth from the perspective of staff involved day-to-day - nurses and community support workers. Data was initially collected, with staff who had some experience with Telehealth ranging from 0-6 months, by holding discussions focusing on pre-conceived notions of Telehealth. One year into Telehealth roll-out, in-depth interviews were carried out to investigate actual experiences of staff with implementing Telehealth. The main theme that arose from data analysis was that Telehealth was a threat to staff's existing roles, the first main area within this being threat to daily work routine. Initially, Telehealth was perceived to add to complex daily user routines and workload, due to equipment installation/maintenance, patient education/assessment and data access via computer. Nurses were also given the task of installing equipment into patients' homes, which they felt was not a part of their role. Data was also required to be added onto two data systems, which increased workload and did not change after a year. After a year, equipment installation was delegated to engineers, and the positive belief of preventing possible hospital readmissions emerged in nurses. Both nurses and community support workers felt they would prefer to give initial training to patients on the Telehealth service rather than an engineer, as they held a relationship with them. The second main area of perceived threat was change to patient interaction. Concerns were raised over Telehealth's ability to diagnose underlying health problems and its contribution to social exclusion. After a year, nurses described Telehealth now as an additional monitoring tool, rather than an alternative to face-to-face visits. They also described a better understanding of its uses and limitations. The final main area of perceived threat was changes to skill set and expertise. Nurses felt their expertise were being challenged by Telehealth, exacerbated by a lack of appropriate training and support. After

a year, many issues surrounding training/support were addressed, however the solutions had been recognised as untimely; many had forgotten how to use the equipment due to training being carried out several months prior. This study demonstrates some of the many potential issues and concerns that may arise with both patients and clinicians upon the implementation of Telehealth, and therefore is useful to inform teams about challenges to expect and consider for upon the employment of a Telehealth service.

Levine et al, (55) sought out to improve understanding of patient perceptions of a healthcare approach that uses Telehealth, 'home hospital'. To do so, a randomised controlled trial took place with 36 patients, of which 19 were being monitored on 'home hospital' and the other 17 receiving in-hospital care; feedback of experiences was obtained via telephone interviews. Upon thematic content analysis of themes portrayed during interviews, three emerged. The first of which was clinician factors; patients felt that interpersonal and communication skills, as well as availability, continuity and expertise of the clinician were one of the most influential factors in the patient perceived experience with those patients receiving at home Telehealth. The second was factors promoting healing; patients at home felt that they got better quality sleep, were able to continue with some daily at home tasks (which aided in continued physical activity), received more social support from family and friends, plus environmental comforts at home promoted positive wellbeing, compared to those receiving in-hospital care who reported these experiences negatively. Both the Telehealth and control group spoke positively about safety; at home patients felt distanced from infections whilst those in-hospital felt reassured that a nurse or doctor was always nearby. The final theme was system factors, with patients at home reporting a positive experience with admission to the virtual platform, including how it was well explained by staff and they were easily accessible when needed. Contrastingly, the control group reported a less positive experience with admission, with some patients reportedly waiting 10 hours waiting to be moved from the emergency department to a ward. Notably, both groups report difficulties with discharge, with an element of confusion around continuing care and others feeling they had a lot to learn and re-learn when leaving hospital. Overall conclusions of this trial presented evidence

that being treated at home enables better and more positive experiences with healthcare overall, but reported difficulties do highlight that attention should be paid to the discharge process for either method of care, to ensure patients continue on a positive trajectory.

4.2 Effect on readmission/length of stay

Georghiou et al. (56) used retrospective patient-level hospital admissions data to build multivariate models. They wanted to analyse the relationship between the implementation of Covid Virtual Ward (CVW) services and hospital activity outcomes: length of Covid-19 related stays and subsequent Covid-19 readmissions within 28 days. More than 98% of Covid-19 hospital stays in England between August 2020 and February 2021 were included in the study. The study found a more extended stay for Covid-19 patients discharged from hospitals where CVW was available compared to patients discharged from hospitals with no CVW. Notably, findings showed no evidence to support the notion that availability of a CVW encourages early discharge or reduced readmissions. Although this study included a large amount of data on an all-England scale, national data tends to lack detail which may pose a barrier to discovering the true impact of a CVW, for example by observing data at local level and on a site-by-site basis. Future research aiming to address questions such as those in this study should make these considerations.

Ward et al (57) looked at the safety of providing oxygen at home to stable patients recovering from COVID-19. In a UK district general hospital, a retrospective analysis was conducted on patients discharged to a COVID-19 virtual ward between January 2021 and March 2021. It was open to patients with improving clinical trajectories and oxygen requirements up to 4 litres per minute. Mortality and readmission rates were measured after 30 days. In the CVW from January 2021 to March 2021 (74 days), 147 patients discharged were included, of whom 71 received continuous oxygen or continuous ambulatory oxygen, and 76 were checked with pulse oximetry only. Unfortunately, two patients died and five were readmitted within 30 days. The readmission and mortality rates did not differ significantly between those discharged with and without oxygen. Ward et al (57) concluded a minimal risk of death or readmission is associated with

supplying oxygen at home for patients recovering from COVID-19, therefore this research supports the body of evidence arguing that Telehealth can reduce readmission rates.

A quality improvement report (58) observed the use of virtual wards for improved practice and performance in long-term condition management. The ability of digital technology in transforming care for the better is discussed, along with how the Community of Practice (CoP) strategy can be utilised to enhance performance, knowledge and practice. It elaborates further on the benefits of using a CoP approach, highlighting that it provides space for knowledge to be shared across boundaries, generate and manage information resources to be drawn upon, and promote standardisation of practice and innovation. The study used CoP principles to support uptake of tech-enabled remote monitoring (Telehealth) solutions, and its qualitative findings showed that having nurses and clinicians at the heart of technological developments in care provided useful insights for technological capabilities.

In a 2022 systematic review and meta-analysis (59) of comparing mortality and hospital readmissions among patients receiving virtual ward transitional care vs usual post discharge care in Canada, it was found that post-discharge deaths and hospital readmissions were fewer in cases of virtual ward implementation for heart failure patients. Further to this, also reduced in all diseases were emergency department visits, length of hospital stays, and health care costs. This comparative review is a strong argument for the use of Telehealth benefits to be had are those extremely sought after for an NHS currently under immense pressures.

O'Malley et al., (60), aimed to evaluate the safety, utilisation, ability to reduce hospitalisation, readmission rates and overall outcomes of a covid-19 "step-down" virtual ward during 2021. In total 43 referrals were accepted, of which 39 were from the respiratory ward - four readmissions occurred due to hypoxia within 5 days of discharge to the virtual ward, all of these were escalated by the clinician on the virtual ward. Variations in conditions of patient included 72% discharged with ongoing oxygen requirement, 14.3% discharged with antibiotics, 9.5% discharged with steroids and 23.8% prescribed both antibiotics and steroids at discharge. The mean length of stay

on the virtual ward was 7.9 days for patients without oxygen requirement, and 15.1 days for this with. Even when combining these figures with length of stay in-hospital following admission from the virtual ward, length of stay times are still below that of a typical covid-19 in-patient, upholding the benefit that virtual wards can efficiently reduce patients' length of stay in hospital. The virtual ward model offered 4 pathways for patients depending on intensity of care required, ranging from mild (low acuity) to palliative. O'Malley and colleagues discuss how discharging patients from in-hospital care for covid-19, to a virtual ward, can ease the burden being faced around hospital bed availability, as well as enable patients to recover safely and effectively at home, despite being of high acuity. As with previous studies, this one also recommends that feedback relative to patient experience and engagement is obtained throughout virtual ward trials and pilots, to further establish the extent to which these factors are important in virtual ward success.

4.3 Cost Effectiveness

When considering the implementation of a virtual covid-19 ward, Swift et al., (61)³ reviewed its impact on resource use and lengths of stay in secondary and intermediate care. Observing the discharge of 310 covid-19 patients to a virtual ward, for reasons including recovery at home, to create bed availability or to aid with oxygen weaning at home, it was reported that the ward did deliver savings and benefits for both services providers and users. Results stated that 1,103 bed days and £529,719 in net financial savings across two groups of covid-19 patients; those going through process of weaning off oxygen following a bout of covid-19, and those with less severe covid disease. It was also reported that even without considering the likely savings of re-admission prevention, an estimated net saving per patient was £1,709. The VW was concluded to have enabled significant financial savings to be made in both groups of patients, at very low cost. Despite this type of ward being that of less dependent on immediate care patients, it does support

³ Paper is a preprint and therefore is yet to be peer reviewed, so should not yet be used to directly guide clinical practice, but to inform only.

the notion that Telehealth can be cost effective, however as it does make assumptions and estimations, its conclusions must be treated with caution.

Niu et al., (62) evaluated the cost effectiveness of Telehealth in a clinical trial whereby postpartum women with hypertension received a Bluetooth tablet, a blood pressure monitor and a scale to submit vitals every day for 6 weeks. Using hospital data, device supplier charges and utilities, a cost-effectiveness threshold was decided, and results indicated that Telehealth was cost-effective and cost-saving; Telehealth even presented cost-effective in comparison of admission cost per patient. Furthermore, the study also notes that Telehealth significantly reduced postpartum readmissions. This study provides more support that the use of Telehealth, is cost-effective and cost saving, and therefore stands in support of the use of Telehealth.

In a 2014 literature review of 32 studies, Grustam et al., (63) observed evidence of the cost effectiveness of Telehealth interventions for heart failure patients, considering studies that included the following in their title or abstract: Telehealth intervention, heart failure, economic analysis and a primary study. The literature was found to lack comprehensive economic evaluation which involved comparison of costs and effects between Telehealth interventions and a comparator; alongside this, data on investment cost of Telehealth was not presented in a number of studies. Studies that did include these, showed considerably low methodological quality, therefore inferring conclusions from these was difficult. The review was unable to determine the cost-effectiveness of Telehealth for chronic heart failure due to the insufficient quality of the available literature. What can be taken from this is that full analysis of all contributing factors must be considered when seeking to evaluate cost effectiveness of Telehealth, along with the utilisation of comparison to the costs associated with standard chronic heart failure care, or any alternative health condition that may be being investigated.

Following an earlier review in 2018 which observed the cost effectiveness of virtual wards, NICE have recently updated this, to consider and review economic evidence that technology enabled virtual wards/hospital-at-home are a cost-effective alternative to in hospital care (64). To do so,

it analysed literature published in the last decade, which investigated cost effectiveness of technology enabled virtual wards/hospital-at-home within the UK or from a healthcare system which aligns closely to the NHS; a total of 15 studies were included in this evaluation. Of these studies, 13 reported virtual wards/hospital-at-home to be cost saving, particularly from the perspective of saving bed days, and driving factors to enable cost savings include ensuring the correct people are identified and accepted onto virtual ward care, therefore reinforcing the need to ensure that clear guidelines and criteria are set for inclusion. The review consists of a detailed discussion and interpretation of several factors including; benefits and harms, impact on carers, health inequalities and applicability and limitations. Detailed in cost effectiveness is how although cost reduction is reported, concerns consistent with the work of Grustam et al., (63), concerns about how the majority of studies suffer from poor methodological quality, for example failure to perform sensitivity analysis, and cases of selective enrolment of 'less unwell' patients. These concerns bring doubt and limitations to the extent which their findings can be inferred and informs that future research should consider this in order for more powerful and valid conclusions to be drawn.

4.4 Effect on the caregiver

When considering and observing the use of Telehealth and remote monitoring, it is important to look at it all angles, one of which is the potential effect it can have, be that positive or negative, on family caregivers. A systematic review of studies with Telehealth interventions and family caregivers' outcomes, of both adult and older patients, as well as parental caregivers of paediatric parents, yielded further support for the use of remote monitoring technologies in that it is accepted and liked by caregivers. Chi and Demiris (65) included a total of 65 articles in their review, which comprised of a range of technologies in the form of video, web-based, telephone-based and Telehealth methods. Results showed that more than 95% of studies report significant improvements in caregiver outcomes, whereby they are satisfied and comfortable with the use of Telehealth modalities; reaching an overall conclusion that Telehealth can have a positive impact

on the care of chronic diseases outside of a hospital setting. The review goes on to note that alongside enhancement of care for the patient, family caregivers also benefit from more efficient communication with healthcare providers and more easily accessible care information (65).

Graven et al., (66) conducted a systematic review of literature published between Jan 2002 and Jan 2017, which aimed to provide an in-depth analysis of Telehealth intervention for family caregivers of individuals with chronic health conditions. Whilst the findings established that Telehealth is an effective method of caregiver intervention delivery, which can result in significant improvement for caregiver outcomes, it is concluded that further research is required to evaluate the effects of Telehealth on caregiving skills, self-efficacy and health outcomes. Particularly, the study states that telephone was the most frequently used method of Telehealth; Telehealth technologies have now progressed far beyond just the use of a telephone and so an accurate evaluation should consider these too.

As previously discussed in the frailty section of this review, Westby and colleagues (38) also examined the caregiver experience of frailty VW, it highlights how a caregiver should feel supported and reassured by the Telehealth systems and teams, not inhibited or burdened by it. Although experiences for caregivers and Telehealth is largely positive and seemingly improving the quality of care, they are able to provide, implications cannot be ignored and where the addition of more responsibilities with a VW, home-environments may not be suitable if it is deemed that a caregiver is unable to cope⁴.

4.5 Environmental factors

The introduction of Telehealth is not only beneficial for patients and clinicians, but also or the environment and the carbon footprint of healthcare. NHS is responsible for around 20 million tonnes of carbon dioxide emissions annually, with an expenditure of £50 million per year on carbon permits; 17% of this of linked to patient and staff travel (67). These figures are also high

⁴ Report is a preprint and therefore is yet to be peer reviewed, so should not yet be used to directly guide clinical practice.

in Wales, with 1 million tonnes of carbon dioxide emissions produced in 2018/19 (68). There is evidence to suggest that Telehealth can reduce the carbon footprint of healthcare, a 2021 systematic review concluded that of all identified papers it is unanimously reported that telemedicine reduces carbon footprint of healthcare, largely due to its reduction of transport-associated emissions (69). Furthermore, a recent article published in the journal of climate change and health details how the growth of telemedicine, which enables remote delivery of healthcare services, gives rise to the chance to reduce the carbon footprint associated with healthcare (70). The authors discuss how integrating telemedicine with artificial intelligence (AI) gives rise to further reduce the carbon footprint of healthcare through Telehealth, with less healthcare professionals required on standby and reduced A&E presentations, as well as a likely reduction in hospital admissions. Although the literature currently assessing the environmental factors associated with Telehealth is sparse, publications so far seem to support Telehealth as an environmentally positive intervention, especially from the perspective of the reduction in carbon emissions as a consequence of patient and staff travel.

4.6 Social Care

The literature is severely lacking in any research that observes the impact Telehealth can have on social care; Lewis et al. (71) examined whether a Community Virtual Ward (ComVW) model could help older adults with social care and complex health needs. A 12-month quantitative observational study was conducted on 54 patients. An analysis of matched data on bed days, emergency department presentations, and unplanned hospital admissions pre- and post-ComVW implementation and emergency department presentations was conducted using the sign-rank test. The Mann-Whitney test was used to examine other factors for hospital admission pre- and post-ComVW admission, such as falls, living alone, and cognition. The correlation between admission avoidance, unplanned hospital admissions, and emergency department presentations was tested using Spearman's ρ test. An improvement in Emergency Department (ED) presentations was seen following ComVW admission. Before admission, those living alone

presented to the ED less often than those living with a caregiver, but no differences were seen during admission to CVW. The study suggests that this is due to specialist MDT involvement during ComVW admissions; caregiver burn-out and stress has previously been associated with greater risk of ED presentations and hospital admissions of the patients. Each extra fall during ComVW admission doubled the odds of needing long-term care. ED presentations were associated with reduced cognition but not unplanned hospital admissions. The study found no significant correlations between the number of unplanned hospital admissions: admission avoidance, or ED presentations. Overall, the results suggest that CVW models can reduce ED presentations and unplanned hospital admissions for older people through an integrated approach to care.

4.7 Quality of Life

Evidence suggests a patient's quality of life (QoL) correlates to the use of Virtual wards. Virtual ward care has been associated with higher patient satisfaction (72, 9, 73), whilst it is also reported that elderly patients with chronic heart failure may experience improved quality of life, depression, and nutritional status. In addition, Wilson et al., (74) suggested that a more personalised care style and the feeling of therapeutic support at home could contribute to greater satisfaction.

A study by Leung et al., (75) examined the effects of Virtual ward services on frail elderly patients and QoL. Three hospitals provided the virtual ward service (intervention), and one provided usual nursing care (control) in a matched-control quasi-experimental study. Patients in the intervention group were at high risk of readmission and supported by home care providers recruited from the three hospitals that provided the virtual ward service. For the results, 39 patients in each of the two groups were recruited. The virtual ward group showed a greater significant reduction in unplanned emergency hospital readmissions and a significant improvement in their overall QoL. However, there was no significant difference in the number of

emergency attendance. Overall, the study findings suggest virtual wards can reduce unplanned emergency medical readmissions and improve QoL for elderly frail patients post discharge.

4.8 Wider Impact on Healthcare services

Current research surrounding Telehealth and virtual wards heavily focuses directly on its impact with in-patient services, e.g., reduced admission to hospital or risk of readmission, but little research seems to identify other areas of the healthcare service which may benefit from, or be challenged by, the implementation of Telehealth. A 2023 Norwegian study by Eines et al aimed to explore healthcare professionals' experiences of interprofessional collaboration in care for patients with multimorbidity in a virtual community ward (13). A qualitative exploratory study was conducted using focus group interviews. Seventeen healthcare professionals working in a Norwegian community virtual ward were interviewed. In addition, a thematic analysis was conducted on the data. Patients with multimorbidity living at home may benefit from interprofessional collaboration in community virtual wards. A patient-centred health promotion approach combined with interprofessional collaboration appears to increase the quality of follow-up for patients with multimorbidity living at home. Interprofessional trust and respect are also crucial for the follow-up of patients with multimorbidity. Eines et al (13) suggests that to develop more sustainable homecare services, patient voices and next of kin opinions should be considered.

5. Future of Remote Monitoring

The NHS is increasingly introducing more Telehealth infrastructure to support people in a variety of places that may be called 'home', including care homes. Currently, there is a national policy to push VW in England, with an ambition for the NHS to have 40-50 'virtual ward beds' per 100,000 members of the population by December 2023 (76). COVID-19 also rapidly amplified the number of VW that were established in communities, especially in instances of patients receiving at home care following admission for COVID-19. Virtual COVID-19 Community Wards were rapidly

developed at scale, using a low-tech model that effectively manages low-acuity COVID-19 patients at home (77).

Whilst the vast majority of Telehealth seen today was implemented during the recent pandemic to ease pressures on hospital wards by freeing up beds and encouraging self - monitoring at home, they presented additional benefits that will extend beyond the pandemic and for future use such as minimised patient to worker disease transmission, reduced personal protective equipment (PPE) provision, stricter patient adherence to isolation guidelines (77), eased patient anxieties and increased patient comfort (78).

However, the patient perspective of Telehealth is much more positive, and many patients feel that Telehealth allows for more personalised care. Patients reported that the service gave them peace of mind; an evaluation into the VW model in Croydon found that Telehealth monitoring on VW detected significant pathology earlier or found potentially fatal pathologies that would have otherwise not been detected at all (79). Patients also noted ease of use and most often reported their VW experience as 'excellent'. Additional to patient experience, Telehealth has been reported to improve staff experience and provides staff with the opportunity to undertake flexible working and blended roles alongside enabling the utilisation of staff who may not be able to easily undertake patient-facing tasks (77).

Upon reviewing the literature related to clinical applications of a range of technologies, including telemonitoring, real time home tracking devices, and wireless technology, Appelboom et al., (80) discussed that despite the evidence indicating how devices used for Telehealth can be accurate, effective and reliable for preventative methods as well as perioperative and rehabilitation across a range of areas in healthcare, it is still underutilised. With particular focus on the use of smart wearable body sensors (SWS), the review highlights that underutilisation may be due to difficulties and barriers faced with reliability and efficiency of sensor systems and data processing software. Although it is likely that progress has been made since this review was written due to

the continuing development of such technology and software, it does emphasise the importance of ensuring that correct infrastructure is available, reliable and implemented to ensure Telehealth services can be used successfully, without limiting its potential or causing further clinical strain for any user. Furthermore, Appelboom highlights that collaboration between industries (physicians, engineers, patients) is also essential to the success of Telehealth for healthcare.

Any intervention should also be subject to assessment, Law and Watson (81) looked to discuss various ways to improve Telehealth evaluation and create recommendations for successfully adopting an adaptive design to overcome typical issues experienced in Telehealth research. They first identified uncertain parameters to calculate sample size within Telehealth research; a sample size review was recommended, utilising interim data to estimate the parameters and then used them for: a new sample size calculation, further recruitment plans then employing the new sample size. Secondly, Telehealth interventions can have multiple endpoints, possibly with the situation of the intervention affecting an endpoint other than the primary to a higher degree than the primary. In this scenario, the authors recommend switching the primary endpoint to the one being affected to the highest degree. They also recommended strategies should be adopted to avoid bias when doing this. The authors feature several design options that can increase efficiency whilst being ethical, the first of which is a group sequential design that offers various interim points at which the trial can be stopped early, either because the intervention has been proven to work or proven to not work, defined by previously determined data stopping rules. The second design is a multi-arm multi-stage design, in which multiple interventions may be run at once. Participants will then be allocated to a control group or one of the interventions. The final design is a seamless phase II/III design in which data from early in the study is used in later trials. This study design is uninterrupted, utilising exploratory aspects of a phase II trial and confirmatory aspects of a phase III trial; interim analyses should be incorporated to assess whether the intervention should continue into the next phase. It is discussed by Law and Watson that adaptive designs can help counteract non-compliance within a study sample, allowing evaluation of the clinical outcomes effectively. Finally, they conclude that for these reasons highlighted, adopting

an adaptive design to Telehealth can allow for higher efficiency within studies with more robust and accurate evidence to be gathered, minimising any potential harm to patients.

6. Conclusion

In conclusion, it is evident from the discussed literature that remote monitoring can be beneficial not only for patients, but also healthcare providers and society too. Exploration into studies which observe Telehealth in a range of models and formats, as well as for a range of chronic and severe health problems shows an emerging theme that care can safely be delivered at home for several types of health conditions, including those more complicated which usually involve frequency hospital visits, e.g., COPD, CVD. Telehealth has further shown to increase the quality of life of patients following discharge, which can be facilitated safely and timely because of Telehealth. The use of Telehealth can also be seen to encourage shortened overall length of hospital inpatient stays and help to keep individuals in their preferred place of care. Reduced unplanned hospital admissions means reduced costs to the NHS as well as increased beds and staff availability at hospitals. From the perspective of patients, the majority of literature discussed in this review finds that patients are satisfied with care provided via Telehealth, with some studies even portraying how Telehealth can encourage better compliance with treatment (30, 41). Clinicians are also keen to utilise Telehealth, where it can work safely and effectively, especially in geographically more secluded areas where access to healthcare is more limited; nevertheless, current literature is deprived of clinician and healthcare professional perspectives. Also, a benefit is that they encourage collaborative, individualised care; and improve upon the communication between care services. Croydon, Devon and Wandsworth all present possible models of VW, those with the implantation of a full time GP seemingly favoured. It is important to note though, that the literature surrounding the efficacy, effectiveness and acceptability of Telehealth is still very sparse, with not all studies finding VW to have significantly positive patient outcome. Further research should aim to address these gaps and consider hearing from those with first hand internal experience of working with a virtual ward. In turn, it should look to present whether a nationalised approach/model can be implemented to introduce Telehealth in Wales.

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