Eastern AHSN

NHS England and NHS Improvement

Technology-enabled care pathway transformation

Implementation Support Pack

August 2021

Part of The AHSN Network

Office for Life Sciences

NHS

Contents

Background

- In June 2021, Eastern AHSN was asked by the NHS East regional team to complete a rapid review of remote monitoring solutions and virtual ward implementation.
- The use of at home remote monitoring has accelerated rapidly during the Covid-19 pandemic, with dedicated funding and 'how to' guidance made available for Covid-19 virtual wards using pulse oximetry at home.
- Integrated Care Systems are now looking at where virtual wards can be used to safely support patients with a range of conditions to avoid hospital (re)admissions and to support early discharge from hospital. This implementation support pack aims to provide 1) **overview of the evidence for remote monitoring** across three clinical pathways: heart failure, respiratory (COPD & pneumonia) and pre-elective and post-operative care. It also brings together 2) **learning from implementation in the East of England** and 3) **summarises remote monitoring devices**.
- The National NHSE/I @home team will be providing tools, pathway SOPs, protocols, training, technical support and a Community of Practice to support implementation. Some examples of the draft guidance are at Appendix D of this document. Funding has also been created to support cardiac networks implementing remote monitoring tools to support cardiology and cardiac surgery pathways through elective care recovery.

Definitions used for this review

- **Remote monitoring**: the process of using technology to monitor patients outside of a traditional care setting, such as in their own home, or care home. Using symptom trackers, monitoring devices, portals or patient dashboards, together with remote consultations, remote monitoring enables patients to maintain a holistic view of their wellbeing through the tracking of disease progress, whilst alerting clinicians to any deterioration in their condition (NHSX, 2020).
- **Virtual ward**: the mechanism by which patients who are being monitored at home are managed. Wards can provide care for a range of patient conditions and may use a variety of remote monitoring solutions. Virtual wards aim to enable early supported discharge from hospital, and to avoid unnecessary hospital (re)admissions. They are staffed by clinicians who admit and discharge patients, have a set patient caseload and number of beds, and who monitor patients at regular intervals.
- **Virtual hospital**: multiple virtual wards for different patient cohorts and conditions, who are monitored remotely.

Learning from systematic reviews

Evidence review: Our approach

- In the slides that follow, we set out our search strategy and results, approaches to remote monitoring, key findings from our review and implementation considerations for each key area (in the order listed above).
- We focused on reviewing the most recent reviews, systematic reviews and meta-analyses in each case. While some studies reflect on the Covid-19 context, others were conducted prior to the pandemic, and therefore recommendations do not always take into account the increased need for remote care.
- Summary tables of the reviewed literature can be found in Appendix B.
- All the studies from our searches are detailed in the Excel file in Appendix C.

Cross-cutting themes

Consider who will benefit from remote monitoring and be clear about what it is aiming to achieve and whether it is replacing another model of care or acting as an adjunct.

Viewing the model as a means of admissions avoidance may not always be appropriate.

Clear governance and protocols must be in place with regards to checking results and acting upon them where necessary – moving from remote monitoring to remote management. As part of this, accountability must be considered.

Attention needs to be given to educating and engaging patients and carers where they are expected to actively participate in monitoring activities. Failure to engage can result in missing or inaccurate data.

Determining who will pay for monitoring – and understanding where the financial benefits will accrue – is important. Efficiency savings may differ depending on whether a block contract or payment by results is in place.

Heart failure (HF)

Search strategy: Heart Failure

PubMed

(Heart failure[Title]) AND (telehealth[Title] OR telemedicine[Title] OR telemonitor*[Title] OR monitor*[Title] OR remote[Title])

2009-2021

Meta-analysis; Review; Systematic review

Results: 165 papers returned. 2 papers removed as not relevant. 14 reviewed.

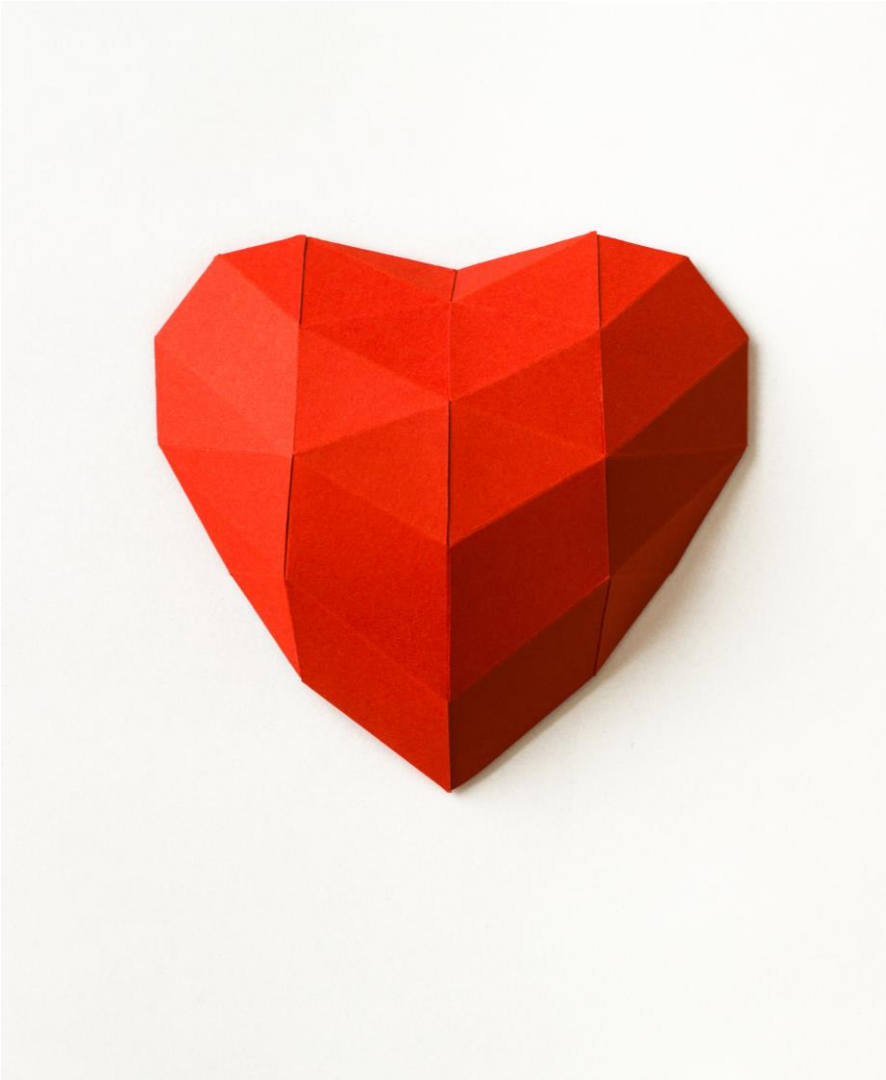
Number of papers reviewed in each review/meta-analysis is detailed in the tables in Appendix B.

All search results detailed in Appendix C.

Remote monitoring for heart failure: Approaches

Remote monitoring for patients with HF mainly consists of:

- Non-invasive monitoring of pre-specified parameters, such as daily weight, blood pressure, ECG, pulse oximetry, subjective assessment of HF symptoms or depression levels and medication adherence.
- Invasive monitoring by implanted devices with the sole function of remote patient monitoring (measuring proxies of left ventricular filling pressures, such as right ventricular pressure, pulmonary artery pressure and left atrial pressure).
- Invasive monitoring by cardiovascular implantable electronic devices (CIEDs), such as ICDs or cardiac resynchronisation devices (CRT-D)
- Structured telephone support



Remote monitoring for heart failure: Key findings (1)

- Remote monitoring for HF shows promise. There is an abundance of clinical evidence, some of which shows that remote monitoring can reduce HF-related hospitalisations and mortality. However, not all results are positive. Much of this may be down to the wide range of parameters and devices that can be used to monitor HF – therefore leading to wide variation in trial design.
- The European Society of Cardiology (ESC) provided limited recommendations for monitoring in its 2016 guidelines for the diagnosis and treatment of acute and chronic HF. Monitoring of pulmonary artery pressure (PAP) using a wireless implantable haemodynamic monitoring system in symptomatic patients with reduced or preserved ejection fraction (EF) and a previous HF hospitalisation was recommended for the risk reduction of recurrent HF hospitalisations. This is the only technique with proven safety as well as efficacy with regard to the prevention of HF-related hospital admissions.
- Multiparameter monitoring by ICD for improvement of clinical outcomes in symptomatic patients with left ventricular EF (LVEF) ≤35% was also recommended.

Remote monitoring for heart failure: Key findings (2)

All other monitoring methods were considered to lack sufficient evidence to support recommendation, based on different clinical trial results and lack of uniformity.

There was no recommendation for non-invasive approaches. However, the updated 2021 guidelines state that non-invasive home-telemonitoring may be considered for patients with HF in order to reduce the risk of recurrent cardiovascular and HF hospitalisations and cardiovascular death This is in line with a systematic review found although there is inconsistency in the reported effects of non-invasive remote monitoring strategies on all-cause mortality, all-cause hospitalization, and HF-related hospitalizations, the overall combined results demonstrated a small beneficial effect on the overall survival, HF-related hospitalizations, and adherence to the guideline-recommended pharmacological therapy. The authors conclude that due to its simplicity, non-invasive nature, and relatively low costs, non-invasive remote monitoring is desirable and to be recommended in lower risk or less symptomatic chronic HF patients.

This is supported by another Cochrane review that found both non-invasive remote monitoring and structured telephone support were shown to reduce all-cause mortality.

Monitoring using multiple parameters has generally shown the most positive results.

Remote monitoring for heart failure: Implementation considerations (1)

The evidence suggests that the following points should be carefully considered ahead of implementation:

- Which patients should be monitored?
- Should monitoring be invasive or non-invasive? Invasive is more effective but it is more costly and not without risk. Non-invasive may be suitable for low-risk asymptomatic patients. Patients need to be selected carefully.
- Which parameters should be used? Using multiple parameters is more effective.
- When should monitoring be done? Should it be at onset of HF or after an episode of decompensation? Cost should be weighed against risk.
- How long should monitoring be done for? Should it only be in high-risk periods or life long? Again, cost should be weighed against risk.

Remote monitoring for heart failure: Implementation considerations (2)

- Who is responsible for reviewing results? There are some concerns about increasing workload. Reviewing results must be appropriately built in to roles and responsibilities. It is also important to ensure there are protocols in place for data to be acted upon – translating remote monitoring into remote management.
- How should patients be engaged? Implementing mechanisms that both monitor and encourage daily measurement along with staff enthusiasm toward using the system can help improve adherence. Lack of patient engagement may lead to missing data or inaccurate results.
- How often should measurements be taken?
- Who will cover the additional costs? Efficiency savings may accrue to acute settings, although a system-wide approach (for example through ICSs) may be appropriate. Efficiency savings may differ depending on whether a block contract or payment by results is in place.

Chronic Obstructive Pulmonary Disease (COPD)

Search strategy: COPD

PubMed

(Chronic obstructive pulmonary disease[Title]) OR (COPD[Title]) AND (telehealth[Title] OR telemedicine[Title] OR telemonitor*[Title] OR monitor*[Title] OR remote[Title])

2009-2021

Meta-analysis; Review; Systematic review

Results: 53 papers returned. 12 reviewed.

Number of papers reviewed in each review/meta-analysis is detailed in the tables in Appendix B.

All search results detailed in Appendix C.

Remote monitoring for COPD: Approaches

Remote monitoring in COPD has been applied to prevent exacerbations, establish a self-management program, improve physical activity, provide education, and deliver pulmonary rehabilitation.

Frequently, telemonitoring devices are used to collect parameters such as vital signs, symptoms, oxygen saturation, electrocardiography (ECG) and/or lung function tests and transmit them to online devices.

Wearables have also been used to try to increase physical activity in people with COPD.

Remote monitoring for COPD: Key findings

- Studies show some positive results for remote monitoring for COPD – including in reducing A&E attendances and hospital admissions. But clinical trials vary significantly in design and there is very little conclusive evidence on the benefits (particularly in a pre-Covid context). In general, results are very mixed and evidence on cost-effectiveness is lacking.
- NICE guidance for diagnosing and managing COPD in over 16s recommends not using routine telehealth monitoring of physiological status as part of management for stable COPD. This is because they found telehealth monitoring does not improve quality of life or reduce hospitalisations for people with COPD, and it leads to higher costs. However, the committee did not want to prevent telehealth monitoring being used for specific reasons that were not covered in the evidence they reviewed, such as short-term monitoring following hospital discharge.
- There is some evidence monitoring can increase physical activity, but it is not conclusive.

Remote monitoring for COPD: Implementation considerations

- Evidence on the benefits of remote monitoring for COPD patients is not conclusive and therefore any implementation needs to be considered carefully, with particular attention given to the risks.
- COPD patients are a very heterogeneous population with variable baselines and different phenotypes. Exacerbations are also highly variable. This can make accurate monitoring difficult. One paper suggested future research could use predictive algorithms to account for individual differences – with an aim to reduce false-alerts, patient anxiety and lack of compliance.
- Patient engagement is particularly important where patients are taking and reporting their own measurements. Patients' age, education, experience in technological devices, cognitive, motor and visual abilities or deficits, and their families and home environment should all be taken into account.
- As with heart failure, consideration needs to be given to who will review the results – particularly given concerns about increasing workload – and this should be built into roles and responsibilities. Again, protocols should enable active management. In the future, there is potential for monitoring parameters to be adjusted remotely, allowing for individualised care.
- Particular consideration needs to be given to who will cover the costs of monitoring for COPD, given the lack of evidence around cost-effectiveness.

Pneumonia

Search strategy: Pneumonia

PubMed

(Pneumonia[Title]) AND (telehealth[Title] OR telemedicine[Title] OR telemonitor*[Title] OR monitor*[Title] OR remote[Title])

2009-2021

Meta-analysis; Review; Systematic review

Results: 0 relevant results

The fact our search revealed 0 relevant results shows that this is a new and emerging area, necessitated by Covid-19. A Google search revealed one systematic review in this area. The results from that review are set out below. National guidance has also been developed for pulse oximetry to detect early deterioration of patients with COVID-19 in primary and community care settings.

Remote monitoring for Covid-19: Key findings from one systematic review

- The review highlighted some positive outcomes including low mortality rates and high patient satisfaction.
- One article presented findings on reduction in length of stay, calculated at 5 days fewer per patient.
- But the review could not reach conclusions in relation to patient safety and the degree to which remote home monitoring models can conclusively identify cases of deterioration at an earlier stage in the disease trajectory. Much of this was due to lack of standardised reporting and not using comparators.
- The review found remote home monitoring needed to be seen as an approach to maintain patients safely in the right setting rather than as an admission avoidance model.

Vindrola-Padros, C., Singh, K., Sidhu, M.S., Georghiou, T., Sherlaw-Johnson, C., Tomini, S.M., Cohen, N., Inada-Kim, M., Kirkham, K., Streetly, A. and Fulop, N.J., 2021. Remote home monitoring (virtual wards) during the COVID-19 pandemic: a systematic review. MedRxiv, pp.2020-10.

Remote monitoring for Covid-19: Implementation considerations from one systematic review

- It is important to consider remote home monitoring models as an approach to maintain patients safely in the right setting.
- The use of apps for monitoring allowed the follow-up of a higher number of patients (compared to paper-based models), but some of the studies indicated that models based on telephone calls were more inclusive (i.e. including patients without internet access or technological literacy).
- Patient/carer training was identified as a key determining factor of the success of these models.
- Coordination between primary and secondary care facilitated implementation.
- Primary care led models were considered, in some cases, as more adaptable to evolving patient and system needs, and easier to replicate in contexts with limited secondary care access and capacity.
- A few models integrated mental health and social care support during and after the monitoring intervention.
- Issues with using pulse oximetry were also highlighted such as: patient physiological measures needed to be recorded several times a day to correctly identify cases of deterioration and pulse oximetry readings were made less accurate by a range of factors including nail polish, severe anaemia and poor cardiac output.

Vindrola-Padros, C., Singh, K., Sidhu, M.S., Georghiou, T., Sherlaw-Johnson, C., Tomini, S.M., Cohen, N., Inada-Kim, M., Kirkham, K., Streetly, A. and Fulop, N.J., 2021. Remote home monitoring (virtual wards) during the COVID-19 pandemic: a systematic review. MedRxiv, pp.2020-10.

Surgery and orthopaedics

Search strategy: Surgery

PubMed

(Surgery[Title]) AND (telehealth[Title] OR telemedicine[Title] OR telemonitor*[Title] OR monitor*[Title] OR remote[Title])

2009-2021

Meta-analysis; Review; Systematic review

Results: 223 papers returned. 24 deemed relevant.

Number of papers reviewed in each review/meta-analysis is detailed in the tables in Appendix B.

All search results detailed in Appendix C.

Search strategy: Orthopaedics

PubMed

(Orthopaedics[Title]) AND (telehealth[Title] OR telemedicine[Title] OR telemonitor*[Title] OR monitor*[Title] OR remote[Title])

2009-2021

Meta-analysis; Review; Systematic review

Results: 3 papers returned. Supplementary Google search identified another systematic review. 4 full text reviews.

2 reviews focused primarily on other applications of telehealth, rather than remote monitoring.

Number of papers reviewed in each review/meta-analysis is detailed in the tables in Appendix B.

All search results are detailed in Appendix C.

Remote monitoring in surgery: Approaches

The vast majority of evidence relating to telemedicine applications in surgery do not concern remote monitoring (i.e. the ongoing monitoring of a patient).

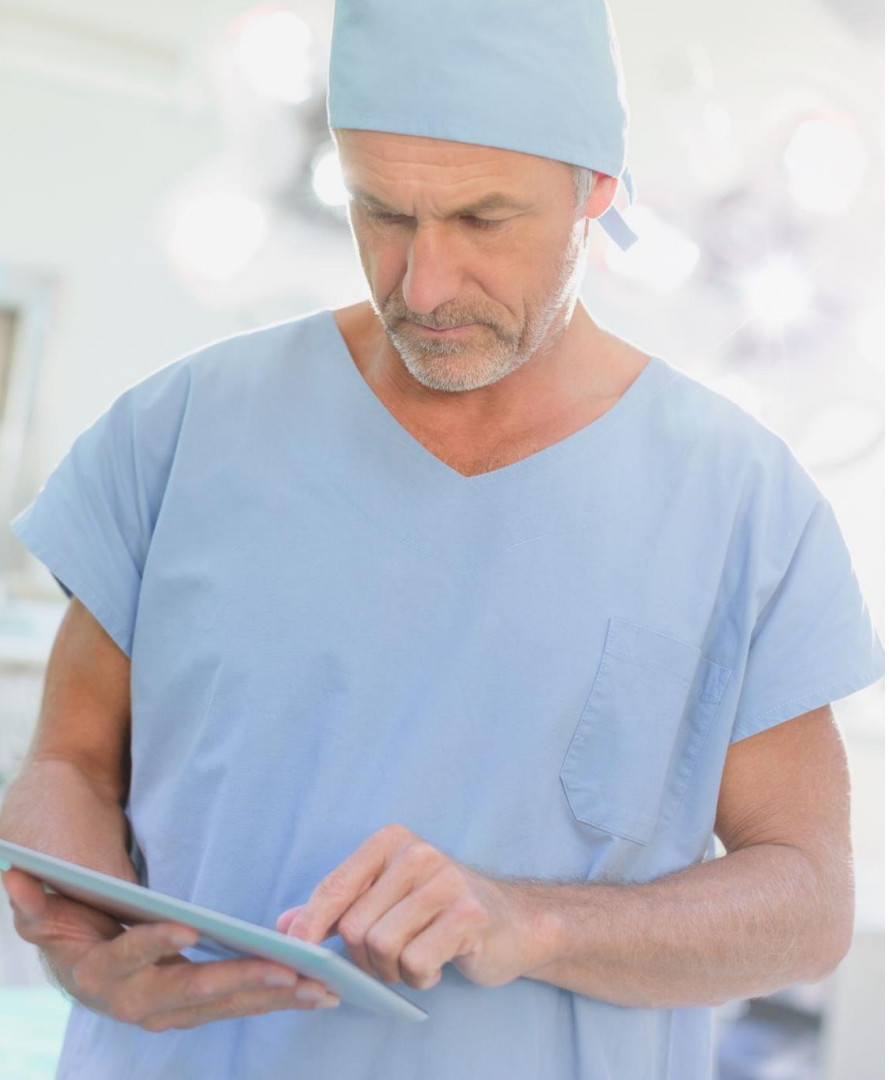
In orthopaedics, the literature we looked at most often related to patient examinations, interpretation of imaging, post-operative care provision, diagnosis, and patient-reported outcomes follow-up.

In other areas of surgery, much of the evidence we explored was related to virtual consultations.

However, there are some examples of remote monitoring being used to monitor physical activity pre- and post-intervention and to support post-intervention care more generally – such as enabling remote monitoring of surgical wounds via images taken by digital cameras.

Remote monitoring in surgery: Key findings

- The literature we identified was diverse and related to different specialties, procedures and monitoring approaches, making it difficult to draw out key themes. It may be that this topic is too broad for the approach and search strategy we adopted.
- In orthopaedics, remote monitoring has been explored to monitor physical activity after surgery and to support rehabilitation, with positive results.
- One paper particularly highlighted the potential of physical activity monitoring pre and post-orthopaedic surgery to provide clinicians with a fuller picture of the patient's status and to support patients to achieve their physical activity targets.
- And another found combinations of regular virtual consultations and remote monitoring of clinical parameters are feasible for cardiac surgery patients and would be useful to assess and triage before surgery. Remote monitoring could also be particularly useful in managing postoperative complications, to help reduce ambulatory visits and rehospitalizations for vascular surgery patients.



Remote monitoring in surgery: Implementation considerations

When deploying remote monitoring to monitor physical activity it is important to identify the desired parameters and choose sensors that can measure them with a high level of precision. Wear location, data analysis skills and tools, customer support, battery life and the evidence for the sensor should all be considered.

Studies suggest that mobile phone apps, online surveys, or online materials for consent are some of the best ways to improve perioperative patient communication and patient education.

It is important to consider the approach in order that it is useful and inclusive. Some studies have asked for text message follow-ups from patients and others have used telephone calls. As above, physical activity monitoring can draw on sensors.

Learning from implementation in the Eastern region

Learning from implementation in the Eastern region

- Significant progress has been made in the East of England to implement non-Covid virtual wards across a range of clinical pathways, including heart failure, respiratory, pre- and post-operative surgery, palliative care, oncology and stroke medicine.
- Eastern AHSN has carried out a deep dive with implementation leads in Hertfordshire & West Essex, Norfolk & Waveney and Suffolk & North East Essex, to understand the process they have been through to establish virtual wards, and the key lessons from implementation.
- Three providers of remote monitoring solutions that have been procured in the region are Current Health, Masimo and Doccla. More information about these companies is at slides 42-44.
- For each example we have included a snapshot of the remote monitoring solution and lessons around:
    - Developing clinical pathways
    - Top tips
    - Future plans
- Also see Appendix E for results from a study awaiting publication regarding implementing remote monitoring for older people living independently at home

Implementation process – summary of key points

Gather data on bed-days, readmissions, length of stay and any other key measures across a range of clinical pathways of interest.

Decide which clinical pathway(s) to focus on and map your ‘as is’ and ‘future state' with clinical and operational leads.

Appoint a clinical lead for each pathway, a project manager/implementation lead, and the virtual ward staff team. Ensure accountability is clear.

Decide on patient cohort, referral criteria, virtual ward admissions and discharge process.

Procure a remote monitoring solution (consider cost, patient onboarding, ease of use, suitability for patient cohort, cleaning, data monitoring). Each patient should have individual parameters set by a lead clinician to enable timely alerts.

Write a Standard Operating Procedure for the virtual ward including management of remote monitoring devices, patient information, referral criteria, clinical pathway(s). Ensure information governance, clinical safety and regulatory requirements are met.

Agree success measures and put data collection processes in place to monitor impact. Gain the appropriate approvals.

Raise awareness of the virtual ward within the hospital, with patients and with partners.

Hertfordshire Community NHS Trust

Developing clinical pathways

- Across Hertfordshire and West Essex Integrated Care Partnership, a Virtual Hospital Operational Group has been established, with distinct task and finish groups for each clinical pathway reporting into it. There is representation from across the system including primary, secondary and community care, and the voluntary sector. This builds on the Covid-19 virtual ward which went live in February 2021.
- The pathways that have been developed are for **heart failure**, **respiratory** (COPD and pneumonia), **infections** (recurrent UTI and cellulitis) and **pre- and post-surgery**. Data for bed-days, readmissions and length of stay has been analysed and discussions with lead clinicians have determined which patients could benefit most from remote monitoring. As an example, data for readmissions of patients with recurrent UTI was analysed showing 24 patients accumulated 326 bed days over 12 months. Remote monitoring at home could enable these patients to avoid readmissions by monitoring hydration, frequency of urination, urine colour and body temperature, and checking in with patients virtually.
- An opportunity for pre-op support identified as a result of mapping the 'as is' pathway against a 'future state', is for those requiring a pre-op orthopaedic assessment. Better patient information and self-assessment resources, alongside remote monitoring for up to six weeks before surgery, could significantly reduce cancelled surgeries.
- The heart failure pathway will accept referrals from primary care, community services, secondary care and from patients, where a) they are previously known to the service, b) they are experiencing an exacerbation of their conditions, c) the service is named on their self-management action plan, and d) the re-referral is within 6 months of discharge from the service.
- Two suppliers have been procured to support the remote monitoring pathways (Doccla and Masimo) including providing the devices, onboarding patients and providing a dashboard for clinicians to monitor patient data and admissions & discharge data for the virtual ward.

Hertfordshire Community NHS Trust

Top tips

- Ensure buy-in from across your system by mapping which organisations need to be involved, and getting sign off for attendance at key planning and implementation meetings.
- Appoint a clinical lead and dedicated manager for each workstream or pathway.
- Include operational staff from the outset (e.g. those managing waiting lists, theatre time, discharge and targets). They are key to identifying any obstacles and driving forward pathway change.

Future plans

- A Virtual Hospital model is being developed which would have three wards at different tiers, monitoring patients with mild, moderate and severe conditions.
- Any number of clinical pathways could potentially sit within the virtual hospital model, as with a physical hospital. Plans are underway to include heart failure, pneumonia, cellulitis, recurrent UTI, palliative care, diabetic and Covid-19 patients.

East Suffolk and North Essex NHS Foundation Trust

Developing clinical pathways

- Pathway development began before the Covid-19 pandemic, and by February 2021 was running in parallel with setting up Covid oximetry @home. A transformation lead worked with the multidisciplinary, dedicated admissions avoidance team to look at options to manage patients safely at home to reduce hospital admissions, and save travel time to and from patients (monitoring could be 2-3 times per day per patient across large rural areas).
- ESNEFT provides both acute and community services which helped facilitate setting up virtual wards across different community pathways. West Suffolk had already procured the remote monitoring solution Current Health and shared positive feedback, so this was adopted by ESNEFT. The admissions avoidance team also had good links with other community nursing teams.
- Virtual wards have been set up for **respiratory**, particularly those patients having acerbations and who require monitoring of response to antibiotics or oxygen weaning; **heart failure**, for patients that require up-titration and optimisation, and to enable quick decisions if patients are deteriorating; and **admissions avoidance** which tends to support elderly and frail patients who require close observation.
- Referrals can be made by GPs, out of hours, ambulance, discharge team, 111, social care and patients, carers or relatives to a care coordination centre, which then alerts the clinical team that an assessment for remote monitoring is needed.
- All 3 pathways have been live since June 2021. Clinical teams have been set up on the virtual dashboard for patient monitoring, nurse training with Current Health has been completed and remote monitoring devices have been issued. There is an easy to use tablet for patients to contact clinicians, and a small wearable device for continuous monitoring of respiratory rate, heart rate, movement, and saturations. The wearable can also connect to various other devices via Bluetooth such as weighing scales and a blood pressure cuff.
- The tablet can be used to message or video call the patient and offer surveys or questions about their daily wellbeing. The devices are monitored (not necessarily in real time) by the relevant community teams and will also alert a clinician if the reported observations start to fall outside of set parameters.

East Suffolk and North Essex NHS Foundation Trust

Top tips

- Keep pathway development simple, involving a small number of clinicians for each pathway and keeping documentation to a minimum.
- Identify a senior operational lead to bring community nursing teams on board and champion the project.
- Ensure that your medical devices governance team is aware of the project and has early sight of the remote monitoring system you are planning to procure.
- Where applicable, factor in staff travel time saved as part of your business case.

Future plans

- The focus currently is on admissions and readmissions, but pathways are in development to see whether length of stay for surgical patients could be reduced.

Norfolk and Norwich University Hospitals NHS Foundation Trust

Developing clinical pathways

- In February 2021 a Covid-19 virtual ward began admitting NNUH patients by establishing a clinical team to mirror a hospital ward. Staff who were shielding or unable to work in the physical hospital were quickly engaged in setting up the virtual ward pathways. As well as providing capacity from experienced professionals, this approach had the added benefit of supporting staff mental health and wellbeing. The service is located within the Digital Health arm of the trust.
- The company Current Health was procured to provide the remote monitoring devices, tablet for communication with patients, and clinical dashboard with clinical alerts depending on the parameters set by clinicians at the outset. The clinical pathways are **gastroenterology**, **hot gall bladder**, **awaiting cardiology treatment**, **pregnant patients with confirmed Covid-19**, **palliative care**, and **awaiting treatment or diagnostics at other centres**.
- The service offered by the NNUH is a fully staffed virtual ward offering 24/7 monitoring of observations and daily video calls to patients. There is pharmacy and medicines support, a daily medical review and coordination of care with community services. Home intravenous therapy can also be offered.
- Individual specialties can identify anyone they think might be suitable for the virtual ward, using the Standard Operating Procedure for inclusion and exclusion criteria. The model has enough leeway to allow for a range of different specialties. The Senior Matron or deputy will speak to the patient and clinician before accepting the referral, and can flex the package of support available. The remote monitoring kit is set up ready for the patient on transfer from the hospital to the virtual ward. The lead clinician will set individual parameters for each patient so that any issues are flagged at the right time via the remote monitoring alert system. Patients remain under the care of the consultant and are therefore not discharged but *transferred* to the virtual ward.
- The trust has set up its own dashboard via BI Analytics to draw together the number of patients on each clinical pathway, bed days saved and patient satisfaction data.

Norfolk and Norwich University Hospitals NHS Foundation Trust

Top tips

- Make sure your definition of a virtual ward is clear for all partners along with which patient groups can be cared for remotely.
- Address accountability at the outset through clinical safety mechanisms and clear delineation of roles and responsibilities.
- Use a provider that offers technical support for patients to avoid overloading your service desk.
- Engage community services to improve your value proposition.
- Winning over hearts and minds is likely to be more of a challenge than establishing the operational process.

Future plans

- Review of inpatients at the hospital to see if more of those patients meeting the referral criteria can be safely transferred to the virtual ward.
- Appropriate patients with a range of conditions attending ED will be transferred to the virtual ward.
- Diabetes, self admin IVs, tissue viability, Gynaecology and oncology pathways are in the pipeline.
- Integration of the NNUH virtual ward with wider Norfolk & Waveney community teams.
- An option for virtual ward 'plus' is also in development which would include community staff attending the patient’s home to deliver specific hands-on services.

Remote monitoring solutions

Remote monitoring solutions

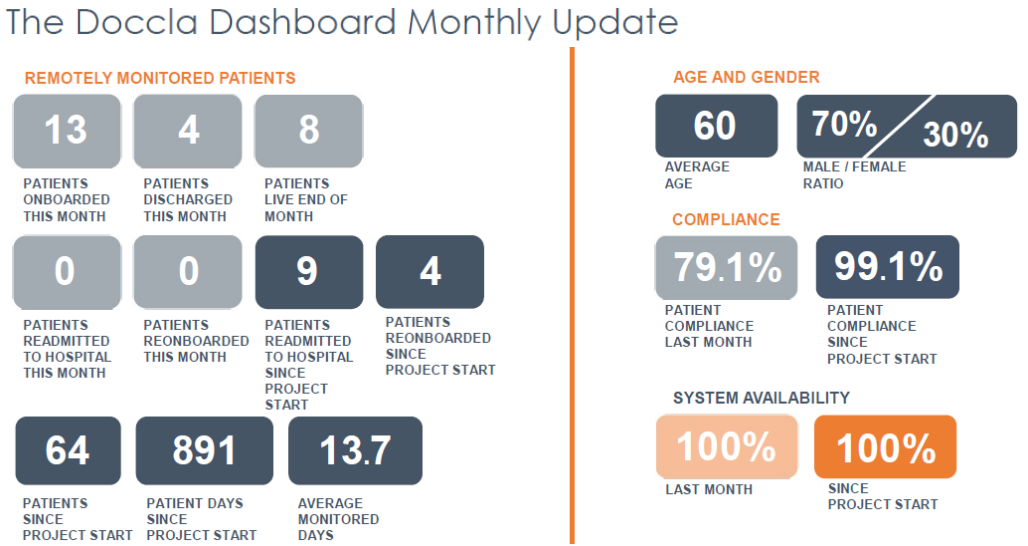
- The following slides summarise a selection of the remote monitoring solutions on the market that are applicable to clinical pathways for heart failure, respiratory (COPD or pneumonia) and pre- and post-surgery.
- In most cases, the company has approached one of the 15 AHSNs in England to ask for advice or to plan for implementation. Doccla, Masimo and Current Health are companies whose services have already been procured by trusts in the Eastern region.
- In May 2021, the Department for International Trade (DIT) published 'The First 100' Digital Health Playbook which lists 100 UK digital health companies with expertise in a range of areas, including remote monitoring, self-care, triage and pre-assessment, screening and diagnostics, and data analysis.
- If you would like to explore any of the following remote monitoring solutions for your system, please get in touch with Sophie Castle-Clarke, Principal Advisor: sophie.castle-clarke@eahsn.org.

Innovator list

Company	Product	Website	Slide #
Doccla	Multiple	www.doccla.com	42
Masimo	Multiple	www.masimo.com	43
Current Health	The Universal Patient Management Platform	www.currenthealth.com	44
Dignio	Dignio Connected Care	https://dignio.com/en/	45
Solcom Ltd	Whzan	www.whzan.uk	46
Rinicare	PRIME	https://rinicare.com/solutions/remote-monitoring	47
Isansys Lifecare	The Patient Status Engine	www.isansys.com/en/Patient-Status-Engine	48
InHealthcare Ltd	Multiple	www.inhealthcare.co.uk	49
Spirit Digital Ltd	CliniTouch Vie	www.spirit-digital.co.uk	50
Qardio Inc	Multiple	www.qardio.com/qardiomd-remote-monitoring-devices	51

Company: Doccla
Product: Multiple
Website: www.doccla.com

Doccla procures remote monitoring devices on behalf of clients, that can apply to a range of clinical pathways including heart failure and COPD. They offer a patient onboarding service and helpline for technical support, as well as a dashboard for clinicians to monitor patient data. The dashboard is accessed via a web browser and therefore does not require integration with clinical systems.



Company: Masimo
Product: Multiple
Website: www.masimo.com

Masimo offers a range of devices for blood constituent monitoring, brain monitoring and airway and gas monitoring (some for use in a hospital setting and some applicable to remote monitoring). Unlike some other providers who procure the devices to link to their dashboard, Masimo design and manufacture their own products. Masimo's pulse oximeter uses advanced signal processing techniques to separate the arterial signal from other sources of noise, to deliver accurate results. Other remote monitoring devices include Centroid, a wearable, wireless patient orientation, activity, and respiration rate sensor.

Company: Current Health
Product: The Universal Patient Management Platform
Website: www.currenthealth.com

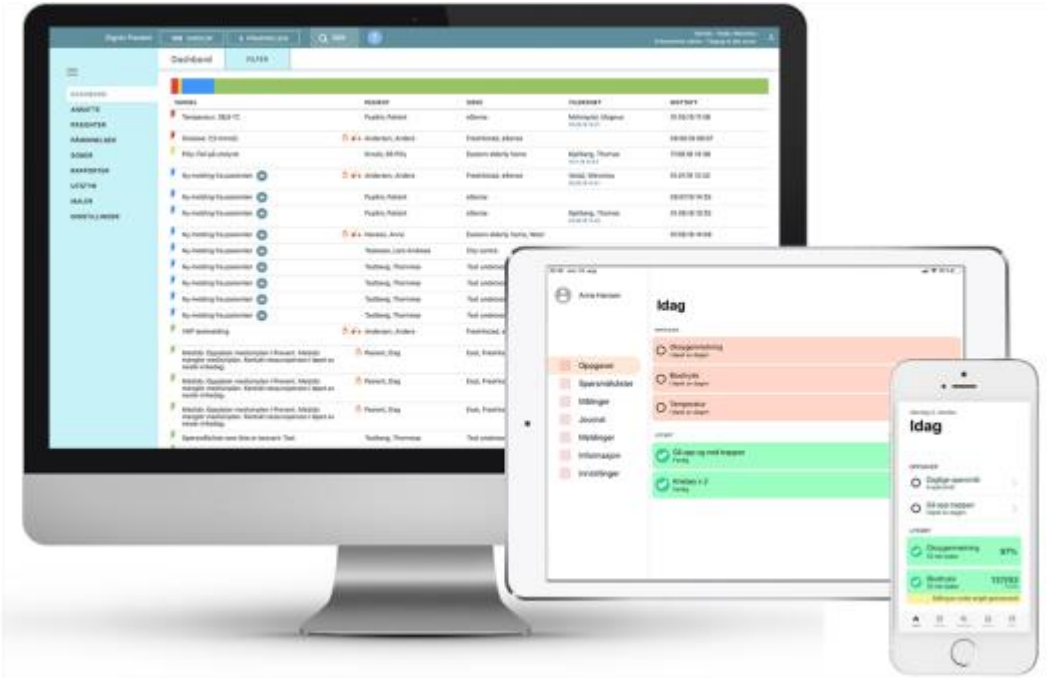
Summary:

Patient monitoring platform that combines vital-sign sensors, connectivity with other devices, and telemedicine capability into a single platform. Their small wearable device allows wireless, passive, and continuous monitoring of patient vital signs with the same accuracy as an ICU monitor. Allows monitoring of patients based on bespoke, controllable parameters. The wearable records RR, SpO2, HR and temperature, and additional devices are provided for recording BP and weight.

Company: Dignio
Product: Dignio Connected Care
Website: https://dignio.com/en/

Summary:

Dignio connects patients and healthcare professionals through a digital platform providing daily monitoring and continuous communication. The solution allows patients to take medical measurements at home with the knowledge that healthcare professionals follow up the results. Current remote monitoring devices measure blood pressure, blood sugar levels, weight, temperature, oxygen saturation and lung function and capacity.



Company: Solcom Ltd
Product: Whzan
Website: www.whzan.uk

Summary:

The Whzan digital health kit has been designed to allow users to take temperature, BP, pulse and blood oxygen saturation using Bluetooth enabled instruments that send readings via a tablet, to the cloud based clinical portal for clinicians to assess. Alerts can also be set against a patient's profile to alert clinicians to a change that would indicate deterioration, allowing for early intervention and preventative care pathways. One of the key assessments on the tablet is NEWS2. Once the assessment is complete and automatically sent to the portal, the score is plotted on the NEWS2 chart on the portal.

As the kit comes ready to use, patients can be trained to take the obs within 30 minutes of receiving the kit. Other users include care homes, community nursing teams and domiciliary care.

Company: Rinicare
Product: PRIME
Website: https://rinicare.com/solutions/remote-monitoring

Summary:

PRIME provides a remote full physiological assessment and data capture solution for patients who are critically unwell. It is a completely wireless IOT system that integrates data from industry standard patient monitoring equipment (12 lead ECG, heart rate, blood pressure, temperature, oxygen saturations) into a report that can be stored and transmitted via existing secure healthcare systems. A patient can be instructed by a healthcare professional to apply the key monitors (oxygen saturations/heart rate, blood pressure and temperature) at home.

Company: Isansys Lifecare
Product: The Patient Status Engine
Website: www.isansys.com/en/Patient-Status-Engine

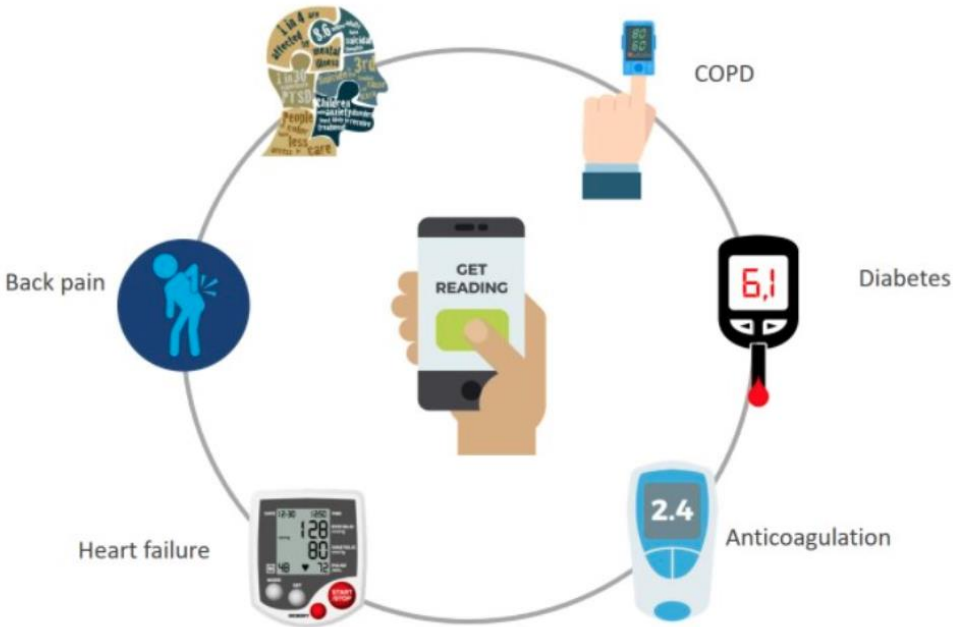
Summary:

The Patient Status Engine (PSE) provides wireless patient data and analysis in real-time, with quantitative patient outcome measures. The product combines sensors, connectivity and clinical AI in a medical platform which collects, analyses and transforms vital sign data into actionable clinical insights. By automating the basic process of taking patient observations, the PSE offers significant efficiency gains and higher quality, continuous data for making better clinical decisions. The system uses trend data combined with the integrated Early Warning Scores to provide alerts to healthcare professionals, enabling timely interventions that enhance the care and safety of patients.

Company: InHealthcare Ltd
Product: Multiple
Website: www.inhealthcare.co.uk

Summary:

InHealthcare offers remote monitoring for high risk patients, enabling them to remain at home whilst still being supported by the NHS. Conditions include COPD, heart failure, hypertension, anti-coagulation, and gestational diabetes. The company also offers a Digital Care Home service which coordinates the monitoring of residents in care homes. Care home staff complete digital assessments of care home staff using a smartphone application. This information is shared with healthcare professionals and allows staff to effectively triage residents. The service integrates with hardware to collect SPo2, HR, BP, glucose levels, and calculate NEWS.



Company: Spirit Digital Ltd
Product: CliniTouch Vie
Website: www.spirit-digital.co.uk

Summary:

CliniTouch Vie offers multiparameter monitoring of patients at home, connecting them to clinical teams to review and monitor patients for signs of deterioration. It can be used with complex patients with long-term conditions. New modules have been added for heart failure, assisted discharge and care homes.

The system
collects temperature, blood pressure, SpO2 and patient questionnaires, and readings can be manually inputted by patients from their own medical devices. Pre paired devices and tablets can be supplied or the software can be uploaded to home computers/tablets. Training and implementation support is available for staff and patients.

Company: Qardio Inc
Product: Multiple
Website: www.qardio.com/qardiomd-remote-monitoring-devices

Summary:

Qardio provides an end-to-end remote patient monitoring and telehealth service to manage a range of chronic conditions including hypertension, cardiovascular disease, obesity, chronic kidney disease, diabetes, and post-surgical care. Products include QardioArm, a wireless blood pressure monitor that measures systolic, diastolic blood pressure, heart rate and detects an irregular heartbeat. They also offer a pulse oximeter, an infrared thermometer and scales, all of which integrate with a remote dashboard for clinicians.

Appendices

Appendix A: Additional remote monitoring products

Additional remote monitoring solutions

Pathway	Company / Product	Description	Link
Heart failure	iRythm Technologies Ltd / Zio	Detects cardiac arrythmias via a wearable single lead ECG, a platform that analyses ECG data and provision of actionable summaries for clinicians.	https://irhythmtech.co.uk/the-proven-ambulatory-cardiac-monitoring-service/
Heart failure	RhythmiaBreathe	Heart clinic focused on rehab and prevention, launching an app to deliver virtual health plans, health tracking and nurse led support	https://rhythmiabreath.com/
Heart failure	Biobeat	Wrist or chest monitor using AI to monitor cardiac health	https://www.bio-beat.com/
Pre- and post-operative	JC Health	Monitoring the recovery state of patients with knee replacement arthroplasty based on the IoT device. Sends analytics data to clinicians.	https://jchealth.ca/pages/telehealth-services
Respiratory	MediTuner / AsthmaTuner	Self-management via an app, a spirometer and a healthcare provider user interface and database backend platform	https://asthmatuner.se/?lang=en
Respiratory	PatientMPower	App that integrates with a pulse oximeter and a spirometer to record saturation, FVC, FEV1 and other lung measures	https://info.patientmpower.com/

Additional remote monitoring solutions

Pathway	Company / Product	Description	Link	AHSN
Respiratory	Propeller Health	Asthma and COPD management via sensors	https://www.propellerhealth.com/	Eastern
Respiratory	PMD Solutions / RespiraSense	Real time measurement of respiratory rate through continuous monitoring	https://www.pmd-solutions.com/	Eastern
Long-term conditions	Weather Flare	Tracking app for patients with chronic conditions, that identifies triggers for their condition	https://www.weatherflare.org/	South West
Multiple	Docobo	A platform for the collection, analysis and display of remote monitoring data	https://www.docobo.co.uk/	Innovation Agency

Appendix B: Literature summary tables

Heart Failure (HF)

Research paper	Implementation considerations	Results and conclusions
Bekfani T, Fudim M, Cleland JGF, Jorbenadze A, von Haehling S, Lorber A, Rothman AMK, Stein K, Abraham WT, Sievert H, Anker SD. A current and future outlook on upcoming technologies in remote monitoring of patients with heart failure. Eur J Heart Fail. 2021 Jan;23(1):175-185. doi: 10.1002/ejhf.2033. Epub 2020 Nov 18. PMID: 33111389. 62 papers from 2005 - 2020	Remaining questions re implementation: Which patients should be monitored? Should RM be done and should it be invasive or non-invasive? When should RM be done? At onset of HF or after episode of decompensation? How long should RM be done for? High-risk periods or life long? Who is responsible for reviewing results? Patient engagement How often should measurements be made? Who will cover the additional costs?	The effectiveness of RM to improve life expectancy, QoL, and to reduce HF rehospitalizations has been demonstrated in several trials. In a recent Cochrane review, both non-invasive RM and structured telephone support were shown to reduce all-cause mortality. A meta-analysis of five trials evaluating the impact of haemodynamic-guided HF management in patients with symptomatic HF showed about 38% reduction in the risk for HF hospitalizations. Overall, remote monitoring is a promising way to monitor and manage patients with HF. RM could be performed non-invasively, through wearable devices, or by using developed algorithms integrated in implanted cardiac devices or invasively through continuous measuring of PA pressure. RM has been shown to improve the management and outcomes in patients with HF, but results do not apply to all technologies in all settings.
Mohebali D, Kittleson MMRemote monitoring in heart failure: current and emerging technologies in the context of the pandemicHeart 2021;107:366-372. 37 papers from 2011 - 2020	The key to successful virtual visits is to use the same systemic evaluation that one would perform during an in person visit. **Table 4 of the study paper outlines a useful checklist of high-yield assessments for history and physical examination** and other key components of the virtual visit	The combination of RM, particularly with PA pressure sensors, and the rise of virtual visits will allow the physician–patient connection to be maintained and strengthened.
Imberti JF, Tosetti A, Mei DA, Maisano A, Boriani G. Remote monitoring and telemedicine in heart failure: implementation and benefits. Curr Cardiol Rep. 2021 May 7;23(6):55. doi: 10.1007/s11886-021-01487-2. PMID: 33959819; PMCID: PMC8102149. 102 papers from 2002 – 2020	RM is still largely underused in clinical practice. Barriers to its implementation are mainly the lack of reimbursement, need for significant changes in hospitals' workflows, data overload, and increased workload for health-care providers. The growing clinical evidence on the safety and usefulness of RM, combined with the overcoming of the reimbursement issue, will probably lead to a wider overall adoption of this valuable tool, which will obviously will markedly benefit from active involvement of general practitioners, caregivers, and empowered patients. Factors that may lead to a more profitable use of RM include a better selection of parameters to monitor and patients to candidate to RM and a more proactive attitude towards disease management of HF, with an appropriate organization of care strictly linking hospital care to home care. A paradigm shift from remote patient monitoring to remote patient management is warranted, translating data into prompt clinical actions.	RM is recommended for the early detection of CIEDs technical issues and early diagnosis and management of cardiac arrhythmias. In recent years, multiparameter RM has gained relevance in the individualized management of HF patients implanted with a CIED. Despite good sensitivity in predicting worsening HF, the role of RM in improving patients' outcome is still matter of debate.

Heart Failure (HF)

Research paper	Implementation considerations	Results and conclusions
Lander MM, Aldweib N, Abraham WT. Wireless Hemodynamic Monitoring in Patients with Heart Failure. Curr Heart Fail Rep. 2021 Feb;18(1):12-22. doi: 10.1007/s11897-020-00498-4. Epub 2021 Jan 9. PMID: 33420917; PMCID: PMC7796686. 69 papers from 2001 - 2020	Intrathoracic Impedance Monitoring with CIEDs: Real-world experience with these devices dictates they are often followed by an electrophysiology or device clinic. Unless appropriate infrastructure is implemented, the clinic or team following the patient's device measurements may be separate from the team managing the patient's heart failure. The device data is also not immediately available to the patient, missing out on an opportunity to generate a patient's interest in their own heart failure management.	Remote monitoring and specifically wireless hemodynamic monitoring are valuable tools that can assist heart failure clinics in keeping patients optimized, out of the hospital and with sustained quality of life. Trial data has been mixed highlighting the importance of tying the data from these devices to an effective and pre-emptive management strategy. As cardiac medical devices become smaller, smarter, and more automated in their data collection, remote monitoring will continue to evolve into an indispensable part of the heart failure patient evaluation, especially with an emerging emphasis on virtual visits in the era of COVID-19.
Radhoe, S.P.; Veenis, J.F.; Brugts, J.J. Invasive Devices and Sensors for Remote Care of Heart Failure Patients. Sensors 2021, 21, 2014. https://doi.org/10.3390/s21062014 45 papers from 1992 - 2020	Efficacy of the products should be carefully weighed against safety when considering patient health outcomes. Devices and implant procedures can be costly compared to standard HF care and so is the associated extra workload to adequately monitor and follow the patients. Invasive monitoring is the most effective but not all HF patients can be monitored remotely with invasive techniques. Invasive implant procedure is not without risk so patients should be selected carefully.	Several remote monitoring techniques have been developed for early detection of worsening disease, potentially limiting the number of hospitalizations. Over the last years, the scope has been shifting towards the relatively novel invasive sensors capable of measuring intracardiac filling pressures, because it is believed that hemodynamic congestion precedes clinical congestion. Monitoring intracardiac pressures may therefore enable clinicians to intervene and avert hospitalizations in a pre-symptomatic phase. Remote monitoring of pulmonary artery pressures (PAP) by the CardioMEMS (CardioMicroelectromechanical system) HF System is the only technique with proven safety as well as efficacy with regard to the prevention of HF-related hospital admissions.
Veenis JF, Radhoe SP, Hooijmans P, Brugts JJ. Remote Monitoring in Chronic Heart Failure Patients: Is Non-Invasive Remote Monitoring the Way to Go? Sensors (Basel). 2021 Jan 28;21(3):887. doi: 10.3390/s21030887. PMID: 33525556; PMCID: PMC7865348.84 papers from 2001 – 2020	Invasive strategies are limited due to their higher costs and invasive nature. The authors believe that these invasive strategies should only be used in more symptomatic and more ill patients. Non-invasive remote monitoring strategies are easier to be widely implemented and should be used to monitor less symptomatic chronic HF patients.	The 2016 European Society of Cardiology (ESC) Guidelines for the diagnosis and treatment of acute and chronic heart failure does not provide any recommendation for the use of non-invasive remote monitoring. There is inconsistency in the reported effects of non-invasive remote monitoring strategies on all-cause mortality, all-cause hospitalization, and HF-related hospitalizations. However, the overall combined results demonstrated a small beneficial effect on the overall survival, HF-related hospitalizations, and adherence to the guideline-recommended pharmacological therapy. Due to its simplicity, non-invasive nature, and relatively low costs, non-invasive remote monitoring is desirable and to be recommended in lower risk or less symptomatic chronic HF patients

Heart Failure (HF)

Research paper	Implementation considerations	Results and conclusions
Senarath S, Fernie G, Roshan Fekr A. Influential Factors in Remote Monitoring of Heart Failure Patients: A Review of the Literature and Direction for Future Research. Sensors (Basel). 2021 May 21;21(11):3575. doi: 10.3390/s21113575. PMID: 34063825; PMCID: PMC8196679. 84 papers -2002 - 2020	Monitoring can be affected by the following factors: • Inaccurate weight measurements (affected by clothing and urine retention) • Low adherence/inconsistency in monitoring compliance: Implementing mechanisms that both monitor and encourage daily measurement along with staff enthusiasm toward using the system can help improve adherence. • Effects of medication: Frequency and degree of HF events can be significantly affected by missed medication or medication not taken at the right time. The subject's adherence to prescribed medication should also be monitored • Water intake and diet may affect weight. Air temperature and physical activity may affect vital signs. A system is needed to make sure the data collection protocols are performed properly. • The rate of diagnosis can vary between models and manufacturers. There is a need to have a platform which can provide a hub with a unifying technology that combines multiple communication protocols to connect different types of sensors, actuators, and devices through a single interface.	It was observed that the most promising results came from studies that used a combination of multiple parameters, compared to using an individual variable. The main challenges discussed includes, compliance with daily monitoring, and consideration of additional factors such as physical activity and diet. The findings demonstrate the need for a shared remote monitoring platform which can lead to a significant reduction of false alarms and help in collecting reliable data from the patients for clinical use especially for the prevention of cardiac events. Heart rate showed promising results in the studies reviewed. Most studies showed that respiration monitoring was significant.
Silva-Cardoso J, Juanatey JRG, Comin-Colet J, Sousa JM, Cavalheiro A, Moreira E. The Future of Telemedicine in the Management of Heart Failure Patients. Card Fail Rev. 2021;7:e11. Published 2021 May 28. doi:10.15420/cfr.2020.32 55 papers from 2005 - 2020	Drivers for telemedicine in HF: Haemodynamic instability; high prevalence; organisational burden; high HF-associated costs; need for patient empowerment Barriers to telemedicine in HF: Reimbursement; policy; regulatory constraints; technological barriers; patients and caregivers adherence Artificial intelligence-powered/telemedical/heart team/multidisciplinary integrated care may be the next step of HF management; hybrid approach recommended	TM can improve healthcare accessibility and overcome geographic inequalities. It promotes healthcare system efficiency gains, and improves patient self-management and empowerment. In cooperation with human intervention, artificial intelligence can enhance TM by helping to deal with the complexities of multicomorbidity management in HF, and will play a relevant role towards a personalised HF patient approach
Brugts JJ, Radhoe SP, Aydin D, Theuns DA, Veenis JF. Clinical Update of the Latest Evidence for CardioMEMS Pulmonary Artery Pressure Monitoring in Patients with Chronic Heart Failure: A Promising System for Remote Heart Failure Care. Sensors (Basel). 2021;21(7):2335. Published 2021 Mar 27. doi:10.3390/s21072335 20 papers from 2009 - 2020	The CardioMEMS HF system consists of an implantable wireless sensor, a patient and hospital electronics system and a patient database (Integrated Merlin.net secure website for patient data management). The sensor is implanted in a branch of the left pulmonary artery through the femoral vein. CardioMEMS is the only invasive heart failure (HF) remote monitoring sensor with Food and Drug Administration (FDA) approval and European Conformity (CE) mark. The CardioMEMS HF system is recommended in the European Society of Cardiology (ESC) guidelines of 2016 with a class II b level B recommendation, which is expected to be upgraded in the newest version of the guidelines in 2021 with evidence from several new studies. Safe and reliable technique.	CardioMEMS HF system is a safe, reliable and proven clinically effective monitoring strategy to prevent HF hospitalizations

Heart Failure (HF)

Research paper	Implementation considerations	Results and conclusions
Nick, Jan M.; Roberts, Lisa R.; Petersen, Anne Berit Effectiveness of telemonitoring on self-care behaviors among community-dwelling adults with heart failure, JBI Evidence Synthesis: April 23, 2021 - Volume - Issue - doi: 10.11124/JBIES-20-00329 12 papers from 1997-2019	Care providers can choose from a variety of TM options to enhance patients' engagement in self-care behaviours. However, due to the possibility of attenuated effect over time, health care providers must be alert to the possibility of declining self-care. Re-motivation strategies may be needed to sustain benefits gained during early periods of TM.	Overall, telemonitoring had a positive effect on self-care behaviour among adult, community-dwelling patients with heart failure, however, there is insufficient and conflicting evidence to determine how long the effectiveness lasts. Longitudinal studies are needed to determine the sustained effect of telemonitoring on self-care behaviors. In addition, the limitations of the current studies (eg, inadequate sample size, study design, incomplete statistical reporting, and self-report bias) should be taken into account when designing future studies.
Drews, T.E., Laukkanen, J. and Nieminen, T., 2021. Non-invasive home telemonitoring in patients with decompensated heart failure: a systematic review and meta-analysis. ESC Heart Failure. 11 papers from 2005-2016	It seems that patient adherence to TM interventions is higher with interventions that are relatively simple and easy to use. It is likely that the most feasible system and environment for implementing a TM intervention remain to be established.	Published trials on non-invasive home TM interventions in recently decompensated HF patients are scarce. This systematic review and meta-analysis of existing data showed that non-invasive home TM had no effect on all-cause hospitalizations or mortality in recently decompensated HF patients. The neutral effect emerging from the included trials may be partly explained by a large amount of clinical heterogeneity between TM trials.
Planinc, I., Milicic, D., & Cikes, M. (2020). Telemonitoring in Heart Failure Management. Cardiac failure review, 6, e06. https://doi.org/10.15420/cfr.2019.12	The European Society of Cardiology (ESC) provided limited recommendations for TM in its 2016 guidelines for the diagnosis and treatment of acute and chronic HF. Monitoring of pulmonary artery pressure (PAP) using a wireless implantable haemodynamic monitoring system (CardioMEMS HF System, Abbott) in symptomatic patients with reduced or preserved EF and a previous HF hospitalisation was recommended for the risk reduction of recurrent HF hospitalisations. The only other approach mentioned was multiparameter monitoring by ICD for improvement of clinical outcomes in symptomatic patients with left ventricular EF (LVEF) ≤35%. All other TM methods were considered to lack sufficient evidence to support recommendation, based on different clinical trial results and lack of uniformity. But consecutive Cochrane reviews show a significant reduction in major outcomes (all-cause mortality and HF hospitalisations) when using structured telephone support or non-invasive TM - these were not included in the latest ESC guidelines. There is a growing number of expert opinion and review publications addressing the issue of equivocal evidence for the use of TM in the management of HF patients An individual approach to the patient and TM method selection was highlighted.	Overall, TM for HF is still scarcely represented in the recommendations from professional associations, except for PAP monitoring, which is supported by RCT data. The paucity of evidence required to base informed recommendations may seem surprising, especially considering the current wide availability of different e-health technologies and the increase in recent popularity of health devices. This reality is a result of the enormous heterogeneity of TM devices tested of differences in selected patient populations, such as type of HF, age, LVEF, clinical stage, background treatment of geographical determinants (densely populated against remote areas far from HF centres) and variabilities between healthcare systems. Furthermore, the strengthening of regulatory processes over time provides additional variability in the testing and approval of TM devices. All these factors contribute to the body of evidence that provides arguments both for and against different types of TM for HF.

Chronic Obstructive Pulmonary Disease (COPD)

Research paper	Implementation considerations	Results and conclusions
Mehdipour A, Wiley E, Richardson J, Beauchamp M, Kuspinar A. The Performance of Digital Monitoring Devices for Oxygen Saturation and Respiratory Rate in COPD: A Systematic Review. COPD. 2021 Jul 5:1-7. doi: 10.1080/15412555.2021.1945021. Epub ahead of print. PMID: 34223780. 7 papers from 1996 - 2020	The pooled analysis indicated that respiratory rate (RR) devices consistently reported approximately two breaths less, per minute, than the Oxycon. Clinicians should be aware that RR monitoring devices may underestimate the RR of patients.	Oxygen saturation (SpO2) and respiratory rate (RR) devices were valid when compared to other respiration monitoring devices, but not precise in predicting exacerbation events. Further evaluation is warranted for SpO2 devices during activity as there were inconsistent findings as to how well they agreed with other devices under exercise conditions.
Jang S, Kim Y, Cho WK. A Systematic Review and Meta-Analysis of Telemonitoring Interventions on Severe COPD Exacerbations. Int J Environ Res Public Health. 2021 Jun 23;18(13):6757. doi: 10.3390/ijerph18136757. PMID: 34201762; PMCID: PMC8268154. 49 papers from 1997 - 2020	The most common telemonitored data were oxygen saturation, symptoms, and vital signs, which were transmitted synchronously or asynchronously with data collection. The information transmitted was usually evaluated by medical professionals so that they could respond to any abnormal or missing data. In some studies, it showed that some RM can cause alarm fatigue, including false alarms from device errors, leading to worsened quality of life. Adding telemonitoring best for reducing A&E visits and well accepted by patients and easily integrated into their existing care	Telemonitoring did not reduce the number of admissions but decreased the number of A&E visits. No benefit in mortality, quality of life, cost-effectiveness. Participation satisfaction levels were high.
Li, Wei Liu, Shengnan Liu, Jing Li, Wenjing Wang, Kun Li, Perceptions of patients with chronic obstructive pulmonary disease towards telemedicine: A qualitative systematic review, Heart & Lung, Volume 50, Issue 5, 2021, Pages 675-684, ISSN 0147-9563, https://doi.org/10.1016/j.hrtlng.2021.03.081. 20 papers from 2000 - 2020	No access to full text	Although patients have different views on telemedicine, most of them have a positive attitude towards it.
Rutkowski S. Management Challenges in Chronic Obstructive Pulmonary Disease in the COVID-19 Pandemic: Telehealth and Virtual Reality. J Clin Med. 2021 Mar 18;10(6):1261. doi: 10.3390/jcm10061261. PMID: 33803853; PMCID: PMC8003143. 93 papers from 1993 - 2020	Patient perceptions were high but recommendations for hybrid implementation for pulmonary rehab between traditional methods, VR and telemonitoring	Studies indicate promising effectiveness, high patient acceptance, and high motivations to undertake physical activity with the use of such a solution, particularly in VR where it may offer more distractions and exposure to different 'worlds' rather than the patient focusing on their pain, tiredness etc.
Jiang W, Wang L, Song Y. Titration and follow-up for home non-invasive positive pressure ventilation in chronic obstructive pulmonary disease: The potential role of tele-monitoring and the Internet of things. Clin Respir J. 2021 Mar 11. doi: 10.1111/crj.13352. Epub ahead of print. PMID: 33705593. 68 papers from 1997 - 2020	Non-invasive positive pressure ventilation (NIPPV) can be used to support breathing. Tele-monitoring may play a major role in promoting the exchange of information and improving NIPPV effectiveness and quality control, but needs to be proven safe, effective, and cost-effective. A wide range of technologies and signals can be used. Future developments may better enable telemonitoring to support NIPPV such as combining telemonitoring with analysing ventilator data to predict exacerbations. Using cloud platforms for remote adjustments to the parameters of the ventilator, immediate feedback and personalisaed treatment drawing on big data.	Clear conclusions based on RCT of tele-monitoring in COPD patients with NIPPV at home are only a few and large-scale multicentre studies are required for replication and further validation. Many RM innovations are very costly such as non-invasive positive pressure ventilation (NIPPV), but these offer more patient empowerment at home, therefore saving patients having to attend hospital visits

Chronic Obstructive Pulmonary Disease (COPD)

Research paper	Implementation considerations	Results and conclusions
Wu F, Burt J, Chowdhury T, et al. Specialty COPD care during COVID-19: patient and clinician perspectives on remote delivery. BMJ Open Respir Res. 2021;8(1):e000817. doi:10.1136/bmjresp-2020-000817 25 papers from 1995 - 2020	Need to establish direct telephone access for urgent questions; developing new or existing online education on how best to deliver remote consultations, expanding video consultation availability for HCP, provide loaning options for pulse oximeters. Clinicians are happy to perform inhaler techniques, provide breathing training, and education etc. but patients would prefer these face-to-face	Adoption of remote care delivery appears high
Bonnevie T, Smondack P, Elkins M, Gouel B, Medrinal C, Combret Y, Muir JF, Cuvelier A, Prieur G, Gravier FE. Advanced telehealth technology improves home-based exercise therapy for people with stable chronic obstructive pulmonary disease: a systematic review. J Physiother. 2021 Jan;67(1):27-40. doi: 10.1016/j.jphys.2020.12.006. Epub 2020 Dec 24. PMID: 33358547. 63 papers from 2000 - 2020	Similar overall benefits to patients' health therefore any implementation should aim to be cost effective and fit in well with HCP/clinician plans	Patient benefits from telehealth vs face-to-face was similar. Patients showed signs of more physical activity due to being able to integrate it in to their house/daily routines
Barbosa MT, Sousa CS, Morais-Almeida M, Simões MJ, Mendes P. Telemedicine in COPD: An Overview by Topics. COPD. 2020 Oct;17(5):601-617. doi: 10.1080/15412555.2020.1815182. Epub 2020 Sep 7. PMID: 32892650. 66 papers from 2006 - 2020	Recommendations to use a flexible approach with RM that can be customised to the patients' requirements. Patients' age, education, experience in technological devices, cognitive, motor and visual abilities or deficits, their families and home environment play an important role in the use of technologies. Some papers established positive results and possibilities for the successful application of telemonitoring interventions: with regard to non-invasive ventilation, forced expiratory volume, peripheral oxygen saturation and physical activity. There are also investigations into new technologies and telemonitoring methods with encouraging outcomes, such as, respiratory oscillometry, exhaled breath temperature or telemonitoring machine learning that will enable treatments to be personalized and early detect COPD exacerbations	Telemonitoring is not generally accepted yet because of a lack of compelling evidence of its beneficial long-term effects and, once again, the results obtained were mixed. Studies report improvements in some outcomes assessed: quality of life, hospital readmissions at three months after discharge, and time to readmissions and all cause emergency department or hospital admissions. Other data suggests it might not have impact in reducing mortality and exacerbation-related outcomes in COPD, with others showing reticence regarding the application of these interventions in a generalized way, stating that the benefits might come from the fact that patients submitted to clinical trials have more attention and support with the disease than otherwise they would receive.
Liu F, Jiang Y, Xu G, Ding Z. Effectiveness of Telemedicine Intervention for Chronic Obstructive Pulmonary Disease in China: A Systematic Review and Meta-Analysis. Telemed J E Health. 2020 Sep;26(9):1075-1092. doi: 10.1089/tmj.2019.0215. Epub 2020 Feb 18. PMID: 32069170. 24 papers	NA	Telemedicine suggested improved quality of life and lower hospital admissions, although implementation varied and results are from China so may have limited relevance to the NHS.

Chronic Obstructive Pulmonary Disease (COPD)

Research paper	Implementation considerations	Results and conclusions
Li X, Xie Y, Zhao H, Zhang H, Yu X, Li J. Telemonitoring Interventions in COPD Patients: Overview of Systematic Reviews. Biomed Res Int. 2020 Jan 17;2020:5040521. doi: 10.1155/2020/5040521. PMID: 32016115; PMCID: PMC6988702 8 systematic reviews and meta-analyses from 2011-2019, from 95 RCTs	Long term effects on patients using RM has yet to be evaluated	There might be insufficient evidence to support the effectiveness of telemonitoring interventions for COPD currently and further investigations are needed
Attaway AH, Alshabani K, Bender B, Hatipoğlu US. The Utility of Electronic Inhaler Monitoring in COPD Management: Promises and Challenges. Chest. 2020 Jun;157(6):1466-1477. doi: 10.1016/j.chest.2019.12.034. Epub 2020 Jan 22. PMID: 31981565. 57 papers from 1991 - 2020	Can be combined with clinician feedback, audiovisual reminders, text messaging	EIM can diagnose nonadherence, improve adherence, and predict exacerbations. Using an EIM-guided protocol has the potential to avoid treatment escalation in the nonadherent.
Smith SM, Holland AE, McDonald CFBeyond forest plots: clinical gestalt and its influence on COPD telemonitoring studies and outcomes reviewBMJ Open 2019;9:e030779. doi: 10.1136/bmjopen-2019-030779 52 papers from 1990 - 2018	When introducing remote monitoring it is important to consider how it aligns with other support and services offered to patients – including access to clinicians – and how this may impact results.	Where group assignment did not limit participants communicating with the clinical or research team, there were a greater number of emergency department attendances and hospital admissions in the usual care group. The length of stay was longer for those who were assigned home telemonitoring in the majority of studies.
Pericleous P, van Staa TP. The use of wearable technology to monitor physical activity in patients with COPD: a literature review. Int J Chron Obstruct Pulmon Dis. 2019 Jun 19;14:1317-1322. doi: 10.2147/COPD.S193037. PMID: 31354259; PMCID: PMC6590412. 30 papers from 1997 - 2019	Physical activity monitors need to become more accurate (insensitive to low walking speeds, altering readings when shaken, memory storage problems, high signal-to-noise ratio) and their placement made more comfortable for the COPD user. In order to be able to apply such a monitoring system more widely, there is a need for a platform where health care practitioners can monitor live data from the technology and health care professionals need to be trained to communicate better with patients.	Health outcomes and activity levels are inconclusive. More RCTs are required to find the effect of physical activity monitors as part of an exercise intervention for COPD patients. There is a need for more and better studies that estimate the costs and benefits of using these technologies and to develop a strategy that will make this kind of technology sustainable beyond the pilot stage.
Barken TL, Söderhamn U, Thygesen E. A sense of belonging: A meta-ethnography of the experience of patients with chronic obstructive pulmonary disease receiving care through telemedicine. J Adv Nurs. 2019 Dec;75(12):3219-3230. doi: 10.1111/jan.14117. Epub 2019 Aug 5. PMID: 31225664. 65 papers from 1992 - 2019	Remote monitoring interventions should include emotional, social, clinical support and regular contact with HCP as studies demonstrate that this is an essential part of health and social care	Remote monitoring can enable a sense of 'belonging' from patients

Chronic Obstructive Pulmonary Disease (COPD)

Research paper	Implementation considerations	Results and conclusions
Kruse C, Pesek B, Anderson M, Brennan K, Comfort H. Telemonitoring to Manage Chronic Obstructive Pulmonary Disease: Systematic Literature Review. JMIR Med Inform. 2019 Mar 20;7(1):e11496. doi: 10.2196/11496. PMID: 30892276; PMCID: PMC6446156. 42 papers from 2003 - 2018	Facilitators to adoption: Improved patient outcomes or satisfaction; reduced need for in-person visits; better disease management; bolstered patient-provider relationship; high-quality data; patient empowerment; ease of use; predictability of exacerbations; provision of additional services; patient engagement; access to patient data; communication. Barriers to adoption: Reduced patient outcomes or no improvement; low-quality or limited data; increased workload for providers; cost; heterogeneity of care; lack of service standardization; exacerbations are highly variable; uncomfortable with technology; less patient autonomy; time-consuming; staff shortages or overworked staff; user perception or perceived lack of usefulness; user or patient resistance	Some articles cited improvements in patient outcomes, satisfaction, anxiety and depression, and hospitalization rates while others stated that no significant improvement occurred. The most frequently mentioned barrier was reduced patient outcomes or no improvement. Policy makers need to carefully endorse those technological interventions that yield positive patient outcomes and recommend that developers work on the rest of the barriers.
Hong Y, Lee SH. Effectiveness of tele-monitoring by patient severity and intervention type in chronic obstructive pulmonary disease patients: A systematic review and meta-analysis. Int J Nurs Stud. 2019 Apr;92:1-15. doi: 10.1016/j.ijnurstu.2018.12.006. Epub 2019 Jan 2. PMID: 30690162. 27 papers	Integrate tele-monitoring alongside coping skills or education by online methods is recommended	Tele-monitoring reduced A&E visits & hospitalisations, particularly in those with severe COPD. Mental health quality of life score improved. Education and pulmonary rehab via RM is recommended.
Sul AR, Lyu DH, Park DA. Effectiveness of telemonitoring versus usual care for chronic obstructive pulmonary disease: A systematic review and meta-analysis. J Telemed Telecare. 2020 May;26(4):189-199. doi: 10.1177/1357633X18811757. Epub 2018 Dec 12. PMID: 30541375. 44 papers from 1999 - 2018	If pulmonary rehab is extended then consider activating telemonitoring. Important to identify the parameter that can accurately predict an exacerbation episode. Physiological variables important to use RM on, because exacerbation of COPD was subject to alterations in lung function (e.g. PEF or FEV1), heart rate, oxygen saturation or respiratory rate.	No significant difference between telemonitoring and usual care. Only difference included longer telemonitoring reduced exacerbation rates when the intervention lasted for longer than 6 weeks. Telemonitoring gives an opportunity for frequent contact and increased support, promoted coordinated care and patient education

Covid-19

Research paper	Implementation considerations	Results and conclusions
Vindrola-Padros, C., Singh, K., Sidhu, M.S., Georghiou, T., Sherlaw-Johnson, C., Tomini, S.M., Cohen, N., Inada-Kim, M., Kirkham, K., Streetly, A. and Fulop, N.J., 2021. Remote home monitoring (virtual wards) during the COVID-19 pandemic: a systematic review. MedRxiv, pp.2020-10. 27 articles	Key lessons in the implementation of remote home monitoring models during the COVID-19 pandemic It is important to consider remote home monitoring models as an approach to maintain patients safe in the right setting. The use of apps for monitoring allowed the follow-up of a higher number of patients (compared to paper-based models), but some of the studies indicated that models based on telephone calls were more inclusive (i.e. including patients without internet access or technological literacy). Patient/carer training was identified as a key determining factor of the success of these models. Coordination between primary and secondary care facilitated implementation Primary care led models were considered, in some cases, as more adaptable to evolving patient and system needs, and easier to replicate in contexts with limited secondary care access and capacity. A few models integrated mental health and social care support during and after patient monitoring, highlighting a wide range of patient needs.	It was difficult to carry out an analysis of the impact of remote home monitoring across all examples because not all articles reported data on the same outcomes. Mortality rates were low, admission or readmission rates ranged from 0 to 29%, and ED attendance or reattendance ranged from 4 to 36%. Six of the models reported data on patient feedback, with high satisfaction rates. Remote home monitoring process outcomes were only included in six of the articles, with time from swab to assessment ranging from 2 to 3.7 days and virtual length of stay from 3.5 days to 13 days. Only one article presented findings on reduction in length of stay, calculated at 5 days fewer per patient.

Orthopaedics

Research paper	Implementation considerations	Results and conclusions
Petersen, W., Karpinski, K., Backhaus, L. et al. A systematic review about telemedicine in orthopedics. Arch Orthop Trauma Surg (2021). https://doi.org/10.1007/s00402-021-03788-1 14 articles reporting 8 RCTs, 2000-2019	Barriers: Expensive hardware and software could be a barrier (particularly if video is used as part of a consultation). Drop-out rates can be higher in asynchronous rehabilitation – possibly because the personal relationship between physiotherapist and patient is missing. In future: One way to improve the precision of telemedical examinations and findings would be to use sensors, particularly in the context of rehabilitation. Powerful motion sensors are so small that they can be attached locally to the knee and thus register movements. In various experimental studies, locally attached sensors have already been used to monitor rehabilitation after prosthetic knee replacement. More research is needed to expand possibilities.	Focus on synchronous patient-doctor interactions. Telerehabilitation after knee or hip arthroplasty: No significant differences between intervention groups and controls for the majority of parameters studied. One study evaluated return to work after total knee and hip replacement - more patients after telerehabilitation returned to work in comparison to the control group with conventional physiotherapy. One study examined the cost effectiveness of telerehabilitation for knee arthroplasty. This study could show that the cost of telerehabilitation was lower than face-to-face treatments when the distance to the hospital was 30 km or more. Overall, there is scientific evidence for telemedical applications in orthopedics for consultations and rehabilitation. The current evidence is very convincing for telerehabilitation after implantation of a knee prosthesis. The positive experiences with telerehabilitation should be transferred to other rehabilitation procedures (e.g., rehabilitation after reconstruction of the anterior cruciate ligament) in the future.
Sliepen, M., Lipperts, M., Tjur, M., & Mechlenburg, I. (2020). Use of accelerometer-based activity monitoring in orthopaedics: benefits, impact and practical considerations. EFORT open reviews, 4(12), 678–685. https://doi.org/10.1302/2058-5241.4.180041	Identify the desired parameters to be measured and choose sensors that can measure these parameters with a high level of precision. Wear location should be considered. When choosing between the market supply of sensors, both the technical and clinical precision of the accelerometer unit, the need for data analysis skills and tools, the commercial customer support, and previous comparable studies performed using the sensor and the cost of the sensor should all be considered. The costs of single-sensor systems are low to moderate, but multi-sensor systems which combine accelerometry with other measures, such as heart rate or respiration, are quite costly. The use of multi-sensor systems will increase precision but are complex and not necessary for overall PA monitoring. Battery life should be appropriate.	The assessment of physical activity (PA) in orthopaedics is feasible. The benefits are numerous; clinicians can obtain an objective measure of total volumes of PA and specific PA parameters that can be used for clinical comparisons before and after surgical or rehabilitation interventions. Furthermore, the added information on patients' PA levels will provide clinicians with a fuller picture of the patient's status before or after an intervention. From a patient perspective, accelerometer-based activity monitoring can be used during orthopaedic pre- or rehabilitation to help patients reach their PA targets. Moreover, accelerometer-based activity monitoring, either patient-administered or clinician-administered, can be used to coach patients towards a more active lifestyle.

Surgery

Research paper	Key lessons for implementation	Results and conclusions
Miller M, Roxburgh CS, McCann L, Connaghan J, Van-Wyk H, McSorley S, Maguire R. Development of a Remote Monitoring Application to Improve Care and Support Patients in the First 30 Days Following Colorectal Cancer Surgery. Semin Oncol Nurs. 2020 Dec;36(6):151086. doi: 10.1016/j.soncn.2020.151086. Epub 2020 Nov 18. PMID: 33218885. 1 paper	App designed and developed with the rationale to support and improve the care of patients in the first 30 days post-operative days following colorectal cancer surgery. Similar approach could be implemented to develop comparable apps	Gives patients the opportunity to report issues of concern to relevant health professionals. This could facilitate the early identification of concerning signs and symptoms, ensuring appropriate and timely interventions to minimize readmission rates. Patients' experiences during the recovery period could also be improved through the provision of reliable and relevant online information. More specifically, health professionals could easily identify those patients requiring additional support to manage their recovery, for example, those with more severe symptoms or problems, facilitating the direction of appropriate health services to those most in need of their expertise
Kolcun JPG, Ryu WHA, Traynelis VC. Systematic review of telemedicine in spine surgery. J Neurosurg Spine. 2020 Oct 30:1-10. doi: 10.3171/2020.6.SPINE20863. Epub ahead of print. PMID: 33126219. 12 papers	Although focused on telemedicine more broadly, there is applicable learning towards remote monitoring too. Studies suggest that it's best to aim towards improving perioperative patient communication and patient education by using mobile phone apps, online surveys, or online materials for consent	Recommended as an adjunct to traditional in-person clinical encounters for certain perioperative tasks such as supplemental patient education and postoperative surveys
Ajibade A, Younas H, Pullan M, Harky A. Telemedicine in cardiovascular surgery during COVID-19 pandemic: A systematic review and our experience. J Card Surg. 2020 Oct;35(10):2773-2784. doi: 10.1111/jocs.14933. Epub 2020 Aug 16. PMID: 32881081; PMCID: PMC7460963. 81 papers from 1994 - 2020	Remote analysis of echocardiograms can support with triaging and has shown good outcomes. Virtual MDT meetings recommended. remote transmission of cardiac magnetic resonance imaging has been successfully used to assess congenital heart disease in children. However, the use of cardiac imaging in remote diagnosis requires the availability of imaging equipment and trained technicians to perform the scans before the images can be interpreted by a remote specialist.	Combinations of regular virtual consultations and remote monitoring of clinical parameters are feasible for cardiac surgery patients and would be useful to assess and triage before surgery. Remote monitoring could also be particularly useful in managing postoperative complications, to help reduce ambulatory visits and rehospitalizations for vascular surgery patients. This is especially vital right now as the social distancing measures are set to stay for the foreseeable future; the utmost priority is to explore the use TM to reduce patient to physician contact as much as possible. However, TM can be limited by the need of sophisticated technological requirement and patients' educational and know-how computer literacy level. Studies have utilized mobile and smartphone technology to assess surgical wounds, in place of standard outpatient care. The accuracy of physician analysis of wound images taken by smartphone and other digital cameras is comparable to that of in-person wound examination Patient self-monitoring has also led to favourable outcomes in BP reduction compared to conventional follow-ups. Single lead portable ECG devices such as the AliveCor Heart Monitor record ECG traces and transmit them to a mobile application with which they are paired, and can then be viewed by specialists. ASCOLTA telemonitoring system to wirelessly collect biometric data from heart failure (HF) patients, including ECG, respiratory rate, and oxygen saturation (SpO2), along with questionnaires on general health data, and found that the combined information allowed cardiologists to effectively determine a patient's health status remotely and with high efficacy.

Other applications of telemedicine in surgery

Research paper	Implementation considerations	Results and conclusions
Moisan P, Barimani B, Antoniou J. Orthopedic Surgery and Telemedicine in Times of COVID-19 and Beyond: a Review. Curr Rev Musculoskelet Med. 2021 Apr;14(2):155-159. doi: 10.1007/s12178-021-09693-9. Epub 2021 Jan 18. PMID: 33460020; PMCID: PMC7812031. 25 papers from 2003 - 2020	Telemedicine requires consideration of the patient's condition and technological literacy, therefore should be coupled with technical support and alternative options.	It has a potential to increase productivity and decrease wait times by providing easier access to the clinician and by decreasing travel-associated limitations and costs. Authors have described the possibility to conduct a reliable virtual assessment of the patient range of motion. Some of the limitations to the use of this technology are technological literacy and access to virtual consultation platforms, the inability to conduct a complete physical examination, potential reduction in identification of intimate and child abuse victims, and limited knowledge about the legal implications of this technology
Morisada MV, Tollefson TT, Shaye DA, Steele TO. The digital doctor: telemedicine in facial plastic surgery. Curr Opin Otolaryngol Head Neck Surg. 2021 Aug 1;29(4):271-276. doi: 10.1097/MOO.0000000000000722. PMID: 34039841. 25 papers from 1999 - 2021	Although a lot of available technology exists, it is not available to everybody and may be costly	Telemedicine has been successfully implemented among subsets of facial plastic surgery patients, with high patient and provider satisfaction
Sohn GK, Wong DJ, Yu SS. A Review of the Use of Telemedicine in Dermatologic Surgery. Dermatol Surg. 2020 Apr;46(4):501-507. doi: 10.1097/DSS.0000000000002230. PMID: 31688234. 51 papers from 1997 - 2019	Digital training for clinicians and patients recommended	For preoperative consultation, teledermatology enables the surgeon to plan ahead and increases access to care by reducing the number of clinic visits. Telepathology has the potential to allow intraoperative consultation with a dermatopathologist to achieve accurate tumour clearance without delay. Smartglasses represent a promising technology for greater care coordination and a teaching tool. Postprocedural monitoring via text messaging provides convenient access to expert advice and early detection of postoperative complications.
Grandizio LC, Foster BK, Klena JC. Telemedicine in Hand and Upper-Extremity Surgery. J Hand Surg Am. 2020 Mar;45(3):239-242. doi: 10.1016/j.jhsa.2019.09.007. Epub 2019 Nov 9. PMID: 31718846. 20 papers from 2001 - 2019	Potential applications for this technology include remote inpatient and emergency room consultations, outpatient clinic visits, and postoperative care. There are unique considerations with respect to confidentiality and security	Videoconferencing visits may provide benefits to patients. Particularly in rural and underserved regions, patients can decrease considerable travel burdens.
Kohler JE, Falcone RA Jr, Fallat ME. Rural health, telemedicine and access for pediatric surgery. Curr Opin Pediatr. 2019 Jun;31(3):391-398. doi: 10.1097/MOP.0000000000000763. PMID: 31090582.	Application in rural or hard to reach areas most beneficial	Telemonitoring enables clinicians to keep children at the home hospital if resources are available, facilitate transfer of patients and relationship building, and develop necessary transfer protocols and guidelines between hospitals.

Other applications of telemedicine in surgery

Research paper	Implementation considerations	Results and conclusions
Harting MT, Wheeler A, Ponsky T, Nwomeh B, Snyder CL, Bruns NE, Lesher A, Pandya S, Dickie B, Shah SR; APSA Informatics and Telemedicine Committee. Telemedicine in pediatric surgery. J Pediatr Surg. 2019 Mar;54(3):587-594. doi: 10.1016/j.jpedsurg.2018.04.038. Epub 2018 May 5. PMID: 29801660. 32 papers from 1996 - 2019	NA	Telemedicine is an emerging strategy for healthcare delivery that has the potential to expand access, optimize efficiency, minimize cost, and enhance patient satisfaction
Bradley LE, Thomas JG, Hood MM, Corsica JA, Kelly MC, Sarwer DB. Remote assessments and behavioral interventions in post-bariatric surgery patients. Surg Obes Relat Dis. 2018 Oct;14(10):1632-1644. doi: 10.1016/j.soard.2018.07.011. Epub 2018 Jul 19. PMID: 30149949. 81 papers from 1995 - 2018	Recommendations to apply remote consultations in to bariatric post op appointments	Bariatric surgery post op requires long term follow ups and being able to offer these remotely shows a higher attendance rate overtime
Coldebella B, Armfield NR, Bambling M, Hansen J, Edirippulige S. The use of telemedicine for delivering healthcare to bariatric surgery patients: A literature review. J Telemed Telecare. 2018 Dec;24(10):651-660. doi: 10.1177/1357633X18795356. PMID: 30343656. 36 papers from 2005 - 2018	70% of the studies in this systematic review used telemedicine to deliver services and bariatric surgery is considered one of the most effective medical interventions for weight loss in the morbidly obese and so consideration of adding telemedicine in to this pathway shows positive results in some studies.	One study found a significant improvement in quality of life score by using telemedicine and telephone support; whereas another found no significant difference in weight loss, health related QOL and eating related disorders. Remote monitoring and virtual consultations may be applied for the use of weight loss, changes in physical activity, diet/eating or other behavioural changes consultations but further research recommended due to mixed results from the studies.
Vyas KS, Hambrick HR, Shakir A, Morrison SD, Tran DC, Pearson K, Vasconez HC, Mardini S, Gosman AA, Dobke M, Granick MS. A Systematic Review of the Use of Telemedicine in Plastic and Reconstructive Surgery and Dermatology. Ann Plast Surg. 2017 Jun;78(6):736-768. doi: 10.1097/SAP.0000000000001044. PMID: 28328635. 23 papers	NA	Studies shows that remote monitoring facilitates interprofessional collaboration across time and space, eliminating a significant number of unnecessary referrals, and connecting patients located far from major medical centers with professional expertise without impinging on-and in some cases improving-the quality or accuracy of care provided. The system was consistently rated as convenient and easy to use by patients, referring physicians, and consulting dermatologists. Teledermatology has also been used as an educational tool for patients
Gardiner S, Hartzell TL. Telemedicine and plastic surgery: a review of its applications, limitations and legal pitfalls. J Plast Reconstr Aesthet Surg. 2012 Mar;65(3):e47-53. doi: 10.1016/j.bjps.2011.11.048. Epub 2011 Dec 16. PMID: 22178033. 41 papers from 1995 - 2010	NA	Benefits include being able to liase with other medical expertise remotely

Other applications of telemedicine in orthopaedics

Research paper	Implementation considerations	Results and conclusions
Cole Jr, P.A., Lezak, B.A., Schroder, L.K. and Cole, P.A., 2021. Global orthopaedic trauma surgeons highlight telenomics during the COVID-19 era: A case for advancing telemedicine in orthopaedics. Journal of Clinical Orthopaedics and Trauma, 17, pp.182-185.	More research is needed to understand which telehealth methodologies yield positive patient outcomes and where limitations may exist. Such limitations may include increased likelihood of misdiagnosis, variability amongst patients in technological literacy and virtual access, inability to replicate complete in-person physical exam inclusive of accurate outcomes assessments such as range of motion, potential difficulties in identifying cases of domestic violence and child abuse, and everchanging legislative implications for telehealth use.	Systematic reviews have demonstrated efficacious uses of telemedicine-based rehabilitation for trauma fracture management and total hip and knee arthroplasty Emerging literature supports three high level but important conclusions: Orthopaedic surgeons globally have implemented telemedicine in the wake of COVID-19; Orthopaedic surgeons globally believe telemedicine will be a permanent change to their practice; Orthopaedic surgeons globally who implemented tele-medicine practices in the wake of COVID-19 are more likely to embrace it in the future.
Haider, Z., Aweid, B., Subramanian, P. and Iranpour, F., 2020. Telemedicine in orthopaedics and its potential applications during COVID-19 and beyond: a systematic review. Journal of Telemedicine and Telecare, p.1357633X20938241.	Orthopaedic assessment relies heavily on patient examination, and thus accuracy and validity of patient examination when using telemedicine is vital. Existing literature has shown that that ROM in hips, knee, shoulder, elbow, wrist and hand can be reliably and accurately measured using telemedicine technology. Further work exploring long-term outcomes of patients utilising telemedicine, validity of various patient examinations and PROMs is required with large, high-quality RCTs and longer follow-up.	Focus on remote consultations rather than monitoring Results reveal that telemedicine can be an accurate, valid, cost effective, safe and acceptable if not a preferable method of consultation for patients and clinicians compared with F2F consultations – including for post-operative follow-up.

Appendix C: All search results

All search results (embedded Excel file)

Microsoft Excel
Worksheet

Appendix D: Draft guidance (NHS@Home)

NHSX and NHS@Home

- NHSX is leading a Regional Scale Programme with associated implementation funding to enable the growth and replication of virtual wards across the country. The focus is on partnering with patients to enable self-care that is supported by a clinical team in the background, and on offering the most appropriate service for each patient.
- The work aligns with the NHS@home programme, moving away from Covid-19 virtual wards to managing long-term conditions from home. The national NHSE/I Community Services Digital team is developing operating guidance and a supporting framework for implementation of Frailty Virtual Wards for patients that would normally be admitted to hospital. This will be connected to UCR and anticipatory care workstreams.
- A National Innovation Collaborative has been established in partnership with the AHSN Network. A workspace has been set up on the FutureNHS Collaboration Platform, which shares best practice and provides example business cases, Standard Operating Procedures and clinical pathways. Email InnovationCollaborative-manager@future.nhs.uk to gain access to the workspace.

NHS@home draft definition of virtual wards (unpublished)

Virtual wards support patients to get the care, monitoring and support they need from a hospital or community health provider without being in a hospital. This may mean providing patients with support to use equipment and/or digital technology such as pulse oximeters and apps to provide regular readings to healthcare professionals to support recovery. This may also include providing clinical care by a multidisciplinary team in people's home including care homes. Virtual wards are not a replacement for face-to-face care. This allows patients to remain or return home more quickly and safely while still getting the care they need in a timely way.

For the NHS, virtual wards support early and safe discharge, alternative pathways to admission as well as effective care for more people. They are suitable for a range of conditions which can be safely and effectively managed and monitored at home. As a result of learning from COVID, many local areas are developing virtual wards for a range of people including those with respiratory problems, frailty and/or heart failure. NHS England and Improvement are working with stakeholders to support this to happen effectively, efficiently and equitably by developing resources to support implementation, facilitating shared learning and arranging an evaluation across England to more fully understand the benefits and application of virtual wards'

NHS@home draft virtual ward principles (unpublished)

- Supporting early and **safe discharge as well as alternative pathways to admission** for patients who have a stable or improving clinical trajectory (symptoms, function, oxygen saturation, NEWS).
- Supporting patients (and/or their carers), who would **otherwise be in hospital**, to get the acute care, **remote monitoring** and treatment they need in their own home.
- Providing patients (and/or their carers) with support to use **equipment or digital technology** such as mobile phone apps or web based tools to provide regular readings to healthcare professionals.
- Have clear pathways in place to support early recognition of deteriorating symptoms and have appropriate **escalation/safety netting** processes in place to maintain patient safety.
- Acute clinical care is usually lead by a Consultant in an acute provider, but this may also be provided by a **multidisciplinary team and or community health provider** in people's home including care homes e.g., community geriatricians.
- Patients and/or their carers will be given adequate information/training on the virtual ward service to allow **informed consent** and clear contact details of who to contact if their symptoms worsen including out of hours. Training should also be provided to carers, staff, MDT etc. as necessary.
- Should be **time specific** and include monitoring for up to 14 days (subject to local clinical decisions).
- Developed for a range of conditions/symptoms/settings (e.g. breathing, frailty, care homes) and should include **specific metrics to measure** appropriate outcomes to demonstrate patient safety and sustainability.
- Virtual wards **do not replace routine or emergency GP consultations**, local care, social services or other face to face care.
- To provide a safe and robust service, virtual ward requires staffing ideally for 12 hours a day seven days a week with locally arranged provision of out of hours cover.
- **Clinical, governance and administrative responsibilities** included in the pathway can be provided by any appropriately trained person and these staff are clinically supervised by an experienced clinically registered professional who is also responsible for making/monitoring the proactive daily reviews and any escalations.
- **Legal responsibility,** including ensuring appropriate **clinical governance, remains with the relevant lead provider** (usually secondary care) and is led by a named consultant or ST3+ doctor with relevant speciality experience (e.g. acute or respiratory physician). Information Governance standards and prescribing regulations should be monitored.
- Should be **adapted at system/local level and fully aligned or integrated with other service** development programmes including; D2A, SDEC and virtual consultations.

NHS@home draft learning points (unpublished)

Information Governance

- Start the journey at the beginning, as this often requires discussion with many system partners. The journey is easier if the data is just being used in a single organisation, but if you want to bring other partners in later try to include them in early discussions.
- Consider what data you may want to share and why, doing this will make the writing of any data sharing agreements much easier.

Useful links;
https://www.nhsx.nhs.uk/information-governance/guidance/use-and-share-information-confidence/

Clinical Safety

- First consideration is does the technology that you are intending to support you ward with have the necessary DCB0129 and other regulatory requirements?
- Do you have access to the clinical safety checklist as this will help you to complete the DCB0160?
- Do you have the necessary support from the CCIO/CIO and CSO to implement the product, this is much easier if you have a clearly defined clinical use case.

Useful links;
https://digital.nhs.uk/data-and-information/information-standards/information-standards-and-data-collections-including-extractions/publications-and-notifications/standards-and-collections/dcb0160-clinical-risk-management-its-application-in-the-deployment-and-use-of-health-it-systems

Procurement

- Do you intend to undertake a full procurement for the technology to support you Virtual Ward?
- There are several ways that you may wish to use;
  - Use of a framework such as HSSF, G-Cloud or the Spark DPS
  - Extension of an existing contract
  - Direct award

Useful links;
Spark-https://www.nhsx.nhs.uk/key-tools-and-info/procurement-frameworks/spark-dps-for-remote-monitoring/
HSSF-https://www.england.nhs.uk/hssf/
G-Cloud-https://www.crowncommercial.gov.uk/agreements/RM1557.12

Appendix E: Implementing remote monitoring for older people living independently at home – results from a recent study (awaiting publication)

Mobilising knowledge to improve assistive technology commissioning, service provision and sustained implementation

Dr Jennifer Lynch, NIHR Knowledge Mobilisation Research Fellow, 2018-21

Aim: To develop learning that supports improved knowledge mobilisation and sustained implementation of local authority commissioned technology programmes.

Objectives: (1)To provide an explanatory account of a technology implementation project; (2)To test and evaluate the Non-adoption, Abandonment and challenges to Scale-up, Spread and Sustainability of health and care technologies (NASSS) framework.

Design: Case study of a local authority drawing on ethnographic methods and knowledge mobilisation approaches with the researcher as participant following technology implementation over 2 years.

Methods: Regular site visits to observe meetings; participation in group conversations about the innovation and workshops involving different organisations and practitioners; interviews with key stakeholders; documentary review. NASSS framework used to organise data and structure analysis.

Dr Jennifer Lynch, Centre for Research in Public Health and Community Care, University of Hertfordshire j.lynch5@herts.ac.uk

Implementing remote monitoring in social care settings: avoiding common pitfalls

The literature shows the following questions are **rarely** considered but are often crucial to successful technology implementation

- **Has there been a realistic assessment** of the heterogeneous nature of service users' needs and how they change over time? Can the technology be adapted to meet those needs?
- **What type of knowledge** will the technology generate and how exactly will that information be used in future decision-making? Who will be responsible for agreeing this?
- **Is the technology worth introducing**? What value does it have to the user and to the service?
- **What is being asked of those working with the technology**? E.g. Acceptance by professional staff could be most significant determinant of successful implementation
- **Has the organisation capacity to adapt what needs to be in place?** E.g. capacity to innovate; level of support for change; what is the commitment to resourcing the implementation and for how long?
- **What is the ongoing support and training needed to sustain technology implementation for different members of staff** to meet the evolving requirements of service users?

Implementing remote monitoring in social care settings: learning from a NIHR Knowledge Mobilisation Research Fellowship

3 key factors in effective, sustainable technology implementation (examples from a research project)

1. The value proposition

Engaging practitioners and achieving cross-system buy-in requires a narrative of real-world improvements to people's lives. E.g. Initial scepticism amongst practitioners about the value of the technology dramatically reduced once carers of older people shared positive stories.

2. The adopter system

Project managers rely on injections of support from key stakeholders at different stages of implementation. Need to identify from the outset where relevant skills and knowledge are located across organisational boundaries, e.g. social work, commissioning, IT, information governance.

3. The organisation

Accepting that innovation takes time to show success creates a safe space to refine and adjust the technology's implementation. E.g. Senior management helped build a shared vision of technology-enabled care by allowing implementation to take 2 years from commissioning to embedding.

Implementing remote monitoring in social care settings: learning from a NIHR Knowledge Mobilisation Research Fellowship

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Eastern AHSN

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